वार्षिक प्रतिवेदन

Annual Report

2020

भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संस्थान ब्यूरो

पूसा कैम्पस, नई दिल्ली – 110012

ICAR-National Bureau of Plant Genetic Resources

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Supervision
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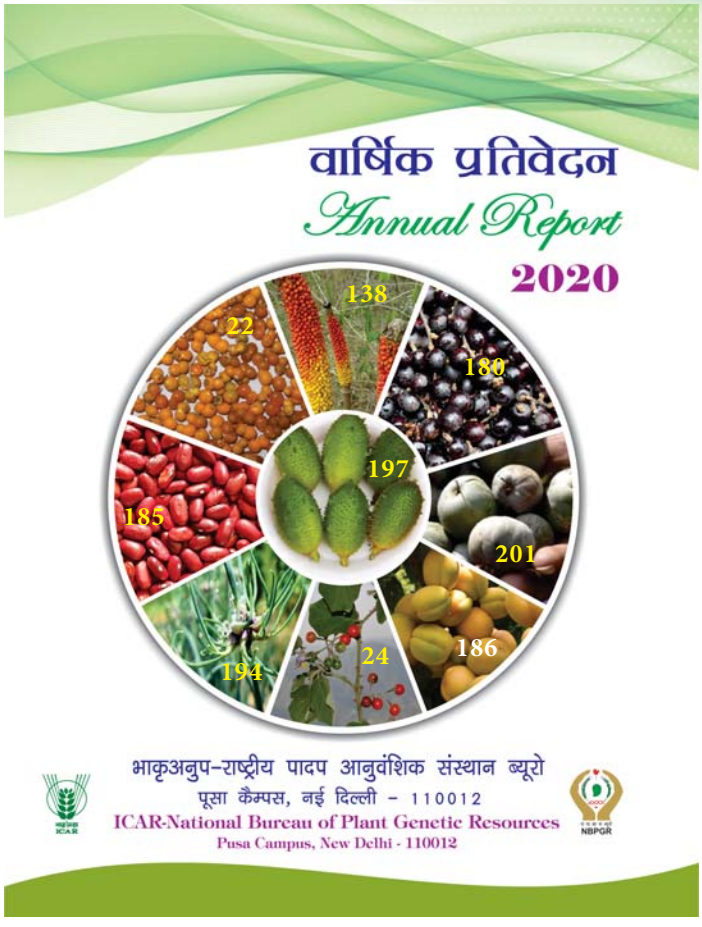
Editorial Team
Manjusha Verma
Sherry R Jacob
R Parimalan
Vartika Srivastava
Bharat Gawade
Kuldeep Tripathi



Photos on Cover Page
(Photos From Clockwise)
1. Pg 138 : ***Amorphophallus paeoniifolius***
2. Pg 180 : **Sohiong fruits**
3. Pg 201 : ***Manilkara littoralis* (JPNAJ/20-9)**
4. Pg 186 : **IC558065, Early maturing apricot**
5. Pg 24 : ***Solanum indicum***
6. Pg 194 : ***Allium cepa* var. *proliferum***
7. Pg 185 : **IC405482 of french bean**
8. Pg 22 : ***Grewia tanax***

(Photo in Center)
9. Pg 197 : **Teasel gourd variety - ArkaBharath**

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Contents

रा पा आ सं ब्यूरो
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 2020 in this extremely challenging year of raging pandemic of Covid19. ICAR-NBPGR has been in the defining role of plant genetic resources research with profound relevance to breeders and other stakeholders throughout the global society. In that perspective, we have implemented various programmes and network projects involving national partners for a diverse, focussed and strategic research on plant genetic resources in 2020.

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 2020.

Feb 20, 2022
New Delhi

Ashok Kumar
Director (Acting)

List of Acronyms

ABD	Augmented Block Design
mM	Micro Molar
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

विभिन्न पीजीआर पहलुओं पर भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवांशिकी संसाधन ब्यूरो (भा.कृ.अनु.प.–रा.पा.आ.सं.ब्यूरो) द्वारा 2020 के दौरान महत्वपूर्ण उपलब्धियां, पादप अन्वेषण एवं जननद्रव्य संग्रहण, जननद्रव्य विनियम आदान प्रदान, पादप जननद्रव्य संगरोध, जननद्रव्य लक्षण वर्णन और मूल्यांकन, जननद्रव्य संरक्षण, MTS और FGB में जननद्रव्य, जननद्रव्य *इन–विट्रो* और क्रायो–संरक्षण, डीएनए फिंगरप्रिंटिंग, जीनोमिक रिसोर्स और जीएम डिटैक्शन और अन्य गतिविधियां 21 संस्थागत रूप से वित्त पोषित कार्यक्रमों और 42 बाहरी वित्त पोषित परियोजनाओं के तहत संक्षेप में नीचे दर्शाई गई हैं:

पादप अन्वेषण एवं जननद्रव्य संग्रहण

2020 में, देश भर में कुल 28 अन्वेषण किए गए, जिसमें भारत के 20 राज्यों में स्थित 100 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों के जंगली रिश्तेदारों और अन्य आर्थिक प्रजातियों के 1,656 संग्रह एकत्र किए गए। इनमें से 628 प्रविष्टियाँ भा.कृ.अनु.प.–रा.पा.आ.सं.ब्यूरो मुख्यालय, नई दिल्ली द्वारा असम, बिहार, दिल्ली, हरियाणा, हिमाचल प्रदेश, जम्मू और कश्मीर, पंजाब, राजस्थान, उत्तराखंड और उत्तर प्रदेश के कुछ हिस्सों में किए गए 13 अन्वेषणों के माध्यम से एकत्र की गईं। अकोला में, वर्ष के दौरान एक अन्वेषण और संग्रह कार्यक्रम शुरू किया गया था और महाराष्ट्र के बुलदाना और औरंगाबाद जिलों से अरहर की कुल 57 प्रविष्टियाँ (खेती और जंगली) एकत्र की गई थी। भोवाली स्टेशन में, एक खोज में 38 विभिन्न संग्रह किए गए। हैदराबाद, तेलंगाना से अरहर, लोबिया और जंगली अरहर जननद्रव्य के संग्रह के लिए एक सहयोगात्मक अन्वेषण किया गया। इसके अलावा, दो विशेष मिशन, एक पूर्वी घाट की शेषचलम पहाड़ी श्रृंखला में *मोमोर्डिका सिम्बलरिया* और जंगली अरहर जननद्रव्य (*राइनकोसिया बेडडोमी*) के संग्रह के लिए भी शुरू किया गया। रांची, झारखंड में अनाज, दलहन, सब्जी, तिलहन और जंगली प्रजातियों की प्रविष्टियों को एकत्र करने के लिए दो सी डब्ल्यू आर अन्वेषण कार्यक्रम शुरू किए गए। शिलांग स्टेशन में, गोलपारा (असम) और मेघालय के आसपास के जिलों में एक बहु–फसल अन्वेषण किया गया। इस अवधि के दौरान लक्षित फसलों और सीडब्ल्यूआर की 37 प्रजातियों को शामिल करते हुए 81 परिग्रहणों का संग्रह किया गया था। शिमला स्टेशन ने फरवरी 2020 के दौरान एक अन्वेषण यात्रा की और विभिन्न फल फसल प्रजातियों के कुल 25 परिग्रहण एकत्र किए गए। किन्नौर हिमाचल प्रदेश के बारी गांव से एक मीठे बीज के आड़ू के जीनोटाइप की पहचान की गई और इसे एकत्र किया गया। श्रीनगर स्टेशन द्वारा कश्मीर के विभिन्न क्षेत्रों से समशीतोष्ण फलों और जंगली खाद्य फलों सहित वाइटिस प्रजातियों की खोज की गई और 63 विविध जननद्रव्य एकत्र किए गए। इस अन्वेषण कार्यक्रम के दौरान स्थानीय लोगों के साथ सक्रिय बातचीत से मूल्यवान जननद्रव्य एकत्र करने और संबंधित आईटीके का दस्तावेजीकरण करने में मदद मिली। त्रिशूर स्टेशन में, रिपोर्ट के तहत वर्ष के दौरान केरल और तमिलनाडु को कवर करने वाली तीन छोटी यात्राओं के अलावा केरल, अंडमान द्वीप समूह और तमिलनाडु को कवर करने वाले चार अन्वेषण मिशनों में जननद्रव्य के 402 नमूने एकत्र किए गए।

इसके साथ संयोजन में कुल 313 हर्बेरियम नमूनों (61 गैर–प्रतिनिधित्व वाले टैक्सा सहित) को संसाधित किया गया और नेशनल हर्बेरियम ऑफ कल्टीवेटेड प्लांट्स (एनएचसीपी), नई दिल्ली में जोड़ा गया। एक स्थानीय तरबूज 'आर्य' की पहचान की पुष्टि एक अलग टैक्सोनोमिक वैरिएटल स्टेटस *कुकुमिस मेलो* में की गई। मूंग के 7,172 स्वदेशी परिग्रहणों और लोबिया के 6,382 परिग्रहणों का भू–संदर्भन और मानचित्रण भी किया गया।

जननद्रव्य विनियम आदान प्रदान

इस वर्ष, 1,07,759 परिग्रहण (1,83,436 नमूने) आयात किए गए, जिसमें परीक्षण के लिए जननद्रव्य के 39,315 परिग्रहण (40,415 नमूने) और सीजीआईएआर नर्सरी की 68,444 प्रविष्टियां (1,43,021 नमूने) शामिल हैं। विभिन्न

फसल सुधार कार्यक्रमों में उपयोग के लिए राष्ट्रीय उपयोगकर्ताओं को विभिन्न फसलों के कुल 16,981 नमूनों की आपूर्ति की गई। इसके अलावा, पुनर्जनन/गुणा/रूपात्मक लक्षण वर्णन/प्रारंभिक मूल्यांकन/वर्गीकरण पहचान/डीएनए फिंगरप्रिंटिंग/व्यवहार्यता परीक्षण के लिए 1,01,030 नमूनों की आपूर्ति की गई। सहयोगी अनुसंधान परियोजनाओं के तहत 11 देशों को गेहूं और अन्य फसलों से युक्त 745 नमूनों का निर्यात किया गया।

पादप जननद्रव्य संगरोध

विभिन्न फसलों और उनके जंगली रिश्तेदारों की परीक्षण प्रविष्टियों सहित आयातित जननद्रव्य प्रविष्टियों के कुल 1,10,464 नमूनों को संगरोध मंजूरी के लिए संसाधित किया गया था। संक्रमित/संक्रमित नमूनों (6764) में कीट (314), सूत्रकृमि (154), कवक (6195), वायरस (95) और खरपतवार (06) शामिल हैं, जिनमें कई विदेशी कीट शामिल हैं। संक्रमित/संदूषित 6764 नमूनों में से 6697 का भौतिक–रासायनिक तरीकों से बचाव किया गया। विभिन्न देशों/स्रोतों से आयातित विभिन्न फसलों के विदेशी जर्मप्लाज्म के कुल 670 नमूने पोस्ट–एंट्री क्वारंटाइन (पीईक्यू) ग्रीनहाउस में उगाए गए और वायरस से मुक्त पौधों की फसल मांगकर्ताओं को जारी की गई थी। इस अवधि के दौरान विभिन्न मांगकर्ता साइटों पर कुल 22 पोस्ट–एंट्री क्वारंटाइन निरीक्षण किए गए। निर्यात के लिए विभिन्न फसलों के कुल 1344 नमूने संसाधित किए गए, जिनमें से 19 संक्रमित नमूनों को बचाया गया, 03 प्रकार की खरपतवार प्रजातियों से ग्रसित 03 नमूनों को बचाया गया और 16 फाइटोसैनिटरी प्रमाणपत्र जारी किए गए। आयातित ट्रांसजेनिक रोपण सामग्री के 24 नमूनों के संगरोध प्रसंस्करण से कपास के बीजों में जीवाणु संक्रमण का पता चला, जिन्हें एंटीबायोटिक उपचार देकर बचाया गया और पीईक्यू निरीक्षण किया गया। बीज स्वास्थ्य परीक्षण के तहत, जननद्रव्य संरक्षण प्रभाग से कुल 6273 नमूने प्राप्त हुए, जिनमें से 264 नमूने कवक (262), बैक्टीरिया (1) और वायरस (1) सहित विभिन्न रोगजनकों से संक्रमित पाए गए। इसके अलावा, क्रायो–संरक्षण से पहले/बाद में बीज स्वास्थ्य परीक्षण के लिए टीसीसीयू से 104 नमूने प्राप्त हुए, जिनमें से सात नमूने विभिन्न कवक से संक्रमित पाए गए और सभी को बचाया गया। हैदराबाद में, कुल 44,979 नमूनों (14,918 आयात एवं 30,061 निर्यात) को संगरोध मंजूरी के लिए संसाधित किया गया और 54 फाइटोसैनिटरी प्रमाण पत्र जारी किए गए। आयात नमूने (12,209) कीट/रोगजनकों से संक्रमित को बचाया गया और जारी किया गया। विभिन्न फसलों की 5,715 फसलों की प्रविष्टि के बाद संगरोध निरीक्षण किया गया। दक्षिण भारत में 43 संगठनों तक क्वारंटाइन सेवाओं का विस्तार किया गया।

जननद्रव्य लक्षण वर्णन और मूल्यांकन

2020 के दौरान, विभिन्न कृषि–बागवानी फसलों के कुल 25,980 परिग्रहणों की विशेषता/मूल्यांकन/पुनर्जीवित की गई। विभिन्न फसलों का मूल्यांकन उनकी उच्च उपज क्षमता के लिए उच्च मूल्य जननद्रव्य संसाधनों की पहचान करने में मदद करता है जो खाद्य उत्पादन (एसडीजी 2.3) बढ़ाने और किसानों की आय बढ़ाने, गरीबी को समाप्त करने और भोजन की उपलब्धता में वृद्धि (एसडीजी 1 और एसडीजी 2) में सहायता कर सकते हैं। कुल गेहूं (1780), मक्का (302), जौ कोर सेट (688), सोयाबीन (500), ब्रासिका (1293), तिल (4895), अलसी (2634), मटर (3054), जंगली लैथिरस (20), राइसबीन (1872), लोबिया (3720) और अन्य (80 एसीसी.) को कृषि संबंधी लक्षणों के लिए विशेषता और मूल्यांकन किया गया था। विभिन्न अजैविक और जैविक तनावों के प्रति सहनशीलता वाले जननद्रव्य संसाधन कमजोर स्थितियों के खिलाफ लचीलापन पैदा करते हैं और एसडीजी 1.5 प्राप्त करने में सहायता करते हैं। विभिन्न फसलों के कुल 940 परिग्रहण अर्थात ब्रासिका, उड़द, लोबिया, मक्का, बैंगन, मिर्च और शिमला मिर्च का फसल विशिष्ट जैविक तनाव के लिए मूल्यांकन किया गया था, जबकि गेहूं, जौ और मसूर से संबंधित कुल 593 अजैविक तनावों के लिए मूल्यांकन किया गया था। प्रोटीन और तेल की गुणवत्ता जैसे पोषण संबंधी महत्वपूर्ण लक्षणों के लिए विभिन्न खाद्य फसलों में जननद्रव्य संसाधनों की पहचान और उनके उपयोग से जनसंख्या की पोषण स्थिति में उल्लेखनीय सुधार हो सकता है और सभी प्रकार के कुपोषण (एसडीजी 2.2) को समाप्त करने में सहायता मिल सकती है। विभिन्न पोषक तत्वों और फाइटोकेमिकल्स के लिए चावल, मक्का, गेहूं, बाजरा, कुल्थी, उड़द, मूँग, ब्रासिका,

अलसी, तिल, हल्दी, बेर, खुरमा, सब्जी ऐमारैंथ, और बकोपा मोनियरी से संबंधित कुल 1991 का मूल्यांकन किया गया था। सीआरपी ऑन एग्रो–बायोडायवर्सिटी–पीजीआर कंपोनेंट–II के तहत गेहूं (812), भिंडी (506) और चना (300) सहित कुल 1618 परिग्रहणों का मूल्यांकन किया गया। अकोला स्टेशन में, रबी 2019–20 के दौरान 592 परिग्रहणों और खरीफ 2020 के दौरान 3,569 परिग्रहणों सहित कुल 4161 परिग्रहणों की विशेषता और मूल्यांकन किया गया। रबी 2019–20 के दौरान अलसी (283), चना (100), कुसुम (59) और अनाज ऐमारैंथ (150) और मोठ (1,545), मूंग (200), कुटकी (31), खरीफ 2020 में कंगनी (100), तिल (1,538) और विंग्ड बीन (155)। भोवाली स्टेशन में, विभिन्न क्षेत्रों, बागवानी, WEUP फसलों के 1209 परिग्रहणों की विशेषता थी, और एमटीएस बीज पुनःपूर्ति के लिए 452 परिग्रहणों को गुणा और कायाकल्प किया गया। कटक में 2627 का सेट विभिन्न फसलों और जंगली प्रजातियों को गुणा/पुनर्जीवित और 573 प्राप्तियों इसमें खेती वाले चावल (201), जंगली चावल (235), ओसीमम प्रजाति (49), *हिबिस्कस सबदरिफा* (21), *मुकुना प्रुरीएन्स* वेर शामिल हैं। *प्रुरीएन्स* (34), *एबेलमोस्कस* (33) को विभिन्न मोर्फो–एग्रोनोमिक लक्षणों के लिए चित्रित प्रविष्टियों को किया गया था। हैदराबाद स्टेशन में, कुल 1,371 प्राप्तियों, विभिन्न कृषि–बागवानी फसलों के लक्षण वर्णन, मूल्यांकन, कायाकल्प और गुणन के लिए उठाया गया था। जोधपुर स्टेशन पर रबी 2019–20 के दौरान 302 और खरीफ 2020 के दौरान 1048 परिग्रहणों सहित विभिन्न फसल समूहों के कुल 1350 जननद्रव्य अभिग्रहण की विशेषता और मूल्यांकन किया गया। रांची में, अनाज की उपज विशेषताओं और रूपात्मक लक्षणों के लिए मसूर के कुल 179, बाकला के 21 और कुल्थी के 2410 उपयोगों का मूल्यांकन/विशेषताएं की गईं। शिमला में, कृषि–रूपात्मक लक्षणों के लिए 1,077 बीज प्रसार फसलों की विशेषता और मूल्यांकन किया गया। श्रीनगर में, रबी 2019–20 के दौरान न्यूनतम डिस्क्रिप्टर के अनुसार बाकला (28), गेहूं (106), जौ (108) और एलियम (9) सहित 251 जर्मप्लाज्म को उनके कृषि–रूपात्मक लक्षणों के लिए चित्रित किया गया था। त्रिशूर में, कुल 185 संग्रहों में सोलनम प्रजातियों के 128, जंगली केले के 9 और फील्ड बीन के 48 संग्रह शामिल थे, और 74 छोटे करेला, 13 करेले के, 20 मूँग, 12 उड़द और 41 लोबिया की विशेषता का मूल्यांकन किया गया।

जननद्रव्य संरक्षण

राष्ट्रीय जीनबैंक में दीर्घकालिक संरक्षण के लिए पुनर्जीवित जननद्रव्य, अधिसूचित की जाने वाली किस्मों, जारी की गई किस्मों और विभिन्न फसलों के विशेषता–विशिष्ट पंजीकृत जननद्रव्य सहित जननद्रव्य की कुल 20616 प्रविष्टियां प्राप्त हुईं। इन्हें जीनबैंक मानकों का पालन करते हुए संसाधित किया गया, विभिन्न कृषि–बागवानी फसलों के 9,057 परिग्रहणों को आधार संग्रह में जोड़ा गया, जिससे कुल जर्मप्लाज्म होल्डिंग बढ़कर 448581 हो गई। संरक्षित परिग्रहणों में से, 4,649 नए थे और 4,408 परिग्रहण पुनर्जनन के बाद प्राप्त हुए थे। संरक्षित जननद्रव्य (5178 परिग्रहण) में अंकुरण और बीज मात्रा की निगरानी और लक्षण वर्णन/मूल्यांकन/पुनरुत्पादन/अनुसंधान के लिए वितरण (64,034) अन्य प्राथमिकता वाली गतिविधियां थीं। आपूर्ति किए गए जननद्रव्य में कृषि जैव विविधता पर कंसोर्टियम रिसर्च प्रोजेक्ट (सीआरपी–एबी) के तहत गुणन और लक्षण वर्णन के लिए भेजे गए जननद्रव्य शामिल हैं। राष्ट्रीय जीनबैंक (11,642 अभिग्रहण) का संपूर्ण मक्का जननद्रव्य संग्रह सीआरपी (एबी) कार्यक्रम के तहत बिहार के बेगूसराय में स्थित भारतीय मक्का अनुसंधान संस्थान के क्षेत्रीय मक्का अनुसंधान और बीज उत्पादन केंद्र में विकसित किया गया है ताकि एक कोर सेट को चिह्नित किया जा सके और प्राप्त किया जा सके। उपयोग बढ़ाने के लिए देश के पूरे चावल उगाने वाले क्षेत्रों का प्रतिनिधित्व करने वाली चावल की भूमि (12000) को उनके कृषि–रूपात्मक लक्षणों के लिए चित्रित किया गया। संरक्षित नमूनों के पुनर्जनन के दौरान खेत में इष्टतम बीज अंकुरण प्राप्त करने के लिए एक भविष्य कहनेवाला मॉडल विकसित करने के लिए हाइड्रोथर्मल टाइम (HTT) मॉडलिंग को दोहराया प्रोबिट विधि का उपयोग करके किया गया और चावल, गेहूं, मक्का, जौ, रागी, मूंग, बाजरा के लिए सहसंबंध विकसित किए गए हैं। बाजरा और प्याज *मैकलुरा कोचीनचिनेंसिस* में त्वरित व्यवहार्यता परीक्षण प्रोटोकॉल

को मानकीकृत किया गया। ग्लूटाथियोन हाफ सेल रेडॉक्स क्षमता को अंकुरण परीक्षणों के माध्यम से बीज व्यवहार्यता निगरानी के विकल्प के रूप में गेहूं, जौ, प्याज और सोयाबीन में मानकीकृत किया गया था, जो बीज व्यवहार्यता के लिए जैव रासायनिक भविष्यवक्ता के रूप में इसके संभावित उपयोग को दर्शाता है।

जननद्रव्य *इन–विट्रो* और क्रायो–संरक्षण

विभिन्न बागवानी फसलों की 149 पौधों की प्रजातियों के 1,916 परिग्रहणों की संस्कृतियों को परिवेशी औरध्या कम तापमान पर, उपसंस्कृति की अवधि 2–24 महीनों के साथ इन विट्रो एक्टिव आईवीएजी जीनबैंक में संरक्षित किया गया। क्रायोजीनबैंक में बीज, पराग और 2,194 जीनोमिक संसाधनों के रूप में कृषि–बागवानी प्रजातियों के कुल 11,906 परिग्रहणों को संरक्षित किया गया। आईवीएजी में कुल 30 नए परिग्रहण जोड़े गए और इन विट्रो बेस जीनबैंक (आईवीबीजी) में 35 परिग्रहण जोड़े गए। गार्सिनिया गमी–गुट्टा और *आर्टोकार्पस लकूचा* में इन विट्रो गुणन प्रोटोकॉल विकसित किए गए, जबकि धीमी वृद्धि संरक्षण प्रोटोकॉल को *गार्सिनिया इंडिका, आर्टोकार्पस लकूचा, एलियम एल्बिडम* और *एलियम रामोसम* में विकसित/परिष्कृत किया गया था। विट्रीफिकेशन, ड्रॉपलेट विट्रिफिकेशन तथा वी– और डी–क्रायोप्लेट तकनीकों का उपयोग करके क्रायोप्रेजर्वेशन प्रयोगों में सफलता की भिन्न डिग्री हासिल की गई थी। *बकोपा मोननेरी* (39 आईएसएसआर मार्कर्स का उपयोग करके), *स्टीविया रेबाउडियाना* (40 एसएसआर मार्कर्स का उपयोग करके) और *डायोस्कोरिया डेल्टोइडिया* (30 एसएसआर और 39 आईएसएसआर मार्कर्स का उपयोग करके) में क्रायोप्रिजर्व्ड पौधों की आनुवंशिक अखंडता के रखरखाव की पुष्टि की गई थी। –160 डिग्री सेल्सियस से –180 डिग्री सेल्सियस के बीच के तापमान पर कुल 123 परिग्रहणों को बीज और पराग के रूप में क्रायोस्टोर किया गया। 12 प्रजातियों में बर्फीली और शुष्कीकरण अध्ययन किए गए और 4 प्रजातियों में बीज सुप्तता को तोड़ने के लिए प्रोटोकॉल को अनुकूलित किया गया। पराग अंकुरण और लंबी अवधि के बीज संरक्षण प्रोटोकॉल को क्रमशः *ज़ीया मेयस* और *ज़ी मैक्सिकाना* और *डोकिनिया इंडिका* में अनुकूलित किया गया। TCCU की गतिविधियाँ SDG 2 और आईवी लक्ष्य 13 और 18 का अनुपालन करती हैं।

डीएनए फिंगरप्रिंटिंग, जीनोमिक रिसोर्स और जीएम डिटैक्शन

सीवीआरसी के लिए डीएनए फिंगरप्रिंटिंग सेवा 19 कृषि–बागवानी फसलों के एक सौ दो (102) नमूनों के लिए की गई। नोवेल सिंपल सीक्वेंस रिपीट मार्कर कम कवरेज वाले पूरे जीनोम अनुक्रमण के माध्यम से इलायची (250,571) और लौकी (2593) में विकसित किए गए। कोंकण क्षेत्र से लोबिया जननद्रव्य में आनुवंशिक विविधता अध्ययन और 2496 तिल परिग्रहण एसएसआर मार्करों और 45 विविध अरहर जीनोटाइप एसएनपी का उपयोग करके किए गए। एसएनपी का उपयोग करते हुए कोर डेवलपमेंट के लिए सेल्फिंग के माध्यम से कुल 2893 अनाज अमरनाथ को शुद्ध किया गया था। *सेसमम* की दो प्रजातियों को अलग करने के लिए एसईएम अध्ययन किया गया है। *सीसमम इंडिकम* और *एस. मालाबारिकम* बीज की सतह की विशेषताओं का उपयोग कर रहे हैं। PSTOL1 ठिकाने के लिए एलील खनन और कम फास्फोरस भूखंड पर चावल की भूमि की स्क्रीनिंग की गई। जीबीएस दृष्टिकोण के माध्यम से पहचाने गए 68925 एसएनपी का उपयोग करके किए गए जीनोम वाइड एसोसिएशन स्टडी (जीडब्ल्यूएएस) ने क्रमशः फूल समय (दिनों से 5%, 50% और 95% फूल) और शारीरिक परिपक्वता विशेषता से जुड़े 15 और 6 एसएनपी की पहचान करने में मदद की है। जीडब्ल्यूएएस को 135 विविध गेहूं जीनोटाइप के एक एसोसिएशन पैनल पर किया गया था और एसएनपी का उपयोग करके 10 नमक सहिष्णुता से जुड़े लक्षणों के लिए 42 विश्वसनीय क्यूटीएन पाए गए थे। अलग–अलग समय अंतराल (यानी, 4 दिन और 7 दिन) पर दो राइस बीन एक्सेसेशन (बोल्ड पॉड और छोटी पॉड) के विकासशील अनाज का ट्रांसक्रिप्टोम सीक्वेंसिंग किया गया था। RNAseq ने 15 miR जीनों की पहचान करने के लिए विश्लेषण किया और सूखा सहिष्णुता में कुल्थी की सहज प्रकृति के लिए जिम्मेदार इसके लक्ष्यों को अंजाम दिया गया। चावल में ट्रांसक्रिप्टोम अध्ययन के माध्यम से, चावल के पत्तों में cpPdc जीन के अपगमन से C2 चावल विकसित करने का अवसर मिलता है जो प्रकाश

श्वसन को बायपास करने में मदद कर सकता है। वनस्पति ऐमारैंथस प्रजाति परिसर की पहचान परमाणु ITS अनुक्रम का उपयोग करके हल की गई। एनजीआरआर (नेशनल जीनोमिक रिसोर्सेज रिपोजिटरी) में 5 प्रजातियों के कुल 2,677 जमाओं को जोड़ा गया। डीएनए निष्कर्षण प्रोटोकॉल को संसाधित खाद्य डेरिवेटिव के जीएम का पता लगाने के लिए अनुकूलित किया गया।

अन्य गतिविधियां

पीजीआर प्रबंधन से संबंधित मुद्दों पर विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय स्तरों पर वार्ता और नीतियों के निर्माण के लिए नीति निर्माताओं की आवश्यकताओं के अनुसार विश्लेषणात्मक इनपुट प्रदान किए गए। जैसा कि भोजन और पोषण संबंधी जरूरतों को पूरा करने के लिए दिल्ली घोषणा में प्रतिबद्ध है, समान पहुंच और लाभ साझा करने के अवसरों को सुनिश्चित करते हुए, आनुवंशिक संसाधनों के आदान–प्रदान की सुविधा के लिए बहु–पक्षीय और द्विपक्षीय दोनों प्रकार के उपकरणों को अपनाया गया। एग्रीकल्चरल नॉलेज मैनेजमेंट यूनिट (AKMU) PGR पोर्टल पर, भा.कृ.अनु.प.–रा.पा.आ.सं.ब्यूरो के प्रमुख वेब–आधारित सूचना संसाधन, को 2020 में प्रति माह औसतनझ 4900 व्यूज के साथ कई देशों से एक्सेस किया गया। ट्विटर के माध्यम से PGR गतिविधियों पर सूचना प्रसारित करने के AKMU के प्रयास को आकर्षित किया है। भा.कृ.अनु.प.–रा.पा.आ.सं.ब्यूरो द्वारा निभाई गई भूमिका को लोकप्रिय बनाने के लिए 2.5 लाख इंप्रेशन (पिछले वर्ष की तुलना में 67 प्रतिशत की वृद्धि) दिए गए।

Executive Summary

The significant achievements during 2020 by ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) on various PGR 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 2020, a total of 28 explorations were undertaken across the country wherein 1,656 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 100 districts located in 20 states of India. Of these, 628 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 13 explorations conducted in parts of Assam, Bihar, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Uttarakhand and Uttar Pradesh. At **Akola**, one exploration and collection programme was undertaken during the year and a total of 57 accessions of pigeon pea (cultivated and wild) were collected from the Buldana and Aurangabad districts of Maharashtra. At **Bhowali**, 38 different collections were made in one exploration. At **Hyderabad**, one collaborative exploration was undertaken for collection of pigeon pea, cowpea and wild pigeon pea germplasm from Telangana. In addition, two special missions, one for the collection of wild pigeon pea germplasm (*Rhyncosia beddomei*) in Seshachalam hill ranges of Eastern Ghats and *Momordica cymbalaria* were also undertaken. At **Ranchi**, two exploration programme were undertaken in Jharkhand to collect accessions of cereals, pulse, vegetable, oilseed and crop wild relatives. At **Shillong**, one multi-crop exploration was conducted in Goalpara (Assam) and adjoining districts of Meghalaya. A collection of 81 accessions covering in 37 species/taxa of targeted crops and CWRs was made during the period. **Shimla** station undertook one exploration trip was undertaken during February 2020, and a total of 25 accessions of different fruit crop species were collected. A sweet kernel peach genotype has been identified and collected from Bari village, Kinnaur HP. At **Srinagar**, an exploration on temperate fruits and wild edible fruits including *Vitis* species was undertaken from various areas of Kashmir and 63 diverse germplasm accessions were collected. Active interaction with locals during this exploration programme helped in collecting valuable germplasm and in documenting associated ITK. At **Thrissur**, during the year under report 402 samples of germplasm were collected in four exploration missions covering Kerala, Andaman group of Islands and Tamil Nadu besides three short trips, covering Kerala and Tamil Nadu.

In conjunction with this a total of 313 herbarium specimens (including 61 unrepresented taxa) were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Identification of a local melon 'Arya' was confirmed a distinct taxonomic varietal status *Cucumis melo* subsp. *melo* var. *alwarensis*. Geo-referencing and mapping of 7,172 indigenous accessions of mung bean (*Vigna radiata*) and 6,382 accessions of cow pea (*Vigna unguiculata*) were also done.

Germplasm exchange

This year, 1,07,759 accessions (1,83,436 samples) were imported, which included 39,315 accessions (40,415samples) of germplasm and 68,444 entries (1,43,021 samples) of CGIAR nurseries for trials. A total of 16,981 samples of different crops were supplied to national users for utilization in various crop improvement programmes. In addition, 1,01,030 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing. 745 samples comprising of wheat and legume crops were exported to eleven countries under collaborative research projects.

Plant germplasm quarantine

A total of 1,10,464 samples of imported germplasm accessions, including trial entries of various crops and their wild relatives were processed for quarantine clearance. The infested/ infected samples (6764) comprised insects (314), nematodes (154), fungi (6195), viruses (95) and weeds (06) including several exotic pests. Of the 6764 infested/ infected/ contaminated samples, 6697were salvaged through physico-chemical methods. A total of 670 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 22 post-entry quarantine inspections were carried out at various indenter's sites during this period. A total of 1344 samples of various crops were processed for export of which 19 infested samples were salvaged, 03 samples contaminated with 03 types of weed species were salvaged and 16 Phytosanitary Certificates were issued. Quarantine processing of 24 samples of imported transgenic planting material revealed bacterial infection in cotton seeds which were salvaged by giving antibiotic treatment and PEQ inspection undertaken. Under seed health testing, a total of 6273 samples were received from Germplasm Conservation Division, of which 264 samples were found infected with different pathogens including fungi (262), bacteria (1) and virus (1). In addition, 104 samples were received from TCCU for seed health testing before/ after cryo-preservation, of which seven samples were found infected with different fungi and all were salvaged. At **Hyderabad**, a total of 44,979 samples (14,918 imports; 30,061 exports) were processed for quarantine clearance and 54 phytosanitary certificates were issued. Import samples (12,209) infested/ infected with pests/pathogens were salvaged and released. Post-entry quarantine inspection was conducted on 5,715 accessions of different crops. Quarantine services were extended to 43 organizations in South India.

Germplasm characterization and evaluation

During 2020, a total of 25,980 accessions of various agro-horticultural crops were characterised/evaluated/regenerated/multiplied. Evaluation of different crops for their high yield potential helps in identification of high value germplasm resources which can aid in increasing the food production (SDG 2.3) and there by income of farmers, end poverty and increase the availability of food (SDG 1 and SDG 2). A total of Wheat (1780 acc.), maize (302), barley corset (688 acc.), soybean (500 acc.), brassica (1293 acc.), sesame (4895 acc.), linseed (2634 acc.), pea (3054 acc.) wild lathyrus (20 acc.), ricebean (1872 acc.), cowpea (3720 acc.) and buckwheat (80 acc.) were characterized and evaluated for agronomic traits. Germplasm resources having tolerance to different abiotic and biotic stresses generate the resilience against vulnerable situations and aids in achieving SDG 1.5. A total of 940 accessions of different crops viz. brassica, urdbean, cowpea, maize, brinjal, chilli, and capsicum were evaluated for crop specific biotic stresses while a total of 593 accessions belonging to wheat, barley, and lentil were evaluated for

abiotic stresses. Identification of germplasm resources in different food crops for nutritionally important traits such as protein and oil quality and their use can markedly improve nutritional status of population and aid in eliminating all forms of malnutrition (SDG 2.2). A total of 1991 accessions belonging to rice, maize, wheat, buckwheat, millets, horse gram, black gram, green gram, brassica, linseed, sesame, turmeric, ber, Persimmon, vegetable amaranth, and *Bacopa monnieri*were evaluated for different nutrients and phytochemicals. Under CRP on Agro-biodiversity-PGR Component-II a total of 1618 accessions comprising wheat (812 acc.) okra (506 acc.) and chickpea (300 acc.) were evaluated. At **Akola**, a total of 4161 accessions comprising 592 accessions during rabi 2019-20 and 3,569 accessions during Kharif 2020 were characterized and evaluated. Crop-wise accessions characterized were linseed (283), chickpea (100), safflower (59) and grain amaranth (150) during rabi 2019-20 and moth bean (1,545), mung bean (200), little millet (31), foxtail millet (100), sesame (1,538) and winged bean (155) in kharif 2020. At **Bhowali**, 1209 accessions of various field, horticultural, WEUP crops were characterized, and 452 accessions were multiplied and rejuvenated for MTS seed replenishment. At **Cuttack**, a set of 2627 acc. of various crops and wild relatives were multiplied/ regenerated and 573 acc. comprising cultivated rice (201), wild rice (235), Ocimum spp (49), Hibiscus sabdariffa (21), Mucuna pruriens var. pruriens (34), Abelmoschus spp (33) was characterized for different morpho-agronomic traits. At **Hyderabad**, A total of 1,371 accs. of different agri-horticultural crops was raised for characterisation, evaluation, rejuvenation and multiplication. A total of 1350 germplasm accessions of various crop groups comprising 302 accessions during Rabi 2019-20 and 1048 accessions during Kharif 2020 were characterized and evaluated at **Jodhpur** station. At **Ranchi**, a total of 179 accessions of lentil, 21 accessions of Fababean and 2410 accessions of Horsegram were evaluated/characterized for grain yield attributes and morphological traits. At **Shimla**, 1,077 accessions of seed propagating crops were characterized and evaluated for agro-morphological traits. At **Srinagar**, 251 germplasm accessions comprising of faba beans (28), wheat (106), barley (108) and Allium (9) were characterized for their agro-morphological traits as per the minimal descriptors during Rabi 2019-20. At **Thrissur**, a total of 185 collections comprising 128 accessions of Solanum species, 9 of wild banana and 48 of field bean were characterized, and 74 of small bitter gourd, 13 of bitter gourd, 20 of greengram, 12 of blackgram and 41 of cowpea were evaluated.

Ex-situ conservation of germplasm

A total of 20616 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 9,057 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 448581. Of the conserved accessions, 4,649 were new and 4,408 accessions were received after regeneration. Monitoring of germination and seed quantity in conserved germplasm (5178 accessions) and distribution (64,034) for characterization/ evaluation/ regeneration/research were the other priority activities. The germplasm supplied includes those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). The entire maize germplasm collection of National Genebank (11,642 accessions) has been grown at Regional Maize Research and Seed Production Centre of Indian Institute of Maize Research, located at Begusarai, Bihar, under the CRP (AB)

programme to characterize and derive a core set for enhanced utilization. Rice landraces (12000) representing the entire rice growing areas of the country were characterized for their agro-morphological traits. To develop a predictive model for obtaining optimum seed germination in field during regeneration of conserved samples Hydrothermal Time (HTT) Modeling was done using repeated probit method and correlations have been developed for rice, wheat, maize, barley, finger millet, mung bean, pearl millet and onion. Quick viability testing protocol was standardized in Maclura cochinchinensis. Glutathione half cell redox potential were standardized in wheat, barley, onion and soybean as an alternative to seed viability monitoring through germination tests indicating its potential use as a biochemical predictor for seed viability.

Germplasm in MTS & FGB

In-vitro and cryo conservation of germplasm

Cultures of 1,916 accessions of 149 plant species of different horticultural crops were conserved in the In Vitro Active Genebank at ambient and/or at low temperature, with subculture duration ranging from 2- 24 months. A total of 11,906 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 30 new accessions were added to the IVAG and 35 accesseions were added to In Vitro Base Genebank (IVBG). In vitro multiplication protocols were developed in Garcinia gummi-gutta and Artocarpus lakoocha, while slow growth conservation protocols were developed/ refined in Garcinia indica, Artocarpus lakoocha, Allium albidum and Allium ramosum. Varying degrees of success was achieved in cryopresevation experiments using vitrification, droplet vitrification and V- and D-cryoplate techniques. Maintenance of genetic integrity of cryopreserved plants was confirmed in Bacopa monnieri (using 39 ISSR markers), Stevia rebaudiana (using 40 SSR markers) and Dioscorea deltoidea (using 30 SSR and 39 ISSR markers). A total of 123 accessions were cryostored as seeds, embryonic axes and pollen at temperatures between -160°C to -180°C. Freezing and desiccation studies were carried out in 12 species and protocols for breaking seed dormancy were optimized in 4 species. Pollen germination and longterm seed conservation protocols were optimized in Zea mays and Z. mexicana and Docynia indica, respectively. The activities of TCCU comply with the SDG 2 and Aichi Targets 13 and 18.

DNA fingerprinting, genomic resources generation and GM detection

DNA fingerprinting service for CVRC were carried out for one hundred and two (102) samples of 19 agri-horticultural crops. Novel Simple Sequence Repeat markers were developed in cardamomum (250,571), ridged gourd (2593) through low coverage whole genome sequencing. Genetic diversity studies in cow pea germplasm from konkan area and 2496 sesame accession were carried out using SSR markers and 45 diverse pigeonpea genotype using SNPs. Total 2893 accessions of Grain Amaranth were purified through selfing for core development using SNPs. SEM studies have been carried out to distinguish the two species Sesamum viz. *Sesamum indicum* and *S. malabaricum*) using seed surface characteristics. Allele mining for PSTOL1 locus and screening of rice landraces at low phosphorus plot were carried out. Genome wide association study (GWAS) conducted using 68925 SNPs identified through GBS approach has helped identify 15 and 6 SNPs associated with flowering time (days to 5%, 50% and 95% flowering) and physiological maturity trait, respectively. GWAS was performed on an association panel of 135 diverse wheat genotypes and found of 42 reliable QTNs for 10 salt tolerance associated traits using SNPs. Transcriptome sequencing of developing grains of two rice bean accessions (bold pod and small

pod) at different time intervals (i.e., 4 days and 7 days) was done. RNAseq analyses to identify 15 miR genes and its targets responsible for the innate nature of horsegram in drought tolerance were carried out. Through transcriptome studies in rice, the upregulation of *cpPdc* gene in rice leaves provide opportunity to develop C_2 rice that could help bypass photorespiration. Identity of vegetable Amaranthus species complex was resolved using nuclear ITS sequence. A total of 2,677 depositions from 5 species were added to NGRR (National Genomic Resources Repository) DNA extraction protocols were optimized for GM detection of processed food derivatives.

Other Activities

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, both multi-lateral and bilateral instruments were adopted to facilitate the exchange of genetic resources, while ensuring equitable access and benefit sharing opportunities. At Agricultural Knowledge Management Unit (AKMU) PGR Portal, NBPGR's principal web-based information resource, was accessed from many countries with an average number of >4900 views per month in 2020. AKMU's endeavor to disseminate information on PGR activities via Twitter has attracted as many as 2.5 lakh impressions (67% increase compared to last year) popularizing the role played by NBPGR.

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.

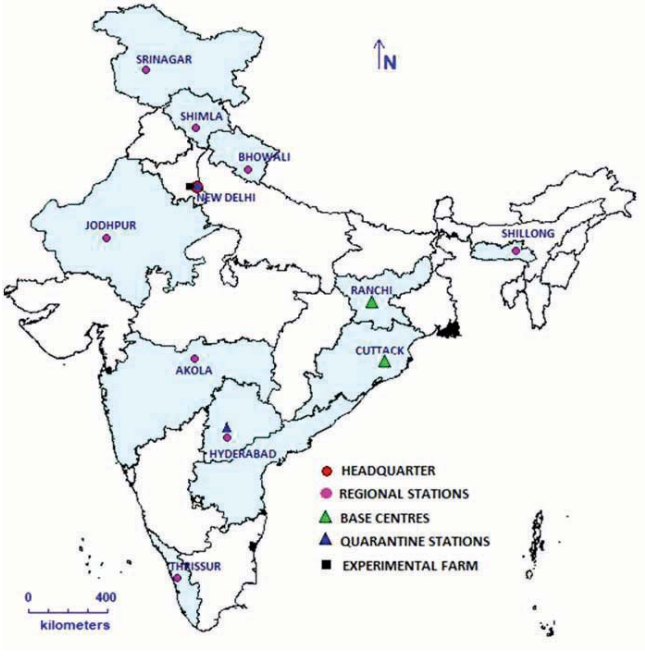


Fig. 1. NBPGR network of regional stations and base centres

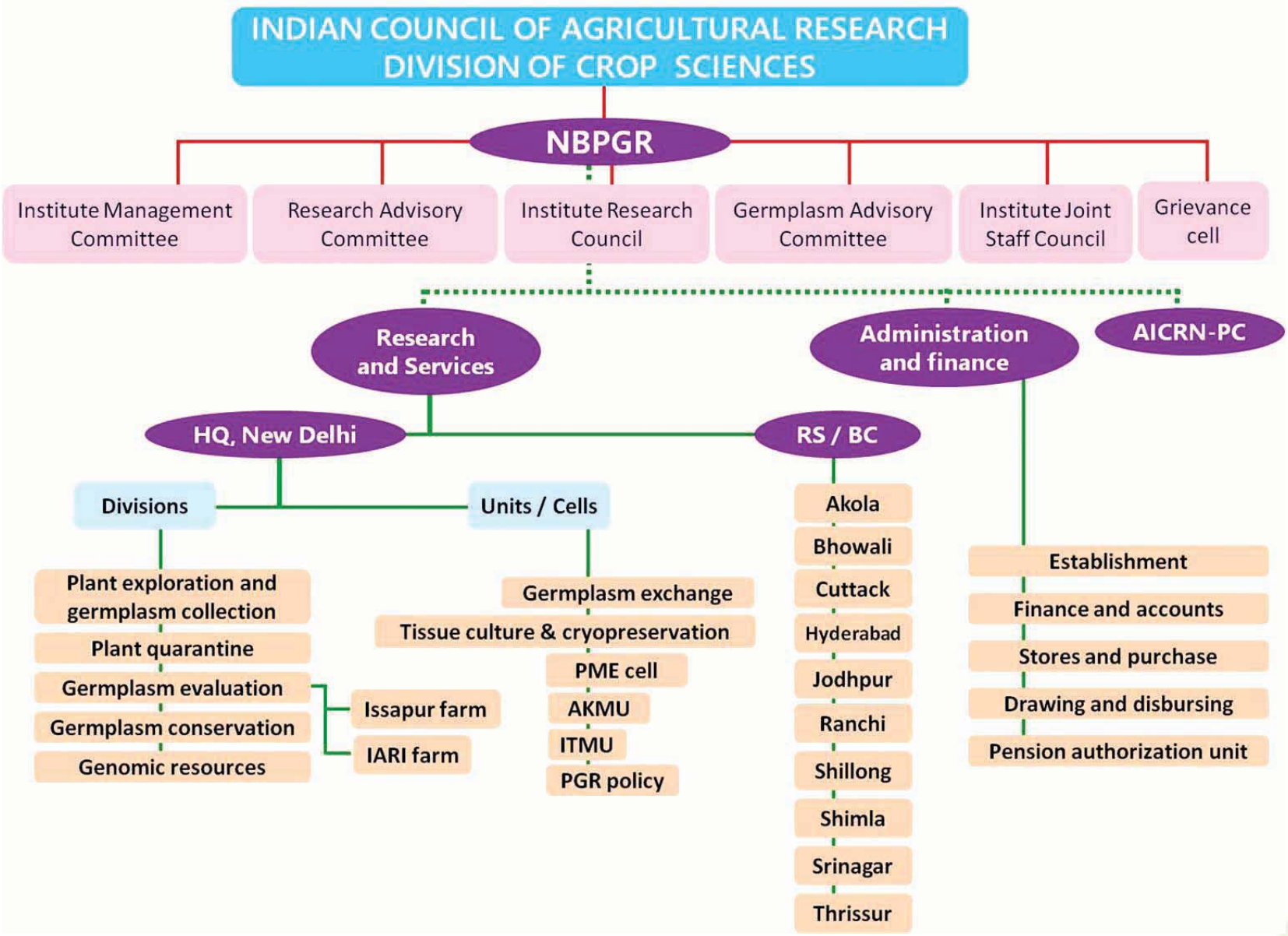


Fig. 2. Organogram of ICAR-NBPGR

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. The total staff strength on December 31, 2019 was 314 comprising 123 scientific, 72 technical, 47 administrative and 61 supporting staff.

National genebank

The National Genebank, ICAR-NBPGR, New Delhi was established to conserve national heritage of germplasm collections in the form of seeds, vegetative propagules, tissue/cell cultures, embryos, gametes, etc. The cold storage facility was initiated with the support of UK wayback in 1983 and later, was augmented with four long-term storage modules (two units of 100 m^3 and two of 176 m^3 capacity) to conserve seeds of orthodox species. Vegetatively propagated clonal materials and recalcitrant seeds germplasm are being maintained through tissue culture and cryo repositories and backed up with its maintenance under field conditions.

The National Genebank facility commissioned in 1997 has 13 modules, each with a storage capacity of 50,000 to 76,000 samples depending upon the size of seeds. One of these modules is used for medium term storage of active germplasm collections and the rest for long- term storage. Its cryopreservation facility contains six liquid nitrogen tanks (cryo-tanks), each containing 1,000 litres of liquid nitrogen. These six cryo-tanks have a capacity to store 0.25 million samples. Thus, the National Genebank has a total capacity to store 0.85 to 1.25 million samples. New modules 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 ang 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. Two M.Sc. and four Ph.D. students were awarded degree in 58th Convocation of P G School IARI. Currently, a total of 29 students including Nine M.Sc. and Twenty 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: In 2020, a total of 28 explorations were undertaken across the country wherein 1,656 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 100 districts located in 20 states of India. Of these, 628 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 13 explorations conducted in parts of Assam, Bihar, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Uttarakhand and Uttar Pradesh. A total of 313 herbarium specimens (including 61 unrepresented taxa) were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Morphological, cytolgical and molecular evidences were drawn to support identification of a local melon 'Arya' a taxon belonging to *Cucumis melo* group from Rajasthan and a distinct taxonomic varietal status *Cucumis melo* subsp. *melo* var. *alwarensis* were confirmed. Geo-referencing and mapping of 7,172 indigenous accessions of mung bean (*Vigna radita*) and 6,382 accessions of cow pea (*Vigna unguiculata*) were done.

1.1 Plant Exploration and Germplasm Collection

In the year 2020, a total of 28 explorations (involving 09 collaborators) were undertaken and 1,656 accessions of different agri-horticultural crops comprising 1,049 accessions of cultivated and 607 of wild species were collected from 100 districts covering 20 states of India. The states include Andaman and Nicobar Islands, Assam, Bihar, NCR of Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttarakhand, Uttar Pradesh and West Bengal. These collections captured diversity in 439 species; cultivated (1049 acc.; 63%) and crop wild relatives (607 acc.; 37%) in various crop- groups (Table. 1.2). Emphasis was given on collecting germplasm from various

Table1.1: Explorations undertaken and germplasm collected in year 2020

Headquarters/Station/Centre	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	1	42	15	57
Bhowali	1	-	36	36
Cuttack	3	155	104	259
Hyderabad	1	72	3	75
New Delhi (HQ)	13	389	239	628
Ranchi	2	77	4	81
Shillong	1	81	-	81
Srinagar	1	19	44	63
Thrissur	5	214	162	376
Total	**28**	**1049**	**607**	**1656**

Table 1.2: Details of germplasm collected in different crop groups during the year 2020

Crop-group (accs.)	Crop/wild species (accessions)
Cereals (212)	*Aegilops tauschii* (1), *Coix lacryma-jobi* (4), *Hordeum vulgare* (9), *Oryza meyeriana* var. *indandamanica* (1), *O. nivara* (23), *O. rufipogon* (23), *O. sativa* (115), *O. sativa* var. *spontanea* (4), *Triticum aestivum* (9), *T. dicoccum* (1), *Zea mays* (22)
Pseudo-cereals (18)	*Amaranthus blitum* (1), *A. cruentus* (2), *A. dubius* (3), *A. hypochondriacus* (3), *A. spinosus* (4), *A. tricolor* (2), *A. tristis* (1), *Chenopodium glaucum* (1), *Fagopyrum esculentum* (1)
Millets & minor millets (63)	*Echinochloa frumentacea* (3), *Eleusine coracana* (28), *Panicum sumatrense* (6), *Pennisetum typhoides* (8), *Setaria italica* (10), *S. pumila* (1), *S. verticillata* (3), *Sorghum bicolor* (2), *S. halepense* (1), *S. nitidum* (1)
Pulses/grain legumes (419)	*Cajanus albicans* (1), *C. cajan* (151), *C. grandiflorus* (1), *C. heynei* (1), *C. mollis* (3), *C. platycarpus* (1), *C. scarabaeoides* (24), *Cicer arietinum* (21), *Dysolobium pilosum* (1), *Lathyrus sativus* (22), *Lens culinaris* (23), *Macrotyloma uniflorum* (27), *Phaseolus coccineus* (2), *P. lunatus* (2), *P. vulgaris* (31), *Rhynchosia beddomei* (1), *R. minima* (5), *R. rothii* (1), *R. viscosa* (1), *Vigna angularis* (1), *V. angularis* var. *nipponensis* (3), *V. dalzelliana* (4), *V. marina* (2), *V. mungo* (20), *V. trilobata* (5), *V. trinervia* (1), *V. umbellata* (19), *V. unguiculata* (41), *V. unguiculata* subsp. *sesquipedalis* (3), *V. vexillata* (1)
Oilseeds (162)	*Arachis hypogaea* (1), *Brassica campestris* (1), *B. juncea* (8), *B. napus* (36), *B. napus* var. *glauca* (8), *B. rapa* var. *toria* (4), *Eruca sativa* (2), *Glycine max* (11), *Guizotia abyssinica* (2), *Linum usitatissimum* (34), *Perilla frutescens* (16), *Ricinus communis* (1), *Sesamum alatum* (5), *S. indicum* (19), *S. malabaricum* (11), *S. prostratum* (3)
Fiber and allied species (61)	*Cannabis sativa* (4), *Corchorus capsularis* (3), *C. olitorius* (13), *C. aestuans* (9), *Crotalaria alata* (1), *C. burhia* (4), *C. juncea* (2), *C. micans* (2), *C. pallida* (4), *Hibiscus acetosella* (1), *H. caesius* (1), *H. calyphyllus* (1), *H. sabdariffa* (3), *H. surattensis* (1), *H. vitifolius* (1), *Sesbania bispinosa* (1), *S. grandiflora* (2), *S. rostrata* (2), *S. sesban* (6)
Fruits & nuts (150)	*Aegle marmelos* (2), *Artocarpus altilis* (1), *A. camansi* (1), *A. lacucha* (1), *Berberis lycium* (2), *Cissus quadrangularis* (1), *Citrus aurantium* (2), *C. aurantifolia* (5), *C. indica* (1), *C. jambhiri* (1), *C. limonia* (1), *C. medica* (1), *C. megaloxycarpa* (1), *C. reticulata* (2), *C. sinensis* (1), *Cornus capitata* (1), *Corylus jacquemontii* (3), *Cotoneaster affinis* var. *bacillaris* (2), *Crataegus laevigata* (1), *C. pseudoheterophylla* (9), *C. songarica* (5), *Crossandra infundibuliformis* (1), *Cycas zeylanica* (1), *Cytisus scoparius* (1), *Diospyros crumenata* (1), *Elaeagnus umbellata* (2), *Elaeocarpus floribundus* (1), *Garcinia andamanica* (2), *G. dulcis* (2), *Grewia calophylla* (1), *G. flavescens* (1), *G. tenax* (1), *Hippophae salicifolia* (1), *Limonia acidissima* (1), *Macroptilium lathyroides* (1), *Malus prunifolia* (1), *Mangifera andamanica* (2), *Manilkara littoralis* (1), *Musa balbisiana* (1), *M. balbisiana* var. *andamanica* (1), *M. indandamanensis* (1), *Phoneix andamanensis* (1), *Phyllanthus emblica* (1), *Physalis minima* (2), *Portulaca oleracea* (1), *Prunus cerasifera* (3), *P. cornuta* (7), *P. domestica* (1), *P. domestica* subsp. *insititia* (2), *P. venosa* (1), *Pyracantha crenulata* (2), *Pyrus pashia* (3), *Rhus mysorensis* (2), *Ribes glaciale* (2), *R. himalense* (2), *Rosa macrophylla* (1), *R. moschata* (1), *Rubus biflorus* (2), *R. ellipticus* (1), *R. fasciculatus* (1), *R. foliolosus* (2), *R. nepalensis* (1), *R. niveus* (1), *R. paniculatus* (1), *R. rosaifolius* (1), *R. ulmifolius* (2), *Sorbus aucuparia* (2), *S. microphylla* (1), *Spondias pinnata* (1), *Syzygium claviflorum* (1), *S. gratum* (1), *S. samarangense* (1), *Toddalia asiatica* (1), *Vanilla andamanica* (2), *Vitis vinifera* (4), *Ziziphus jujuba* var. *jujuba* (2), *Z. jujuba* var. *spinosa* (8), *Z. mauritiana* (8), *Z. nummularia* (5), *Z. oenoplia* (1)
Vegetables (364)	*Abelmoschus angulosus* (3), *A. angulosus* var. *purpureus* (2), *A. esculentus* (7), *A. ficulneus* (1), *A. manihot* (4), *A. manihot* var. *pungens* (2), *A. manihot* var. *tetraphyllus* (1), *A. moschatus* (1), *Allium consanguineum (1), A. humile* (1), *A. proliferum* (1), *A. tuberosum* (1), *Amorphophallus oncophyllus* (1), *A. paeonifolius* (3), *Basella alba* (2), *Benincasa hispida* (8), *Brassica juncea* var. *rugosa* (6), *B. rapa* (5), *Canavalia ensiformis* (1), *C. gladiata* (1), *C. rosea* (1), *C. virosa* (1), *Capsicum annuum* (16), *C. chinense* (4), *C. frutescens* (1), *Celosia argentea* (1), *Coccinia grandis* (10), *Colocasia esculenta* (7), *Cucumis sativus* var. *hardwickii* (8), *C. melo* (4), *C. melo* var. *agrestis* (20), *Cucumis melo* var. *momordica* (3), *Cucumis sativus* (4), *Cucurbita maxima* (5), *C. moschata* (6), *C. pepo* (1), *Cyamopsis tetragonoloba* (3), *Cyclanthera pedata* (3), *Dioscorea alata* (8), *D. bulbifera* (2), *D. bulbifera* var. *sativa* (2), *D. esculenta* (1), *D. glabra* (1), *D. hamiltonii* (1), *D.*

Crop-group (accs.)	Crop/wild species (accessions)
	nummularia (2), *D. oppositifolia* (2), *D. pentaphylla* (1), *D. pyrifolia* (3), *Lablab purpureus* (7), *L. purpureus* var. *lignosus* (23), *L. purpureus* var. *typicus* (2), *Lagenaria siceraria* (6), *Luffa acutangula* (8), *L. acutangula* var. *amara* (5), *L. hermaphrodita* (2), *L. aegyptiaca* (8), *L. cylindrica* (6), *Lycopersicon esculentum* (2), *Malva verticillata* (3), *Momordica charantia* (1), *M. charantia* var. *muricata* (9), *M. cochinchinensis* (1), *M. dioica* (3), *M. subangulata* subsp. *renigera* (1), *Moringa oleifera* (6), *Mukia maderaspatana* (5), *Pachyrhizus erosus* (1), *Praecitullus fistulosus* (1), *Phaseolus coccineus* (1), *Pisum arvense* (8), *P. sativum* (13), *Raphanus sativus* (2), *Solanum aethiopicum* (1), *S. incanum* (10), *S. indicum* (4), *S. lycopersicum* var. *cerasiforme* (1), *S. melongena* (6), *S. pseudocapsicum* (1), *S. pubescens* (2), *S. sisymbriifolium* (2), *S. spirale* (1), *S. viarum* (8), *S. villosum* (1), *S. virginianum* (1), *Spinacia oleracea* (1), *Trichosanthes bracteata* (4), *T. cucumerina* (12), *T. tricuspidata* (8), *Vicia faba* (3), *Xanthosoma sagittifolium* (1)
Medicinal and aromatic plants, spices and condiments (195)	*Abrus precatorius* (4), *Abutilon indicum* (3), *Acorus calamus* (2), *Aerva javanica* (1), *Alpinia conchigera* (1), *A. manii* (1), *A. nigra* (1), *Amomum andamanicum* (1), *Andrographis paniculata* (1), *Aristolochia tagala* (1), *Brassica nigra* (1), *Bryonia laciniosa* (3), *Bryonopsis dioica* (1), *Caesalpinia bonduc* (1), *Callicarpa macrophylla* (2), *Cardiospermum halicacabum* (1), *Cassia occidentalis* (2), *Cassia tora* (1), *Catharanthus roseus* (1), *Centratherum anthelminticum* (1), *Cipadessa baccifera* (1), *Citrullus colocynthis* (3), *Cleome viscosa* (3), *Clerodendrum glandulosum* (2), *Coleus forskohlii* (1), *Corallocarpus epigaeus* (1), *Coriandrum sativum* (4), *Corypha utan* (1), *Costus speciosus* (3), *Curcuma amada* (1), *C. codonantha* (1), *C. longa* (3), *C. mangga* (2), *C. zedoaria* (1), *Diplocyclos palmatus* (2), *Drimia indica* (2), *Eclipta alba* (2), *Elephantopus scaber* (1), *Etlingera linguiformis* (1), *Glycosmis pentaphylla* (1), *Helicteres isora* (2), *Ilex aquifolium* (1), *Lawsonia inermis* (1), *Leucas aspera* (1), *Martynia annua* (1), *Merremia dissecta* (1), *Micromelum integerrimum* (1), *Miliusa andamanica* (1), *Murraya koenigii* (15), *Mucuna nigricans* (2), *M. pruriens* (1), *Myrtynia annua* (1), *Nicotiana tabacum* (2), *Ocimum americanum* (10), *O. basilicum* (2), *O. gratissimum* (2), *O. tenuiflorum* (13), *Papaver somniferum* (1), *Pavetta crassicaulis* (1), *Pedalium murex* (3), *Piper betle* (2), *P. miniatum* (1), *P. pedicellosum* (4), *P. wallichii* (1), *Podophyllum hexandrum* (3), *Polygonatum multiflorum* (1), *Rauvolfia serpentina* (1), *Rubia cordifolia* (1), *Semecarpus kurzii* (1), *Sida acuta* (1), *Solanum nigrum* (3), *S. torvum* (10), *S. trilobatum* (2), *S. violaceum* (2), *S. xanthocarpum* (2), *Tamilnadia ulginosa* (1), *Tephrosia purpurea* (1), *Teramnus labialis* (1), *Tinospora cordifolia* (2), *Trigonella foenum-graecum* (6), *Viburnum grandiflorum* (1), *Withania somnifera* (5), *Zanthoxylum armatum* (1), *Zingiber montanum* (1), *Z. odoriferum* (5), *Z. officinale* (5), *Z. ottensii* (1), *Z. squarrosum* (2), *Z. zerumbet* (1)
Forages (6)	*Calopogonium mucunoides* (1), *Cenchrus setigerus* (1), *Pueraria phaseoloides* (2), *Sorghum arundinaceum* (1), *Vicia sativa* (1)
Other economic species (6)	*Acacia senegal* (1), *Albizia procera* (1), *Macaranga nicobarica* (1), *Planchonella longipetiolata* (2), *Tamilnadia uliginosa* (1)

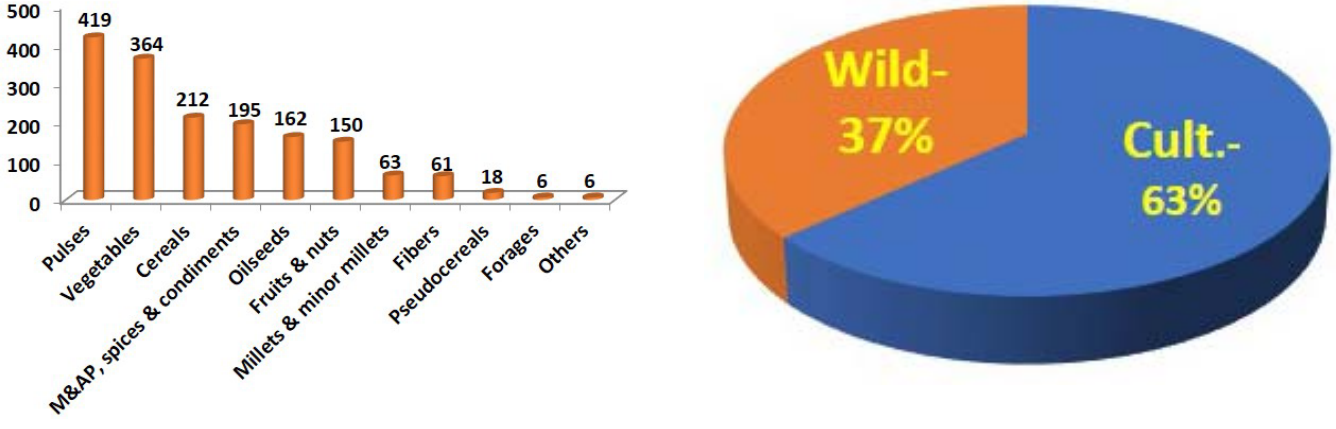


Fig. 1.1. Germplasm accessions collected across different crop-groups and % share of Crop Wild Relatives (37% CWR 63% other crops) in 2020

diversity-rich, remote/ tribal inhabited, disturbed and under-explored areas mainly in Andaman and Nicobar Islands, Assam, Jammu & Kashmir, Rajasthan and Uttarakhand. A total of 1125 collected accessions were sent to Germplasm Handling Unit (GHU) for conservation, while the remaining accessions were sent for multiplication and maintence in National Active Germplasm Sites (NAGS). Status of germplasm collected in explorations conducted by ICAR-NBPGR and its regional stations/base centres is given below (Table 1.1 & 1.2). Significant progress is made, as this year majority of planned explorations (NEP-2020-21) could not be conducted due to restriction on movement in wake of Covid-19 epidemic.

1.2 Explorations undertaken and germplasm collected by the Headquarters

During the reporting period, 13 explorations were undertaken in parts of Assam, Bihar, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Rajasthan, Uttarakhand and Uttar Pradesh. A total of 628 accessions (cultivated: 389 and crops wild relatives species: 239) of different agri-horticultural crops were collected (Table 1.3).

1.3 Grasspea germplasm collection from parts of West Bengal

Crop specific exploration was undertaken in under-represented areas of West Bengal (Purbi and Paschim Medinipur and Murshidabad

Table 1.3 Explorations undertaken by the ICAR-NBPGR, Headquarters (2020)

Sl . No.	Crops collected	Districts, state and period	No. of Accsessions			Collaborating Institute/SAU
			Cult.	Wild	Total	
1	Crop specific (Grass pea)	Medinipur (East & West), Murshidabad (W. Bengal), 29th Feb.- 08th Mar., 2020	23	-	23	BCKV,Mohanpur, West Bengal
2	CWR, minor economic spp.	NCR Delhi & adjoining areas in Haryana & Rajasthan, 21-23rd Sept., 2020	6	22	28	-
3	CWR, minor economic spp.	NCR Delhi & adjoining areas in Haryana & Uttar Pradesh, 6-8th Oct., 2020	1	32	33	-
4	CWR, minor economic spp.	Alwar incl. Sariska National Park, (Rajasthan), 12-16th Oct., 2020	11	31	42	SKNAU, Jobner, Rajasthan
5	Multi crops incl. CWR	Hastinapur (UP); Lower part of Pauri (Uttarakhand) 12-19th Oct., 2020	49	39	82	-
6	Multi- crops	Udaipur (Rajasthan), 26-31st Oct., 2020	14	10	24	-
7	Multi-crops incl. CWR	Champawat (Uttarakhand); 2-11th Nov., 2020	60	27	87	-
8	Multi-crops and CWR	Una, Kangra (Himachal Pradesh); Pathankot (Punjab); Kathua, Udhampur (Jammu & Kashmir), 06-12th Nov., 2020	29	15	44	-

Sl . No.	Crops collected	Districts, state and period	No. of Accsessions			Collaborating Institute/SAU
			Cult.	Wild	Total	
9	Multi-crops and CWR	Swai Madhopur and Tehla (Sariska National Park), Alwar in Rajasthan, 23-28th Nov., 2020	17	19	36	-
10	CWR & minor economic spp.	Kishanganj, Araria (Bihar), 9-18th Dec., 2020	68	07	75	Dr. KalamBAU, Bihar
11	CWR & minor economic spp.	Flood prone areas in Lakhimpur, Dhemaji, Dibrugarh, Sibsagar & Jorhat (Assam), 15-22nd Dec., 2020	36	13	49	RARS, Lakhimpur & KVK, Dhemaji, (AAU, Jorhat)
12	CWR & minor economic spp.	Hailakandi (Assam), 15-22nd Dec., 2020	43	4	47	KVK, Hailakandi, Assam
13	CWR & minor economic spp.	Dima Hasao (Assam) 15-22nd Dec., 2020	38	20	58	-
	TOTAL		**628**	**389**	**239**	

Fig. 1.2. Grain variability in grass pea from West Bengal

Fig. 1.3. Products of grass pea for sale in local market

districts) for collection of grasspea and a total of 23 accessions belonging to grasspea (21) and field pea (2). Large variability in grasspea (Lathyrus) for biomass, earliness, plant architecture, leaf width, grain size and colour, and tolerance to salinity was observed. It was observed that boro rice has replaced areas of grass pea in Purbi Medinipur district due to increased irrigation facility. Small seeded types are prefered over bold seeded because it requires low moisture for germination. Information on occurrence of lythyrism was not reported in surveyed areas.

1.4 Collection of CWR and wild economic species from NCR of Delhi and adjoining Rajasthan

Twenty-eight samples belonging to crop wild relatives and wild economic species were collected from Asola Bhati forest area of Delhi

and Faridabad; Bilaspur, Pataudi, Farukhnagar, Haileymandi, Sultanpur National Park Areas of Gurugram, Haryana; Firozpur Jhirka of Nuh, Haryana and Bhiwadi, Tapukara, Tijara areas of Alwar, Rajasthan. Among cultivated crops, 8 samples containing *Cucumis melo* var. *agrestis* (2), *C. melo* var. *alwarensis* (1), *C. melo* (1), *Cymopsis tetragonoloba* (1) *Triticum aestivum* (1), *Pennisetum glaucum* (1), *Sesbania sesban* (1) and 20 samples of wild species comprising of *Sesamum indicum* subsp. *malabaricum* (2), *Solanum insanum* (2), *Momordica dioica* (1), *Momordica charantia var. muricata* (1), *Trichosanthes cucumerina* (1), *Hibiscus calyphylla* (1), *Mukia madraspatana* (1), *Cardiospermum helicacabum* (1), *Withania somnifera* (1), *Pedalium murex* (1), *Citrullus colocynthis* (1), *Corchorus olitorius* (1), *Corchorus aeustans* (1), *Rhynchosia minima* (1), *Zizyphus oneopolia* (1), *Grewia tenax* (1), *Moringa oleifera* (1) and *Albizia procera* (1). *Ocimum americanum* having high aroma with good population in Asola Bhati forest area; *Cucumis melo* var. *alwarensis* locally known as 'Arya' collected from Jatauli, Pataudi (Gurugram) area of Haryana, (being cultivated in limited pocket); round shaped 'Foot kakari' (*C. melo*) from Jatauli, Pataudi (Gurugram); *Momordica balsamina* and *Momordica charantia* var. *muricata* (growing in ravines in Tizara area of Alwar district, consumed as vegetable by locals); 'Bajri' local landrace of pearl millet, grown in limited areas (plant height 10-12 ft, narrow candle shaped panicle, also used as fodder) in Mokalvas, Pataudi (Gurugram) and dark brown seeded wheat (may be introduced type, maintained by a farmer) collected from Budhera, Farukhnagar (Gurugram) supposed to have nutritional traits, were some of the interesting collections/observations.

1.5 Collection of CWR and other potential species from parts of Haryana and Uttar Pradesh

In this exploration, highly disturbed areas of Haryana and Uttar Pradesh were shortlisted due to very high potential for crop wild relatives and minor economic species. Parts of Sonipat, Baghpat, Shamli, Bahadargarh, Sampla and Jhajjar were surveyed and collected 33 accessions (16 species) belonging to *Sesamum indicum var. malabaricum* (5), *Trichosanthes cucumerina* subsp. *cucumerina* (3), *Cucumis melo* var. *agrestis* (3), *Cucumis maderaspatanus* (3), *Crotalaria burhia*, (3), *Setaria verticillata* (3), *Coccinia grandis* (2), *Sesbania rostrata* (2), and others (9) in crop wild relatives, local landraces and minor economic species. Rapid erosion of local varieties and wild relative's diversity of almost all the crops was noted due to urbanization activities in NCR region. Significant

Fig. 1.4. Diversity in *Momordica* spp. collected from ravines near Tijara, Alwar, Raj.

Fig. 1.5. Diversity in *Cucumis melo* var. *alwarensis* from Pataudi, Gurugram

Fig. 1.6. *Grewia tanax*- a rare wild fruit from Jasola Bhati forest, Delhi

high use of pesticides was identified to erod many potential wild germplasm- kachri, makoi, etc. that were usually abundant in the farmers' field and some protected areas around the farmer's fields are still holding poor populations of these wild species. Good population of *Sesame*, cucurbits and other potential crops of *kharif* season were frequently observed.

1.6 Collection of landraces and wild relatives from Alwar and Sariska National Park, Rajasthan

A total of 42 accessions belonging to 23 genera and 29 species including 20 wild species (29 accns.) were collected from buffer zone of Sariska national park and adjoining forest areas of Alwar district of Rajasthan. The important collections are *Cucumis callosus* (2), *Momordica dioica* (2), *Momordica muricata* (3), *Ocimum americanum* (2), *Pedalium murex* (2), *Rhus mysorensis* (2), *Trichosanthes cucumerina* (2), *Withania somnifera* (2), *Cucumis melo* (2), *Cucurbita moschata* var. *chakti* (2), *Luffa acutangula* (2), *Sesamum indicum* (2), *Zea mays* (2) and others (16). Variability in chakti, sesame and maize was observed for maturity,plant height, seed shape, size and colour. Indigenous knowledge on *Cucurbita* sp. having white coloured fruits locally known as *Chakti* was documented. The farmers have informed that presently, its cultivation has declined in many parts of Haryana and Rajasthan.Local people in tribal villages of Alwar district use fruits as vegetable and for medicinal purposes. Another minor wild edible fruit locally known as '*Dansri*' (*Rhus mysorensis*) was gathered through interaction with farmers of Thanagaji village from nearby forest areas of Alwar district. Its seeds are mixed with salt and oil and are consumed during autumn season (October) as snacks by tribal/local people of Rajsthan.

1.7 Multi-species collection from lower parts of Pauri Garhwal district and Hastinapur in Uttar Pradesh

Eighty-two accessions comprising of *Capsicum annuum* (6), *Eleusine coracana* (5), *Cucumis sativus* var. *hardwickii* (5), *Oryza sativa* (4), *Cajanus scarabaeoides* (4), *Cannabis sativa* (3), *Hordeum vulgare* (3), *Abelmoschus angulosus* var. *pungens* (2), *Cyclanthera pedata* (2), *Echinochloa frumentacea* (2), *Glycine max* (2), *Perilla frutescens* var. *frutescens* (2), *Raphanus sativus* (2), *Lens culinaris* (2), *Pueraria phaseoloides* (2), *Brassica rapa* (2), *Vigna umbellata* (2), *Sesamum indicum* var. *malabaricum* (2), *Vigna dalzelliana* (2), others (28) were collected from Hastinapur Forest area in Uttar Pradesh and buffer areas of Corbett National Park in Pauri district (Uttarakhand). Samples from a population of *Sesamum indicum* var. *malabaricum* having about 2m high plants with 4-6 secondary branches and 50-60 capsules in main rachis was collected from canal side near

Fig. 1.7. *Sorghum halepense*- wild relative of sorghum from Rajasthan

Fig. 1.8. A minor fruit from Rajasthan '*Dansri*' (*Rhus mysorensis*) being sold in local market

Fig. 1.9. *Chakti* a white pumpkin variety from Rajasthan

Fig. 1.10. Fruit variability in wild & cultivated cucumber from Uttarakhand

Fig. 1.11. *Solanum indicum* -a wild relative of brinjal from Uttarakhand

Fig. 1.12. *Mucuna nigricans*-a medicinal plant from Uttarakhand

Fig. 1.13. *Vigna dalzeliana*-a close relative of urdbean from Uttarakhand

Paltupur; samples of wild cucumber (*Cucumis sativus* var. *hardwickii*) from boundary of kitchen garden's where cultivated types (big sized fruits, eaten as raw), were also grown in surveyed villages of Uttarakhand. The fruits of wild cucumber samples collected from forest fringes were small in size in copmarision to samples from nearby cultivated sites may be because of gene flow between both cultivated and wild types. Wild cucumber (*Cucumis sativus* var. *hardwickii*) locally known as 'Yeladu', collected with rich variability in fruit size (4.5 cm - 12.5 cm length & 12 cm -23 cm width), weight (40 g - 281 g), shape (round, oval, elongate), colour (yellow, pale yellow, brownish yellow) and bitterness (sample having brownish yellow colour, locally known as 'Bhoj' is considered medium bitter while rest of the samples were highly bitter) from parts of Lensdowne, Rikhnikhal, Dhumakot and Corbett National Park buffer areas.

Population of *Vigna dalzelliana*, a wild relative of mung/urd was growing mainly along road side in open, dry habitat along with *Cajanus scarabaeoides*-a wild relative of pigeon pea. Sample of *C. scarabaeoides* having profuse fruiting was collected from same habitats. *Cannabis sativa* locally known as 'Bhangyul' cultivated in kitchen gardens in entire Rikhnikhal block for its seeds to use as a condiment to prepare chutney. Population of weedy form of *Perilla frutescens* var. *frutescens* was common in patches along the roads and open areas in the buffer zone of Corbet national park. *Pyracantha crenulata* locally known as '*Ghingaru*',-a wild edible fruit, which generally ripes in the month of August, was collected with ripened fruits (late maturity type) from Raiba village of Lansdowne. Occurrence of *Solanum indicum* and *S. violaceum* was scanty in entire surveyed area of Pauri district. Samples of *Abelmoschus angulosus* var. *pungens* & *A. manihot* subsp. *tetraphyllus* were collected from buffer areas of park with limited population. In *Capsicum annuum,* a local genotype having orange yellow fruits is being grown in large scale in entire Lansdowne block. It has good demand in local market and sold as a colouring agent for namkeen.

1.8 Collection of multi-crop germplasm from Jhadol Tehsil of Udaipur, Rajasthan

Panarwa block in Jhadol Tehsil has rich diversity of crops, wild and semi wild plant species. Villages in Panarwa are surrounded by high ranges of Aravallis and forest has wild banana, wild *Ocimum* spp., *Luffa* spp., *Ziziphus* spp. Custard apple, and wild okra. Twenty-four samples of crops and wild species comprising of

Fig. 1.14. A progressive women farmer conserving and cultivating wild okra (*Abelmoschus esculentus*)

Vigna mungo (2), *Abelmoschus esculentus* (2), *Eleusine coracana* (2), *Luffa acutangula* var. *amara* (2), and others (16) belonging to diverse crops and crop wild relatives were collected with good variability from surveyed area.

1.9 Multi-crop species from remote areas of Champawat district of Uttarakhand

Exploration for collection of multi-crops including crop wild relatives and wild edibles was conducted in remote areas of Champawat district and adjoining areas in Uttarakhand and Uttar Pradesh and total 87 germplasm samples belonging to 43 species were collected. Twelve diverse named landraces (*Borani, Dhur basmati, Kalathuni, Karmuli, Jaulia dhan, Jhusia dhan, Nimui dhan*, *Laladhan, Pyolia dhan, Raiman* and *Uskodhan)* with variability for grain size and shape, bran colour, kernel colour stickiness, and scented types in rice and four landraces in wheat (*Daulat khani, Jhusia, Gerua* and *Safed Jhusia*) were important collections. Landrace *Daulat khani is* popular and occuping larger area in comparision to others. In other crops/species variability was observed for fruit size, shape and colour in wild cucumber (*Cucumis sativus* var. *hardwickii*); and for grain colour (dull white, brown, dark brown, ash grey) and size in Perilla (*Perilla frutescens*). Among crop wild relatives, species belonging to *Abelmoschus*, *Amaranthus, Cajanus*, *Coix, Cucumis, Momordica, Perilla, Solanum, Trichosanthes, and* in wild economic species *Cornus, Abrus*, *Ilex, Mucuna, Pyrus,*

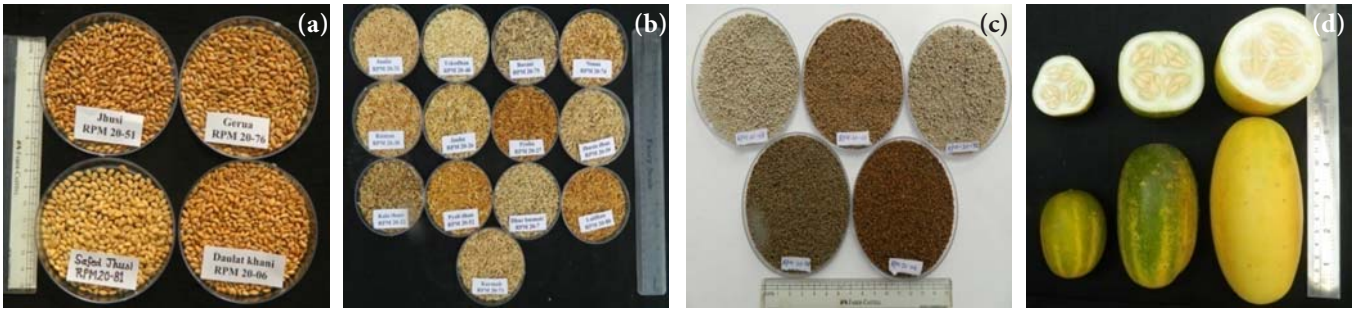


Fig. 1.15. Grain variability in a) wheat, b) paddy, c)Perilla and d) Fruit variability in *Cucumis sativus* var. *hardwickii* from Uttarakhand

Pyracantha and *Ziziphus* were some important collections. Population of weedy *Perilla* was observed in lower hills and plain areas of Champawat, Tanakpur and Haldwani. Wild species of *Ablemoschus angulosus* is cultivated in pokhri, Lohaghat for its roots. Its root is a good source of polysaccharides and root powder is mixed with rice floor for chapatti making. Unripe seeds of *Mucuna nigricans* are good source of polysaccharide and these seeds are used by local inhabitants as natural gum source.

1.10 Collection of CWR and landraces from foot-hills of Himachal Pradesh and Jammu & Kashmir

Forty-four accessions belonging to 21 genera and 27 species including 11 wild species (15 accns.) comprising of *Zea mays* (5), *Triticum aestivum* (4), *Solanum viarum* (3), *Sesamum indicum* (3), *Vigna unguiculata* (3), others (26) including CWR were collected from foot hills and hilly areas of Una, Kangra (Himachal Pradesh), Kathua and Udhampur districts (Jammu and Kashmir). Variability in cowpea and sesame was observed for maturity, plant height, seed shape, size and colour.The landraces of wheat possess significant characteristics as variation in maturity, plant height, grain yield and grain quality (softness); while in maize, variability was observed for grain colour (red, creamy, off-white, white and yellow), cob shape and size. Indigenous knowledge on *Jhar ber* (*Ziziphus nummularia*) and bold sized ber (*Z. mauritiana*) was also gathered from local farming communities. As informed by local people a tree >100 years old, having sweet and tasty fruits was also sampled. Variability in ber was observed for maturity, plant height, fruit shape, size and colour.

1.11 Collection of crops landraces and wild relatives from Sawai Madhopur and Tehla in Rajasthan

In this exploration trip, total 36 accessions belonging to cultivated (18) and wild (18) were collected. Maximum accessions of *Ziziphus* spp. (5) followed by sesame (4) and remaining 27 acc. of others depending on availability were collected from five villages lying in Sariska national park in Tehla block of Alwar district and Sawai Madhopur district of Rajasthan. Among crop groups, minor fruits (5), fiber (4), medicinal and aromatic plants (7), oilseeds (4), pulses (3), spices (3), cereals - Maize (1), vegetables (1), were collected. Variability in ber for fruit size and colour; and in sesame seeds colour was collected. Among wild relatives, *Luffa acutangula var. amara* was commonly seen on farm fences in Gola Ka Vaas village in Sawai Madhopur and *Sesamum indicum* var. *malabaricum* was collected from Ranthambore national park. In Tehla block, tobacco cultivation is predominant;

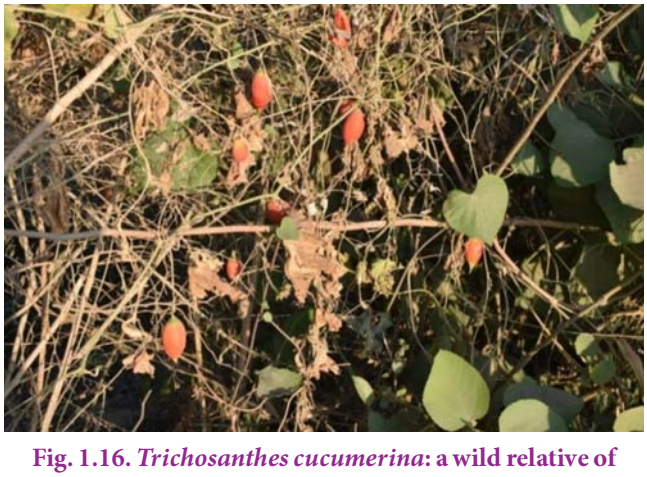


Fig. 1.16. *Trichosanthes cucumerina*: a wild relative of snakegourd from Himachal Pradesh

Fig. 1.17. Jhar ber (*Ziziphus nummularia*) - a minor fruit from Himachal Pradesh

Fig. 1.18. a. Collecting fruits of *Ziziphus* sps. from wild, and b. Sale of fruits in local market

its two accessions were collected. Tobacco landrace has developed unique quality (preferred by hookka smokers across the northern region) and adaptive characters suitable to the climatic and edaphic conditions of the valley. Trees of minor fruits like mango (*Magnifera indica*), Jamun (*Syzygium cumini*), Ber (*Zizyphus mauritiana*), and Tamarind (*Tamarindicus indica*) Khajur (*Phoenix sylvestris*), Karel (*Capparis decidua*), Khirni (*Manilkara hexandra*) and Tendu (*Diospyrous melanoxylon*) were observed in Ranthambore park.

1.12 Wild rice and other CWR collected from interior areas of Kishanganj and Araria district in Bihar

An exploration was conducted for the collection of multi-crops germplasm from Kishanganj and Araria in the interior and diverse areas of the targeted districts of Bihar. A total of 75 accessions representing significant diversity in rice landraces, Jute, Pulses, Finger millet, *Luffa* sp., Coriander, *Brassica* sp., *Lagenaria siceraria*, leafy and tuberous vegetables including important crop wild relatives namely *Cucumis medraspatanus*, *Ocimum* americanum, *crotalaria pallida*, *Solanum sisymbriifolium*, *Trichosanthes bracteata* and *Tamilnadia ulginosa*. Rich variability in rice landraces (*Sada sarna, Kukarjali, Ranjeet saran, Kala nania, Phool pakari, Kala khudhani, Biranphool safed, Desi manshuri, Safed khudhani, Biranphool kala, Desi basmati, Jasua dhan, Khaira dhan, Kaima dhan, Chanachur dhan, Samanjeera dhan Kanakjeera dhan and Hapsal/Gussad dhan*) for husk colour, grain shape and size, awn, scented, early types were collected. Farmers informed that the

Fig. 1.19. Grain variability in rice landraces from Bihar

Fig. 1.19. *Malva verticilatta*- a local leafy vegetable from Bihar

cultivated area of majority of landraces is reducing gradually. During the survey, farmers have also informed that about 20 rice landraces have been eroded in last 15-20 years from this region. Ethno-botanical information on local leafy vegetables was also documented. *Malva varticillata* is most liked leafy vegetable, which is grown in kitchen garden by each family.

1.13 Exploration of wild rice and landraces of crops from parts of Assam

Fourty-nine accessions (32 cultivated and 14 wild) consisting mostly landraces of deep-water paddy (20), vegetables (9), minor fruits (4), fiber (5), vegetables, oilseeds and pulse were collected from both-side of Brahamputra river in Lakhimpur, Dhemaji, Dibrugarh and Sibsagar districts of Assam in collaboration of the RARS, Lakhimpur and KVK, Dhemaji (AAU, Jorhat, Assam). Notable collections include semi-domesticated landraces of *Oryza nivara* (*Kokua bao*), deep water landraces namely *Lao Dubi, Guduli Joha, Dol Bahu, Nageri Bao, Amuna Bao, Majuli Bao, Ali Dhepa, Baoi* from Lakhimpur*; Bogi Amena Bao, Jira Joha, Haldharan, Rangi Bao, Maghuri Bao, Bangi Lohi, Moina Jaan, Kala Joha, Bora Dhan* and *Daal Kachi*. Some of them can withstand 6-8 feet water, and all differed in kernel shape and size, kernel colour, awns and plant morphology. Explored areas remain inundated in flood of Brahamputra for a long period from June to September. For such areas, these landraces are only option to farmers to grow and meet daily staple food requirement. Cucurbits, brinjal and *Rabi*-season vegetables were grown in very limited scale mostly in kitchen garden at higher reaches. Accessions of black gram, sesame, mustard, jute were also collected as their cultivation is very low. Minor fruits like *Elaeocarpus floribundus (Jalpai), Phyllanthus emblica (Amlokhi), Ziziphus mauritiana (Bagodi), Musa* sp. (*kol*) were very common and consumed by local people in surveyed area.

1.14 Exploration in parts of Hailakandi district (Assam) and adjoining areas of Mizoram and Manipur

Fourty-seven accessions consisting of *Phaseolus vulgaris* (15), *Oryza sativa* (10), *Vigna mungo* (5), *Sesamum indicum* (4), and others (13) were collected from parts of Hailakandi district (Barak Valley) of Assam and adjoining areas of Mizoram and Manipur. Good variability in paddy for grain husk colour, scented types, grain size, awned & awnless, sticky and non-sticky; in black gram, seed size and colour (small seeded, black and light black); and in sesame seed size and colour (small and medium seeded, black and dull white) was collected. About 10-15 types of rajmah (mainly bush types) having mottled black, red, white, golden, purple grains are being

Fig. 1.20. Collecting deep water paddy landraces from Mr. Kamnak Narah custodian farmer of village Kawoi Bhuruka, Lakhimpur, and *Corchorus capsularis* from kitchen garden in Dibrugarh, Assam


Fig. 1.21. Rajmah 'Pharas' cultivation along river banks of Barak and sale of dried grains in Hailakandi (Assam)


Fig. 1.22. Fruits of *Gol kheera* (*Cucumis sativus*) and Sale in local market at Hailakandi

grown by the farmers at large scale in and around Diyara land (near river bank), agricultural fields and kitchen gardens. The farmers are fetching good price through its sale (young pods, shelled beans /half matured grains are sold @ Rs 300-400/kg and dried ones @ Rs 100-120/ kg). Trailing type is also grown by a few farmers. The grains are used in the preparation of a local dish '*Panilawo*' by adding fried fish in boiled grains. A paddy landrace *Beroin maimin* is used by Reyang tribe of Mizoram in preparation of local beverage called 'Arak', which is used in every occasion (birth to death), and also reported good in reliving pains during delivery. A local cucumber popularly known as "*Gol kheera*"having oval shaped fruit with brown scaly skin is also grown by the farmers. It is dual purpose, as young fruits are consumed as salad and matured fruit as vegetable. This local type is being grown by local farmers since 60-70 years. Its keeping quality is also good as compared to other long type local varieties of cucumber.

1.15 Multi-crops and CWR collection from Dima Hasao district of Assam and adjoining areas

Exploration for germplasm collection of multi-crops including CWR and wild edibles was conducted in Dima Hasao district of Assam and adjoining parts in other states and a total of 58 collections (32 species, 17 wild) of different crops including landraces of cereals/millets (10), pulses (7), oilseeds (6), vegetables (14) and Crop Wild Relatives (CWR), M&AP and other economic plants species were collected. Variability was observed for fruit shape, size and colour in *Cucurbita moschata, C. maxima, Benincasa hispida, Legeneria siceraria* and *Capsicum* sps. Pumkin is cultivated by all the farmers and samples of diverse material were collected. Good diversity was also collected in *Perilla* for grain size and colour and in foxtail millet for panicle and grain size and grain colour. Crop wild relatives and wild economic species collected


Fig. 1.23. Variability in fruits and seeds of pumpkin Dima Hasao, Assam

Fig. 1.24. *Dysolobium pilosum*- a distant relative of *Vigna* from Dima Hasao, Assam

belonging to *Abelmoschus, Cajanus, Coix, Dysolobium, Hibiscus, Momordica, Rhynchosia, Trichosanthes, Vigna, Andrographis, Calopogonium, Canavalia, Cleodendrum, Diplocyclos, Mucuna, Sesbania* and *Solanum*. Wild populations of *Andrographis paniculata* was observed near Lumding jungle towards Langting.

1.16 On-farm crop diversity and wild rice habitat survey and conservation

Seeds of landraces of *Kharif* crops namely *Chwaridhan* of rice to 18 farmers of 8 villages; *Kala bhatt* (*Gycine max*) to 45 farmers of 11 villages; foxtail millet (*Setaria italica*) to 37 farmers of 10 villages; and proso millet (*Panicum miliaceum*) to 11 farmers of 5 villages were reintroduced in villages identified for on farm conservation in Dehradun, Tehri and Uttarkashi districts of Uttarakhand. This activity is taken to strengthen the local seed chain system. While in rabi crops, *Menshre* landrace of wheat was distributed to the 37 farmers of 14 villages during 2018-20 and being cultivated by 25 identified farmers of 13 villages, so that could be spread in more adjacent villages. The performance of wheat landrace (*Menshre*) was assessed on farm of selected farmers in these villages during March, 2020. It was observed that 67% farmers (out of 37) are taking keen interest in cultivation of introduced landraces. To strengthen the local seed chain system, seeds of local landraces have been provided to the community and place for community seed bank (CSB) has been identified in Purola of Uttarkashi district. In addition to this, the farmers were also sensitized about the importance of on-farm management of traditional crop diversity, livelihood and nutritional security through organizating PGR conservation awareness camp on March 17,

Fig. 1.25. Performance of *Menshre* landrace of wheat on farmers field in different villages during *Rabi*, 2019-20

Fig. 1.26. Distribution of seeds of local landraces to the farmers during March 2020 for *on-farm* management

Fig. 1.27. PGR Awareness workshop at Maindrath village in Dehradun (Uttarakhand)

2020 at village-Maindrath, Chakrata in Dehradun district, which was attended by over 140 farmers from 20 villages.

1.17 Guava diversity in Pithoragarh, Uttarakhand

Guava is regenerating naturally in East Ramganga Valley of Uttarkhand for more than 100 years. Guava trees are found in cultivated terraces and natural hill slopes. The guava trees are associated with *Cotoneaster officinalis, Bauhinia purpurea, Murraya koenigii, Mangifera indica, Syzygium cumini, Bombax ceiba, Punical granatum, Phyllanthus emblica, Ziziphus mauritiana, Woodfordia fruiticosa, Diploknema butyracea, Ficus* spp., *Bamboo* spp. etc. Fruits are harvested by villagers and transported to Pithoragarh, Lohaghat and Champawat for sale. East Ramganga Valley between 29^{0}75" to 29^{0}76"N; 80^{0}11" to 80^{0}13"E and 700-1000m was surveyed in November, 2020 to observe the guava distribution area. It is distributed from Bhakunda village to Nachani areas covering about 50 villages. Scattered population in forests and in form of orchards were observed along road and river.

Variation was also observed in fruit shape (round, oblong, conical, and lattoo type), fruit size (small, medium, large); fruit colour, pulp colour (pink/reddish and normal) and fruit taste. Research is required to document the available phenotypic and genotypic diversity in entire valley. This area was visited to explore the possibility of declaring as Biodiversity Heritage Site of Guava.

1.18 National Herbarium of Cultivated Plants (NHCP)

A total of 313 herbarium specimens, forty two seed samples/economic products were added to the National Herbarium of Cultivated Plants (NHCP), making total collection of 24,436 herbarium specimens (representative of 4,357 plant species belonging to 1,544 genera and 267 families), 3148 seed samples and 740 economic products. During 2020, twenty seven new taxa, not represented earlier, were added as specimens and digital images to the NHCP (Table 1.4). A total of 342 specimens/taxa belonging to crop genepool were authenticated and digitized including 27 taxa unrepresented in NHCP resulting into a total of 9,319 digitized images. The webpage for herbarium digital resource was made available for the users (www.nbpgr.ernet.in › nhcp).

Herbarium specimen of *Momordica subangulata*, *Tupistra clarkei*, *Trichosanthes quinquangulata*, *T. dunniana*, *T. wallichiana*, *Garcinia speciosa*, *Vigna trinervia, Prunus nepalensis, Rubus nepalensis, Guizotia abyssinica, Oryza nivara, Senna tora,* etc. were added from explorations to Andaman & Nicobar Islands, Gujarat, Manipur, Madhya Pradesh, Meghalaya, Sikkim, Uttarakhand and Uttar Pradesh; and

Fig. 1.28. Guava populations and fruit variability in the Ramganga river valley of Pithoragarh, Uttarakhand

Table 1.4: Taxa added in NHCP during 2020

Family	New species to NHCP	State	W/C*
Acanthaceae	*Strobilanthes dalhousianus* C.B. Clarke	Himachal Pradesh	W
Asparagaceae	*Tupistra clarkei* Hook.f.	Sikkim	C
Asteraceae	*Vernonia elaeagnifolia* DC.	Delhi	W
Brassicaceae	*Senebiera didyma* (L.) Pers.	Himachal Pradesh	W
Clusiaceae	*Garciniaspeciosa* Wall.	A & N Islands	C
Cucurbitaceae	*Trichosanthes quinquangulata* A. Grey *Benincasa pruriens f. pruriens* (Parkinson) W. J. de Wilde & Duyfjes *Scopellaria marginata* (Blume) W. J. de Wilde & Duyfjes *Trichosanthes inthanonensis* De Wilde & Duyfjes	A & N Islands Meghalaya	W W
Fabaceae	*Sesbania sericea* (Willd.) Link. *Uraria crinita* (L.) Desv.ex DC.	A & N Islands	W
Liliaceae	*Aloe ambigens* Chiov.	Delhi	C
Malvaceae	*Sida alnifolia* L. *Hibiscus calyphyllus* Cav.	A & N Islands Rajasthan	W W
Moraceae	*Ficus binnendijkii* Miq.	Delhi	C
Musaceae	*Musa acuminta* Colla subsp. *malaccensis*	Mizoram	W
Myristicaceae	*Knema malayana* Warb. *Knema andamanica* (Warb.) de Wilde subsp. *nicobarica* (Warb.) de Wilde	A & N Islands	W
Myrtaceae	*Decaspermum parviflorum* (Ridl.) Schott	A & N Islands	W
Pedaliaceae	*Pedalium murex* L.	Haryana	W
Poaceae	*Brachypodium pinnatum* (L.) Beauv. *Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	Sikkim Delhi	W
Rhamnaceae	*Ziziphus javanensis* Blume	A & N Islands	W
Sapotaceae	*Manilkara littoralis* (Kurz) Dubard	A & N Islands	C
Scrophulariaceae	*Leucophyllum frutescens* (Berland.) I. M. Johnst. *Veronica anagallis-aquatica* L.	Delhi	C W
Smilacaceae	*Smilax parvifolia* Wall. ex Hook.f.	Himachal Pradesh	W

***: C: Cultivated, W: Wild**

Andrographis, Balanites, Momordica and *Glycosmis* from Rajasthan, Haryana and NCR region of Delhi. Experimental vouchers of *Vigna unguiculata* var. *sesquipedalis*, *Vigna vexillata*, *Capsicum annuum* and *Lathyrus sativus* from ICAR-NBPGR, New Delhi and *Cymbopogon martini* from Bangalore University, Karnataka. Diverse seed material of *Citrullus lanatus* was added from Rajasthan; grains of *Panicum, Eleusine* and *Sorghum* from Gujarat; seeds of *Vicia faba* and *Sapindus mukorossi* from Meghalaya; *Selaginella bryopteris* (a candidate for Sanjeevni Booti) as economic product from Uttarakhand were added. Identification services were provided and authentication certificates (17) issued to students and researchers.

1.19 Biosystematic studies

Biosystematics studies were undertaken on material collected through various explorations. Morphological, cytolgical and molecular evidences were drawn to support identification of a melon locally known 'Arya' (a taxon belonging to *Cucumis melo* group) collected from Rajasthan and a distinct taxonomic varietal status *Cucumis melo* subsp. *melo* var. *alwarensis* A. Pandey & S Rajkumar was assigned.

A total of 39 accessions of distinct types in less-known melons namely *Cucumis melo* subsp. *agrestis* var. *agrestis* (local names-'choti kachri', 'badi kachri', 'sukkangai'), *C. melo* subsp. *agrestis* var. *momordica* ('phunt', 'vellari'; snap melon), *C. melo* subsp. *agrestis* var. *conomon* ('soththiar'; oriental pickling melon), *C. melo* subsp. *melo* var. *flexuosus* ('kakdi', 'tar'; snake melon) and *C. melo* subsp. *agrestis* var. *alwarensis* ('arya') were studied for morphological characters of fruit to understand their genetic resource value. Morphologically 'choti kachri' and 'badi kachri' were identical except for the fruit size and weight; arya and snake melon grouped together with snap melon and other intermediate forms; identity of oriental pickling melon was observed to be closer to the musk melon but fruit had lighter aroma. Based on floral diversity study, 'choti kachri' and 'badi kachri' were grouped together whereas snake melon and 'arya' were closer and snap melon showed intermediary position. Floral diversity characters were identitified as marker characters for crossability programme. Field identification keys were developed in *Cucumis melo* group and a semi-wild *C. melo* var. *agrestis*.

Field study based on morphological and floral biology of a local *Allium* species known as 'jamboo' (used as seasoning spice) in diverse regions of Uttarakhand Himalaya was earlier identified as *A. stracheyi* (subg. *Polyprason*) showed characters closer to the subg. *Rhizirrhideum*. Grow-out test undertaken in field genebank at Bhowali Station has revealed substantial differences in the floral and bulb characters for taxonomic delineation.

1.20 Diversity mapping of mung bean and cowpea

Geo-referencing and mapping of 7,172 accessions of mungbean (*Vigna radiata*) (Fig.1a) and 6382 accessions of cowpea (*Vigna unguiculata*) (Fig.1b) collected from various parts of country was done. Mapping of assembled diversity has shown that Rajasthan (1,010) followed by Maharashtra (681), Bihar (672), Gujarat (619), Madhya Pradesh (382), Telangana (382), Punjab (303), Andhra Pradesh (204), Odisha (177), Himachal Pradesh (157), Uttar Pradesh (156) and Karnataka (153) in mung bean crop. The areas have been identified for future collection in mung bean are Bihar (Bhojpur, Bhagalpur, Rohtas, Madhubani and Madhepura); Gujarat (Banaskantha, Kachchh, Patan, Sabarkantha and Surendra Nagar); Odisha (Kandhamal, Ganjam, Balangir, Jajpur and Khordha), Maharashtra (Amravati, Buldhana, Dhule, Jalgaon and Wardha).

The mapping showed that Gujarat (933) followed by Rajasthan (903), Kerala (509), Himachal Pradesh (454), Andhra Pradesh (372) and Madhya Pradesh (361) in cowpea were extensively explored states. 6382 accessions of cowpea (*Vigna unguiculata*) (Fig.1b) collected from various parts of country was done.Rajasthan (Bikaner, Barmer, Churu, Jhunjhunu, Jaisalmer, Jodhpur and Nagaur) and in cowpea Sikkim (West Sikkim), Nagaland (Tuensang, Longleng, Wokha, Zunheboto and Phek), Assam (Kokrajhar, Barpeta, Dhubri, Bongaigaon and Goalpara), Meghalaya (East Khasi hills and East Garo hills) and Tripura (South Tripura, Gomati and Shipahijala) as gaps for collection.

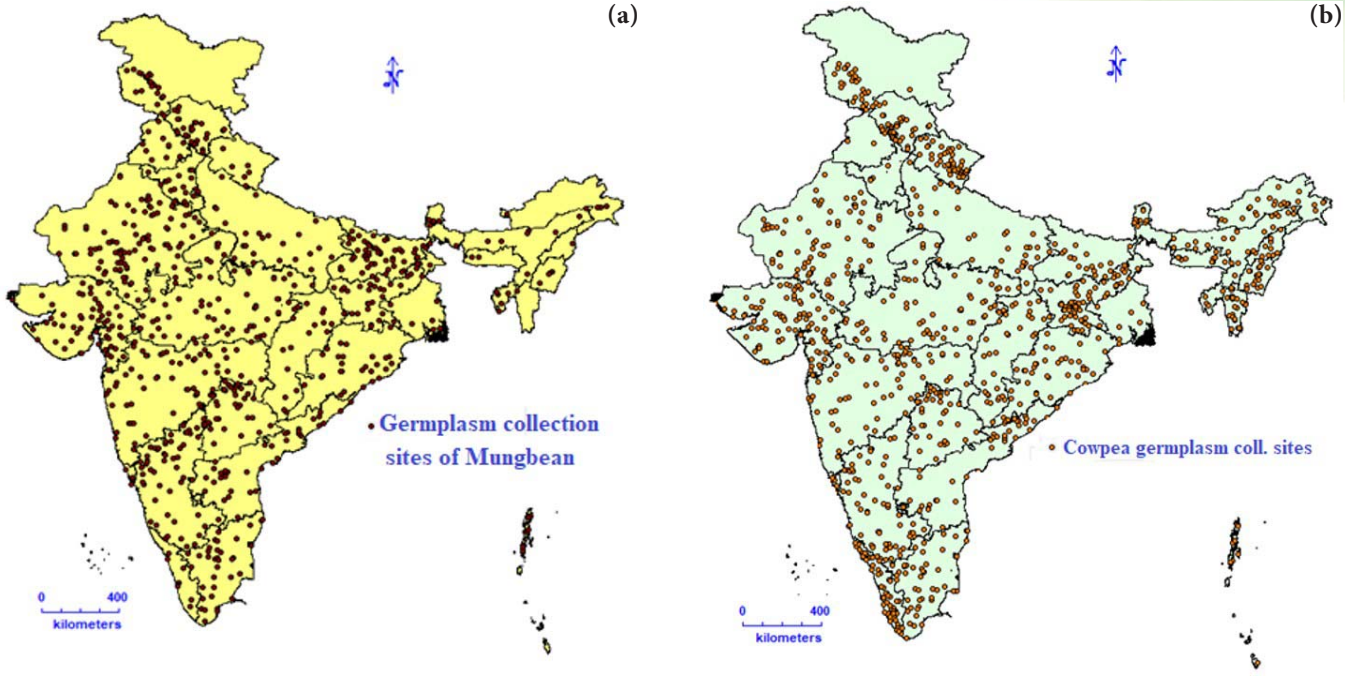


Fig. 1.29. Germplasm collection sites of (a) mungbean and (b) cowpea

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, Soyimchiten, S Nivedhitha, RK Pamarthi, PK Malav (w.e.f. 27-05-2020), Resmi Raj (upto 14.7.2020), 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, S Nivedhitha, 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,** K Pradheep**,** S Nivedhitha, RK Pamarthi 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 (w.e.f. 27-05-2020), 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 (w.e.f. 27-05-2020), NS Panwar and PS Mehta)

2 GERMPLASM EXCHANGE AND POLICY UNIT

Summary: During the period under report 1,07,759 accessions (1,83,436 samples) were imported which included 39,315 accessions (40,415 samples) of germplasm and 68,444 entries (1,43,021 samples) of CGIAR nurseries for trials. A total of 16,981 samples of different crops were supplied to national users for utilization in various crop improvement programmes based on requests received from research workers under Material Transfer Agreement (MTA). In addition, 1,01,030 samples 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, adopted both multi-lateral and bilateral instruments to facilitate the exchange of genetic resources, while ensuring equitable access and benefit sharing opportunities (Aichi Target -Strategic Goal D, Target 17; SDG 2.5))

2.1 Import of plant genetic resources

The unit continued its efforts for germplasm introduction to meet the specific requirements of scientists working in ICAR research institutes, State Agricultural Universities (SAUs), other public and private sector organizations with DSIR recognized R&D, and non-governmental organizations (NGOs). Plant genetic resources import/ introduction comprised of material obtained on request from the scientists as well as collaborators for international trials to be conducted in India. Import of seed/planting material made during the year were as follows:

Germplasm accessions procured and processed	:	39,315 accessions (40,415 samples)
CGIAR nurseries for trials	:	68,444 entries (1,43,021 samples)
No. of countries involved	:	30
No. of Import Permits issued	:	636
Resource generated	:	Rs 77,41,193/-

Trait specific germplasm imported during 2020 is listed in Table 1.

Cereals: *Hordeum vulgare* (125) from Netherlands, (6) from Switzerland, (817) from USA; *Oryza sativa* (4022) from Philippines, (2) from Spain, (724) from USA and (7) from Vietnam; *Triticum aestivum* (334) from Australia, (626) from Mexico, (209) from UK; *Triticum aestivum* subsp. *sphaerococcum* (31) from USA; *Triticum turgidum* subsp. *dicoccum* (13) from Mexico; *Zea mays*(23) from Australia, (653) from Brazil. (15132) from Chile, (156) from France, (224) from Indonesia, (47) from Kenya, (1910) from Mexico, (477) from Philippines, (865) from South Africa, (2800) from Thailand, (1202) from USA and (18) from Zimbabwe.

Millets: *Eleusine coracana* (847) from Kenya, (198) from Zimbabwe; *Pennisetum glaucum* (67) from Kenya, (807) from Niger, (494) from Zimbabwe; *Sorghum bicolor* (123) from Argentina, (841) from Kenya, (1303) from Niger and (68) from Zimbabwe.

Grain legumes: *Cicer arietinum* (16) from Ethiopia; *Lathyrus amphicarpos* (2), *Lathyrus annuus* (2), *Lathyrus aphaca* (2), *Lathyrus cicera* (3), *Lathyrus clymenum* (3), *Lathyrus hirsutus* (2), *Lathyrus latifolius* (2), *Lathyrus ochrus* (3), *Lathyrus setifolius* (1), *Lathyrus sphaericus* (2) and *Lathyrus tingitanus* (2) all from Spain; *Phaseolus vulgaris* (3) from Switzerland, (101)

from Columbia; *Pisum saivum* (1) from Czech Repulic; *Tylosema esculentum* (1) from Namibia; *Vigna sequipedalis* (4) from Philippines; *Vigna subterranea* (10) from Ghana; (10) from Mali, (9) from Niger; (16) from Tanzania; (8) from Uganda; *Vigna unguiculata* (5) from Mali and (5) from Niger (Fig. 2.1).

Oilseeds: *Arachis hypogaea* (2) from Niger; *Brassica napus* (39) from Australia; *Helianthus annuus* (7) from Netherlands, (9) from USA; *Glycine max* (622) from USA; *Guizotia abyssinica* (15) from USA; *Linum aristatum* (1), *Linum lewisii* (2) both from USA; *Sesamum indicum* (68), *Sesamum prostratum* (1), *Sesamum rigidum* (2), *Sesamum* sp. (1) all from USA.

Fibres: *Gossypium hirsutum* (18) from France and (3) from Uganda.

Vegetables Crops: *Abelmoschus caillei* (4) from Taiwan,*Abelmoschus esculentus* (67) from Taiwan; (433) from Thailand; (20) from UAE; (95) from USA; *Abelmoschus manihot* (6),*Abelmoschus moschatus* (4),*Abelmoschus* sp. (48) from Taiwan; *Allium cepa* (4) from Indonesia (56)from USA, *Allium fistulosum* (9),*Allium longicuspis* (3) both from USA; *Allium porrum* (4) from Switzerland; *Allium sativum* (3) from USA; *Brassica oleracea* (1) from USA, *Brassica oleracea* var. botrytis (1) from Chile; (32) from Netherlands, (108) from USA, *Brassica oleracea* var. *capitata* (3) from Chile; (131) from Netherlands, (16) from USA; *Capsicum annuum*(14) from Japan; (83) from Netherlands; (241) from Taiwan; (7) from Thailand; (3) from UK; (26) from USA; *Capsicum annuum* var. *grossum* (10) from Taiwan, *Capsicum baccatum* (2) from Taiwan; (1) from USA; *Capsicum chacoense* (1) from Taiwan; (1) from USA; *Capsicum chinense* (1) from Taiwan; (5) from USA; *Capsicum frutescens* (9) from UK; *Citrullus lanatus* (3) from Thailand; (3) from USA; *Cucumis melo* (48) from USA; *Cucumis sativus* (8) from France; (23) from Netherlands; (101) from USA; *Cucurbita moschata* (3) from Thailand; *Daucus carota* subsp. *sativus* (5) from Japan; *Lagenaria siceraria* (3) from Taiwan; *Luffa acutangula* (14) from Taiwan; (3) from Thailand; (63) from USA; (20) from Vietnam; *Luffa aegyptiaca* (7) from Taiwan; (22) from USA; *Momordica charantia*(36) from Philippines, (1) from Taiwan; (737) from Thailand; (2) from Vietnam; *Raphanus sativus* (59) from USA; *Lycopersicon chmielewskii* (1) from USA;*Solanum arcanum* (1) from Netherlands; (2) from USA, *Solanum cheesmaniae* (3) from USA; *Solanum chilense* (2) from Netherlands; (3) from USA; *Solanum corneliomulleri* (1) from Netherlands; *Solanum galapagense* (4) from USA; *Solanum habrochaites* (6) from Netherlands; (3) from USA; *Solanum huaylasense* (2) from Netherlands; (2) from USA; *Solanum lycopersicum* (33) from Bulgaria; (12) from Japan; (641) from Netherlands; (110) from Taiwan; (20) from Thailand; (26) from UAE; (24) from UK; (196) from USA; *Solanum melongena* (16) from Japan; *Solanum neorickii* (2) from Netherlands; (2) from USA; *Solanum pennellii* (2) from USA; (2) *Solanum peruvianum* (2) from USA; *Solanum pimpinellifolium* (4) from Netherlands; (46) from USA.

Fruit crops: *Carica papaya* (2) from Thailand; (8) from USA; *Citrus limon* (6) from South Africa, (6) from USA; *Diospyros digyna* (3) from USA; *Malus domestica* (3) from USA; *Psidium guajava* (35) (Fig. 2.2); *Poncirus trifoliata* (2), X *Citroncirus* spp. (1) both from USA; *Vasconcellea pubescens* (2) from USA.

Medicinal and Aromatic plants: *Duboisia hopwoodii* (1) *Duboisia leichardtii* (1) *Duboisiamyoporoides* (1) *Duboisia* spp (2) allfrom Australia, *Plectranthus scutellarioides* (21) from UK.

Tubers: *Solanum tuberosum* (49) from Netherlands.

Fig. 2.1. Under STOL Project imported accessions of bambara nut grown at RS, Hyderabad from Mali (Fig. 1a, b) from Niger (Fig. 2a, b).Cowpea accessions grown at Delhi (Fig. 3), Bambara nut (Fig. 4)

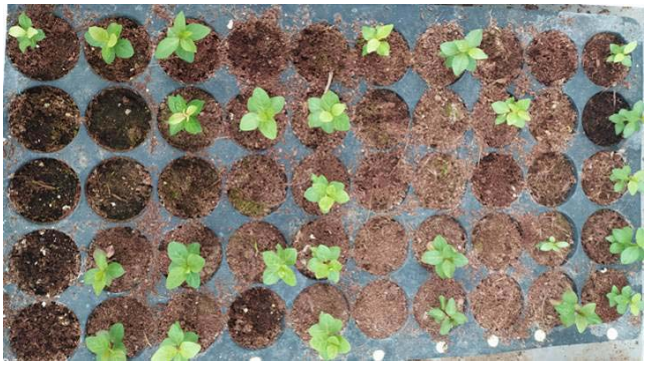


Fig. 2.2. Seedlings of Guava accessions EC 1041365-399 imported from USA

Beverages: *Coffea arabica* (1), *Coffea canephora* (8) both from France.

Spices: *Crocus nevadensis* (1) *Crocus sativus* (1) from Spain.

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 2020 are indicated below.

2.2.1 Under collaborative research projects

Under collaborative research projects total 45 accessions (405) samples of *Dolichos* under Indo-African collaborative research project on stress tolerant orphan legumes were exported to 9 African partners namely Burkina Faso, Ghana, Kenya, Mali, Niger, Nigeria, Uganda, Namibia and Senegal; 700 samples of wheat (350 to

Table 2.1: Trait specific seed/planting material imported in 2020

Crop/ EC No/Country	Traits	Recipient
Cereals		
Maize		
EC1033247 / USA	Landrace (dent)- NSL 3788 with red cobs	ICAR-NBPGR, New Delhi
EC1058831-1058852 / Mexico	Genetic stocks and inbred lines resistant to downy mildew, blister smut, stem rot, drought tolerant of high commercial value seeds dry out fast after ripening)	ICAR-IIMR, Ludhiana
Rice		
EC1030717 – 745 / Philippines	Low (12.6-15.4), intermediate (19.9-23.4) to high (25.5 -27.2) amylose content	J K Agri Genetics Limited, Hyderabad
EC1034353 - 357 EC1038714 - 1038763EC1038764- 1038863 EC1038914 -1038963/ USA	Lines having excellent grain quality, drought tolerance	Savannah Seeds, Gurugram
EC1038964 / Philippines	Kitaake, a Japonica rice variety, is neutral to photoperiod changes and has a very short life cycle (10 weeks). It is easy to transform and propagate. Kitaake has emerged as a model for studies of diverse monocotyledonous species.	ICAR-NRRI, Cuttack
Wheat		
EC1041468 – 1041498/ UK	Mutant lines and genetic stocks	ICAR - IARI, New Delhi
EC 1059295-1059307/ Mexico	*Triticum turgidum* subsp. *dicoccum*	ICAR-NBPGR, New Delhi
Oilseeds		
Sunflower		
EC1035323 / USA	High yield combined with disease resistance. and high oleic acid in the seed oil	ICAR-NBPGR, New Delhi
EC1035324 - 325 / USA	Restorer inbred germplasm lines, with high yield potential combined with disease resistance, and high oleic acid	ICAR-NBPGR, New Delhi
EC1035326 – 328 / USA	High yield potential, high oleic acid, herbicide tolerance (e.g.to imidazolinones) and resistance to *Sclerotinia* and *Phomopsis* stem canker	ICAR-NBPGR, New Delhi
EC1035329 - 331 / USA	Contain mutations that increase the y- and gamma tocopheril level of the seed, leading to a more stable vegetable oil product	ICAR-NBPGR, New Delhi
Soybean		
EC1037521-1061194/ USA	Core collection	ICAR-NBPGR, New Delhi ICAR-IISR, Indore
Grain legumes		
Bambara groundnut		
EC1036853-1036862/ Mali EC1036863-1036869/ Niger EC1050866-1050871/ Tanzania EC1050872-1050881/ Ghana	African landraces and landraces derived genotypes for diversification of agrifood system, resilient to adverse environmental conditions	ICAR-NBPGR, New Delhi

Crop/ EC No/Country	Traits	Recipient
Marama bean		
EC1058893	Drought tolerant, high nutritional value (high protein content)	ICAR-NBPGR, New Delhi
Frenchbean		
1037927-1038027/ Columbia	Biofortified lines	ICAR-IIPR, Kanpur
Lathyrus		
EC1061207-1061230/ Spain	Wild spp-*L. aphaca, L. anuus, L. cicera, L. amphicarpos, L. clymenum, L. hirsutus, L. latifolius, L. ochrus, L. setifolius, L. sphaericus, L. tingitanus*	ICAR-NBPGR, New Delhi
Fibres		
Cotton		
1058933-105895/ Uganda	Local varieties fairly drought tolerant, medium to long staple length	SIMA cotton Development Research Association, Coimbatore
Vegetables		
Cucumber		
EC1041437-1041438/USA	Downy mildew resistant lines	ICAR-NBPGR, New Delhi
EC1041420-1041422/USA	Carotenoid rich line	ICAR-NBPGR, New Delhi
Chilli		
EC1030751-1030762/ UK	Improved chilli varieties (sweet pepper and hot pepper) namely redskin, liberty belle, atomic, longhorn, chenzo, garden pearl, loco, fire cracker, megabite	Namdhari Seeds Private Limited, Bangalore
Fruits		
Apple		
EC1053881-882/ USA	Geneva 890 and Geneva 969 - semidwarfing rootstock resistant to fire blight (*Erwinia amylovora*), crown rot (*Phytopthora* spp.) and woolly apple aphid	Mahyco Private Limited, Jalna
Guava		
EC1041365-1041399/ USA	Improved varieties namely Indonesian Seedless, Hong Kong White, Patillo, Pink Acid, Thailand seedless, Golden, Ruby X White, Patillo, Pink Acid, Thailand seedless, Golden, Ruby X S upreme, Hong Kong Pink, Puerto Rico 2, Kona 1, Waiakea, Gushiken sweet, JB White, Fan retief, Ka Hua Kula, Beaumont, Poamoho Pink, Bon Dov, N90-53, Khao Niyom, Klom Amporn, Klom Sa Lee, Khao Sa Waive, Holmberg, klom Toonklao, Pearl, Rica	ICAR-NBPGR, New Delhi
Spices		
Saffron		
EC1056936/ Spain	Wild sp. *C. nevadesis* having rounded keel	CSIR-IHBT, Palampur

Bolivia and 350 to Bangladesh) under ICAR-CIMMYT Project. A total of 08 DNA vials of Phytoplasma extracted from brinjal to Taiwan and 07 Bioresources of infected leaves of *Impatience glandulifera* and *Rubus niveris* were exported to UK.

A total of 435 samples [rice (1) to Germany, 100 to USA, 334 to Philippines were exported for research with approval from National Biodiversity Authority (NBA). Also, facilitated supply of 6,926 samples of ICRISAT mandate crops (FAO designated accessions) to different countries and 23,135 samples of CIMMYT maize trials/nurseries.

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, 16,981 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 1,01,030 samples were supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

Table 2.2: National supply of seed/planting material to recipients during 2020

Crop	Accns.	Indentor
Cereals (675)		
Barley	119	IIWBR, Karnal; SKN College of Agriculture, Rajasthan
Maize	115	VPKAS, Almora; IIMR, Ludhiana; Loyola Academy of Degree and PG College, Secunderabad; Super Seeds (P) Ltd., Hisar
Rice	66	CSKHPAU, Palampur; Annamalai University, TN; PAU, Ludhiana; IARI, New Delhi; KA, Kerala; ; Jamia Hamdard, Delhi; Department of Commerce, MOCI, Delhi&Progressive farmer (Vinod Kumar, Village, Anjanthali, Nilokheri)
Wheat	375	NABI, Mohali; IIT, Roorkee; IFTM University, Moradabad; IARI, New Delhi; Shreeoswal Seed and Chemical Ltd., MP; Banda University of Agriculture and Technology, UP; UAS, Dharwad; Dayal Seeds Pvt Ltd, UP & Progressive farmers (Arjun Singh, Village Mojpur, Faridabad; Swati Devi, Krishan Kumar, Ankur Malik, Palwal; Manohar Lal, Mohit & Parveen all from Palwal, Haryana)
Millets (318)		
Barnyard millet	14	ANGRAU, AP
Finger millet	26	ANGRAU, RARS, Nandyal; WASSAN, Hyderabad
Italian millet	48	ANGRAU, RARS Nandyal,
Kodo millet	107	MDU, Rohtak
Little millet	23	IIMR, Hyderabad
Pearl millet	100	Rani Lakshmi Bai CAU,Jhansi
Grain legumes (3675)		
Adzuki bean	10	Eternal University,Sirmour
Cluster bean	50	CCSHAU,Hisar
Cowpea	1423	KAU, Thrissur; IGKVV, Raipur; IGFRI, Jhansi; NIPGR, Delhi; IIIPR,Kanpur; Rani Lakshmi Bai CAU, Jhansi; SHUATS,Prayagraj; IARI, New Delhi; SKUAST-K, UAS, Dharwad
Chickpea	202	IGKVV, Raipur
French bean	150	ICAR RC, NEH Nagaland; SKUAST-J
Horsegram	4	KAU, Thrissur
Lentil	481	NIPGR, Delhi; IARI, New Delhi; TNAU, Coimbatore, IGKVV, Raipur

Crop	Accns.	Indentor
Moth bean	150	IIPR RS, Rajasthan; Jiwaji University, Gwalior
Mung bean	200	TNAU, ,Coimbatore; Rani Lakshmi Bai CAU, Jhansi; AAU, Jorhat; SSKUAST (K), Bundelkhand University, Jhansi
Pea	15	IARI, ND
Pigeon pea	2	KAU, Thrissur
Rice bean	70	Eternal University, Sirmour; Rani Lakshmi Bai CAU, Jhansi
Urd bean	918	NIPB, ND; Annamalai University, TN; SKUAST-K (J); Rani Lakshmi Bai CAU,Jhansi; Banda University of Agriculture and Technology,UP; IARI, ND
Oilseeds (7746)		
Groundnut	1	IIPR, Kanpur
Linseed	350	Vasantrao Naik Marathwada Krishi Vidyapeeth, Jalna; CAU, Umiam
Sesame	5926	UAS, Dharwad; GKVK, Bengaluru; Sri Karan Narendra Agriculture University,Jobner; Bundelkhand University,, Jhansi; TNAU, Coimbatore
Soybean	10	IARI, ND
Mustard	1459	IARI, ND; Rasi Seeds (P) Ltd., Delhi; Ch Chhotu Ram PG College, Muzaffarnagar; Eagle Seeds and Biotech Ltd., Indore; VPKAS, Almora; Shreeoswal Seed and Chemical Ltd., MP;GBPUAT, Pantnagar; University Of Delhi, ; ICAR-RCEastern Region, Patna; RHRTS-JachhKangra; DRMR, Bharatpur; Rani Lakshmi Bai CAU, Jhansi
Vegetables (1653)		
Bottle gourd	135	SKUAST-K; SVPUAT, Meerut
Brinjal	121	DAV University,Jalandhar; Farming System Research Centre for Hill and Plateau Region, Plandu;TNAU, Coimbatore; WASSAN, Hyderabad
Carrot	20	Dr. YSPUHF, Hamirpur
Cauliflower	102	Noble Seeds Private Limited, Delhi; RHRTS-Jachh, HP; UPL, Hyderabad
Chilli	442	Seed Works International Pvt Ltd., Telangana; BCKV Nadiya; Maharashtra State Seeds Corporation Limited, Akola; M/s ACSEN Hy. Veg. Private Ltd., Gurugram; Horticultural Research Station, Guntur; UPL, Hyderabad; IARI,ND; TNAU, Coimbatore; University of Horticultural Sciences, Belgaum; Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi; SKUAST-K, Jammu and Kashmir; Annamalai University, TN; UPL, Hyderabad
Jackbean	15	KAU ,Thrissur
Okra	153	Maharashtra State Seeds Corporation Limited, Akola; CCSMU,Meerut; UPL, Hyderabad; Sri Karan Narendra Agriculture University, Jobner
Onion	49	SKLTHSU, Hyderabad and progreesive farmer (M L Jakhar)
Ridge gourd	25	SKLTSHU, Hyderabad
Sponge gourd	47	SKLTSHU, Hyderabad
Tomato	544	RHRTS-Jachh, Kangra; DAV University, Jalandhar; IIPR, Kanpur; CCS HAU, Hisar; UPL Hyderabad; SKUAST-K; Seed Works International Private Limited, Banaglore; Noble Seeds Private Limited, Delhi, Annamalai University, TN, RHRTS-Jachh, Kangra; IARI, ND; KAU, Thrissur; Rani Lakshmi Bai CAU, Jhansi; M/s ACSEN Hy. Veg. Private Ltd., Gurugram; Scottish Church College, Kolkata; AAU, Anand
Fruit crops (93)		
Apricot	6	Dr. YSRUHF, Solan
Banana	5	NRCB, Trichy
Grape	40	NRCG, Pune; IARI, ND
Kiwi	6	CSKHPKVV, Palampur

Crop	Accns.	Indentor
Peach	7	Dr. YSRUHF, Solan
Pear	15	Dr. YSRUHF, Solan
Plum	12	Dr. YSRUHF, Solan
Persimmon	2	Dr. YSRUHF, Solan
Tubers (10)		
Greater Yam	5	KAU, Thrissur
Taro	5	KAU, Thrissur
Fibres (7)		
Roselle	7	SKLTS Horticultural University, Rajendranagar
Forages (2209)		
Avena	1586	IGFRI, Jhansi; PAU, Ludhiana
Buffel grass	79	IGFRI, Jhansi
Guinea grass	150	IGFRI, Jhansi
Lablab bean	165	IGFRI, Jhansi
Lucerne	229	IGFRI, Jhansi
Medicinal and Aromatic plants (79)		
Bacopa	28	IIHR, Bengaluru
Centella	08	DTU, Delhi
Catharanthus	4	University of Delhi, Delhi
Eclipta	13	IIHR, Bengaluru
Kalmegh	4	University of Delhi, Delhi
Mucuna	7	Jamia Hamdard, Delhi; University of Delhi, Delhi
Neem	2	IIT-BHU, Varanasi
Ocimum	5	University of Delhi, Delhi
Plumbago	8	DTU, Delhi
Potential Crops (516)		
Amaranth	55	ICAR-RC- Eastern Region, Patna; Eternal University,Sirmour
Chenopodium	245	ICAR-RC- Eastern Region, Patna; Eternal University,SirmourIIVR, Varanasi
Buck wheat	10	Eternal University, Sirmour
Faba bean	206	CAU, Imphal

2.4 Policy issues on agrobiodiversity management

2.4.1 Preparation for ninth meeting of the governing meeting 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 is Vice Chair from Asia Region)
- For initiating the organisation of the GB9 in India composition of three organising committees at National Inter-ministerial level was proposed and approved by Ministry of Agriculture.
- National organising committee prepared the EOI document requirements for organisation of GB9 (Event Management vendors) in August 2020.

- Participated in the Ad Hoc Committee on Conservation and Sustainable Use under the ITPGRFA (held on line), as Member of the Committee approved by the DAC&FW, Ministry of Agriculture.

2.4.2 Analysis of the Biological Diversity Act (BDA) 2020 towards revision of the Act, Rules and Guidelines

- Presentation on identification of issues related to BDA, 2002 which need revisiting related to access to germplasm by researchers outside India was made at ICAR under the Guidance of DG, ICAR.

- Draft revisions proposals sent (for BDA, 2002, BDA Rules, 2004 and ABS Guidelines, 2014) and inputs provided on draft proposals for all the meetings organised for the purpose by MoEF&CC, after compilations of suggestions from all the five ICAR Bureaus and other stakeholders.

- Prepared documents for discussion on possible revisions of BDA, 2002 during Brainstorming Sessions at NAAS organised in September 2020 and Policy brief on the issues was drafted.

2.4.3 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 at SOW-PGRFA is being compiled in the format suggested.

2.4.4 Data for UN Sustainable Development Goals submitted

- SDG 2.5.1 data submitted to FAO and for Country Status on SDGs related to conservation of PGR.

- Status data submitted to Ministry of Statistics and Programme Implementation (MoSPI after participation in the preparatory meetings organised by MoSPI to discuss the reporting format shared by FAO

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

- Inputs provided to NBA in the 60th and 61st Meeting of the Expert Committee on Access and Benefit Sharing (ABS) for recommendation on access and Patent applications related to biological resources considered by NBA

2.5 Policy issues related to Biosecurity

2.5.1 Inputs provided to ICAR/ DARE/ MoA

- The Plant Quarantine (Regulation of Import into India) Order 2003 was further 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.

- Participated in discussions with DAC on European Union requirements for accreditation of seed production units for export of seeds from India to EU. Meetings were held online and EU team presented on the new phytosanitary regulations and discussions ensued.

- In continuation of providing advisory in 2018 and follow-up in 2019, provided further policy inputs on Fusarium wilt disease (Panama lethal disease) caused by *Fusarium oxysporium* f.sp. *cubense* Tropical Race 4 (FocTR4) to ICAR for taking it up with the Plant Protection Advisor (PPA) to the Government of India for its containment and eradication.

- Undertook country specific, pathway-based generic PRA for listed crops (Table 2.3) facilitating import of these crops for the first time by ICAR-NBPGR (Table 2.3).

Table 2.3: List of crops for which pathway based genome PRA was undertaken

S.No.	Crop species	Pathway	Country
1.	Industrial Hemp (*Cannabis sativa* L.)	Seed	Australia
2.	Buckwheat (*Fagopyrum esculentum*)	Seed	Japan
3.	Persimmon (*Diospyros kaki*)	Cuttings	USA
4.	Bottle gourd (*Lagenaria siceraria*)	Seed	USA
5.	Sponge gourd (*Luffa aegyptiaca*)	Seed	USA
6.	Ridge gourd (*Luffa acutangula*)	Seed	USA
7.	Linseed (*Linum usitatissimum*)	Seed	Canada
8.	Persimmon(*Diospyros dignya*)	Scion Wood	USA
9.	Guava (*Psidium guajava), P. sartorianum, P. cattleyanum*	Seed	USA
10.	Canavalia (*Canavalia brasiliensis*)	Seed	CIAT, Colombia
11.	Centrosema (*Centrosema molle*)	Seed	CIAT, Colombia
12.	Cratylia (*Cratylia argentea*)	Seed	CIAT, Colombia
13.	Desmodium (*Desmodium velutinum*)	Seed	CIAT, Colombia
14.	Lablab (*Lablab purpureus*)	Seed	CIAT, Colombia
15.	Stylo (*Stylosanthes guianensis*)	Seed	CIAT, Colombia
16.	Leucaena (*Leucaena diversifolia*)	Seed	CIAT, Colombia
17.	Demodium (*Desmodium heterocarpum*)	Seed	CIAT, Colombia
18.	Brachiaria (*Brachiaria brizantha* cv Toledo; *B. brizantha* cv Piata	Seed	CIAT, Colombia
19.	Guinea grass (*Panicum maximum*)	Seed	CIAT, Colombia
20.	Stylo (*Stylosanthes guianensis*) cv Ubon	Seed	CIAT, Colombia
21.	Paspalum (*Paspalum atratum*)	Seed	CIAT, Colombia
22.	Wild linseed (*Linum volkensii, L. trigynum, L. bienne, L. keniense* and *L. strictum*)	Seed	Ethiopia
23.	*Lathyrus* spp.	Seed	Australia, France, Germany, Hungary, Russia, Spain, Turkey, USA
24.	Cassabana (*Sicana odorifera*)	Seed	USA
25.	Finger millet (*Eleusine coracana*)	Seed	Kenya
26.	Monk fruit (*Siraitia grosvenorii*)	Seed	Vietnam
27.	*Alyssum* spp.	Seed	Bulgaria, Israel, Italy, Spain, UK, USA, Poland
28.	Okra (*Abelmoschus esculentus*)	Seed	UAE
29.	*Lepidium* spp.	Seed	Armenia, Australia, Germany, Israel, Italy, Kenya, Peru, Poland, Spain, Sweden, UK, Ukraine, USA

S.No.	Crop species	Pathway	Country
30.	Marama bean (*Tylosema esculentum*)	Seed	Namibia
31.	Spinach (*Spinacia oleracea*)	Seed	Japan
32.	*Crambe abyssinica*	Seed	Australia, Germany, Israel, Italy, Spain, USA, UK
1.	*Crambe hispanica*	Seed	Germany, Hungary, UK
1.	*Crambe maritima*	Seed	Germany, UK
1.	*Crambe* spp.	Seed	Australia USA
33.	*Arabidopsis thaliana*	Seed	UK
34.	*Stylosanthes* spp.	Seed	Thailand
35.	*Casuarina equisetifolia*	Seed	China
36.	*Centrosema molle*	Seed	Colombia
37.	*Cratylia argentea*	Seed	Colombia
38.	*Desmodium velutinum*	Seed	Colombia
39.	*Lablab purpureus*	Seed	Colombia
40.	*Stylosanthes guianensis*	Seed	Colombia
41.	*Desmodium heterocarpum*	Seed	Colombia
42.	*Brachiaria brizantha*	Seed	Colombia
43.	*Leucaena diversifolia*	Seed	Colombia
44.	Brinjal (*Solanum melongena*)	Seed	Bangladesh
45.	Quinoa (*Chenopodium quinoa*)	Seed	UAE
46.	*Diplotaxis cossoniana*	Seed	Australia, USA
47.	*Diplotaxis erucoides*	Seed	Germany, Israel, Spain. USA, UK
48.	*Diplotaxis harra*	Seed	Israel, Spain. USA, UK
49.	*Diplotaxis muralis*	Seed	Austria, Germany, Israel, Sweden, Spain, UK, USA
50.	*Diplotaxis simplex, Diplotaxis* spp.	Seed	USA
51.	*Diplotaxis tenuifolia*	Seed	Australia, Austria, Israel, Germany, Hungary, Spain, Sweden, UK, USA
52.	*Diplotaxis viminea*	Seed	Australia, Israel, Spain, USA
53.	*Enarthrocarpus arcuatus*	Seed	Israel, Spain, USA, UK
54.	*Enarthrocarpus clavatus*	Seed	Spain, USA
55.	*Eruca vesicaria*	Seed	Austria, Hungary, Italy, Russia, USA
56.	*Erucastrum brevirostre, E. elatum, E. gallicum, ifniense, E. leucanthum E. rifanum E. strigosum*	Seed	Spain, USA
57.	*Erucastrum littoreum, E. varium*	Seed	Australia, Spain, USA
58.	*Erucastrum nasturtiifolium*	Seed	Spain, USA, UK
59.	*Erucastrum virgatum*	Seed	Germany, Spain, USA, UK

• Comments given on the risk involved in import of several agricultural commodities, certain insect cultures, pathogens and other biocontrol agents.

2.5.2 Inputs provided to MEA

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

2.5.3 Inputs provided to MoEF&CC

- Provided inputs to MoEF&CC for 24th SBSTTA on Review of the International Initiative for the Conservation and Sustainable use of Soil Biodiversity and Updated Plan of Action
- Inputs also provided on Aichi Target 9: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their incursion.
- 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 (**Code:** Title, **PI**, Co-PIs and *Associates*)

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

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

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

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

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

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

PGR/GEPU- BUR-DEL-02-01: Analysis of emerging policy issues on agro-biodiversity management and preparation of technical inputs for use by policy makers/Indian delegations at national and international meetings/ negotiations (**Pratibha Brahmi,** SC Dubey, Gurinder Jit Randhawa, Veena Gupta, Kavita Gupta, Vandana Tyagi, Sunil Archak, K Pradheep, Pragya, Ruchi Bansal and Rajeev Gambhir)

PGR/GEPU- BUR-DEL-02-02: Policy Issues Related to Biosecurity. **(S C Dubey,** Kavita Gupta, Pratibha Brahmi, Gurinder Jit Randhawa)

3 DIVISION OF PLANT QUARANTINE

Summary: A total of 1,10,464 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 (6,764) comprised insects (314), nematodes (154), fungi (6,195), viruses (95) and weeds (06) including several exotic pests. Of the 6,764 infested/ infected/ contaminated samples, 6,697 were salvaged through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test. The remaining 67 samples could not be salvaged and hence rejected. Fourteen infected samples could not be salvaged, hence rejected. These rejected samples included 2 samples of maize from Thailand (1) and USA (1) due to *Bipolaris maydis*; 2 rice samples from USA due to *Tilletia barclayana*; one sample of saffron from Switzerland due to *Fusarium solani* and 9 samples of garlic from USA due to heavy fungal infection. In addition; one *in vitro* sample of potato due to mechanical damage and 13 pesticide treated samples consisting of rice from USA (10) and sunflower from Netherlands (2) and maize from USA (1) were rejected. In addition, 53 samples of *Glycine max* from USA were rejected due to viruses of quarantine significance for India. A total of 670 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 22 post-entry quarantine inspections were carried out at various indenter's sites during this period. A total of 1344 samples of various crops were processed for export of which 19 infested samples were salvaged, 03 samples contaminated with 03 types of weed species were salvaged and 16 Phytosanitary Certificates were issued. Quarantine processing of 24 samples of imported transgenic planting material revealed bacterial infection in cotton seeds which were salvaged by giving antibiotic treatment with streptocyclin @100 ppm; absence of terminator gene was ensured; all samples were salvaged prior to release and PEQ inspection undertaken. Under seed health testing, a total of 6,273 samples were received from Germplasm Conservation Division, of which 264 samples were found infected with different pathogens including fungi (262), bacteria (1) and virus (1). A total of 10 samples including rice infected with *T. barclayana* from Assam (2), Odisha (1), Delhi (1) and Telangana (1); wheat infected with *T. indica* from Haryana (3) and *Echinochloa esculenta* infected with *Ustilago crameri* from Uttarakhand (1) and *Glycine max* infected with *Peronospora manshurica* from Uttarakhand (1) were rejected as they could not be salvaged. In addition, 104 samples were received from TCCU for seed health testing before/ after cryo-preservation, of which seven samples were found infected with different fungi and all were salvaged. In addition, one sample each of *Arachis* sp. and *Vigna ungiculata* from Telangana and *Setaria* sp. from Uttar Pradesh and *Cajanus cajan* from Delhi were rejected due to heavy fungal infection and three pesticide treated samples *Gossypium* sp. from Gujarat were also rejected.

3.1 Import quarantine

3.1.1 Quarantine examination

A total of 1,10,464 samples comprising germplasm accessions, nurseries/ trial breeding material of various crops including both true seed and vegetative propagules were processed for the detection of associated exotic insect pests, mites, plant parasitic nematodes, plant pathogens (fungi, bacteria, viruses) and weed seeds by various detection techniques. Of the import samples, 747 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids. Of these, 314 samples were found infested with insects/ mites, including 107 with hidden infestation; 154 samples infected with nematodes, 6195 infected with fungi, 95

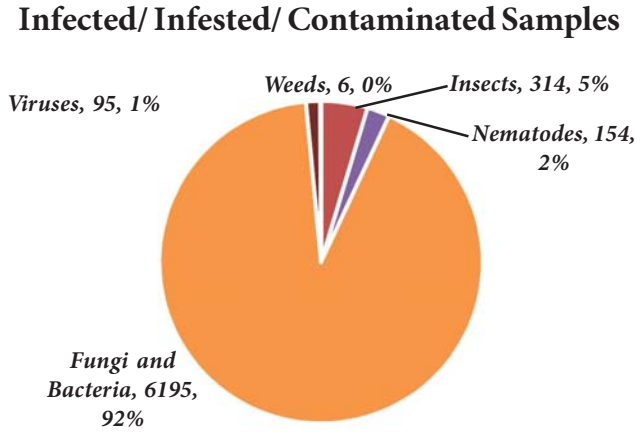


Fig. 3.1. Infected/ infested/ contaminated samples detected through quarantine examination

with viruses and 06 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 6,764 infested/ infected/ contaminated samples, 6,697 were salvaged by various disinfestation/ disinfection techniques/ treatments like mechanical cleaning to remove damaged/ abnormal seeds, soil clods, plant debris, etc., fumigation with ethylene dichloride-carbon tetrachloride (EDCT) mixture at 320 mg L^{-1} for 48 h or Aluminium Phosphide fumigation (Phosphine at 2 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 314 insect infested samples, all were salvaged by X-ray radiography (107), fumigation (204) using aluminium phosphide (Phosphine @ 2 g per cubic metre for 72 hrs)/Ethylene dichloride Carbon tetrachloride @ 320 mg/litre for 48 h and mechanical cleaning (3). Of these, 6,181 infected samples with fungi were salvaged by various disinfection techniques/ treatments such as fungicidal seed treatment and ethyl alcohol wash and remaining 14 infected samples were rejected. The 154 rice samples infected with nematode were salvaged by hot water treatment. A total of 06 samples contaminated with weed seeds were salvaged by mechanical cleaning.

3.1.3 Prophylactic treatments

A total 8,866 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 h and 777 vegetative propagules were given pesticidal dip/spray treatment against insect-pests. A total of 1,109 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 (231) and tomato (394) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate (Fig 3.3).

Bromus secalinus *Sorghum almum* *Echinochloa crus-pavonis* *Polygonum lapathifolium* *Phalaris paradoxa*

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

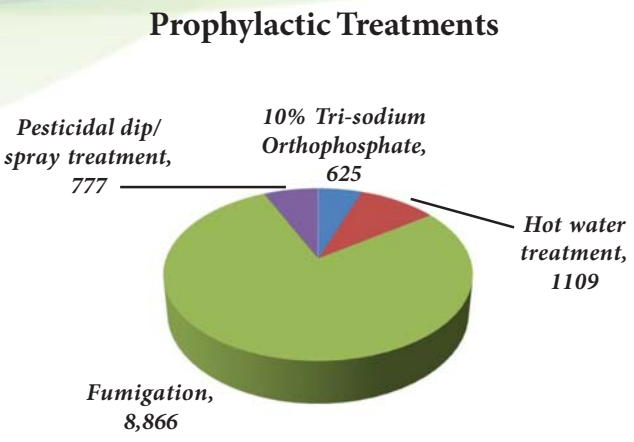


Fig. 3.3. Prophylactic treatments of introduced germplasm samples

3.1.4 Growing out test for detection of viruses

A total of 670 samples of exotic germplasm comprising *Glycine* spp. (239), *Phaseolus vulgaris* (412), *Pisum sativum* (1), *Vigna sesquipedalis* (4) and *V. unguiculata* (14) were grown in PEQ greenhouses at Headquarters. The plants showing virus-like symptoms were tested by electron microscopy, reverse-transcription PCR and using specific antiserum against various seed-transmitted viruses using enzyme-linked immunosorbent assay. A total of 53 samples of *Glycine max* from USA were rejected due to viruses of quarantine significance for India. The

Table 3.1: Pests intercepted in the exotic germplasm during 2020

Pests	Host	Source/ Country
Insect pest		
*Bruchidius atrolineatus**	*Vigna unguiculata*	Tanzania
*B. ervi**	*Lens culinaris*	Lebanon
*B. dentipes**	*Vicia faba*	Lebanon
*B. rufimanus**	*Lathrus sativus*	Spain
Callosobruchus maculatus	*Vigna unguiculata*	Tanzania
*C. subinnotatus**	*Vigna subterranea*	Uganda
Corcyra cephalonica	*Zea mays*	Chile
Rhizopertha dominica	*Oryza sativa*	Philippines
	Triticum aestivum	Mexico
Sitotroga cerealella	*Oryza sativa*	USA
	Zea mays	Chile
Immature stages of bruchid	*Vigna subterranea*	Niger
	Vigna unguiculata	Niger, Ghana
Fungi and Bacteria		
Bipolaris cynodontis	*Triticum aestivum*	Australia
B. maydis	*Zea mays*	Thailand, USA
B. oryzae	*Oryza sativa*	USA
B. rostrata	*Hordeum vulgare*	USA
	Momordica charantia	Thailand
B. sorghicola	*M. charantia*	Thailand
B. sorokiniana	*T. aestivum*	Australia, Mexico
	H. vulgare	USA
B. tetramera	*Capsicum annuum*	Netherland
Cercospora sp.	*Vigna subterranea*	Ghana
Colletotrichum capsici	*M. charantia*	Thailand
	Z. mays	USA
Diplodia zae	*Z. mays*	USA
Fusarium solani	*Crocus serotinus*	Spain
	Solanum lycopersicum	Netherlands
	Tylosema esculentum	Namibia
	Z. mays	USA

Pests	Host	Source/ Country
Fusarium subglutinans	*Citrullus lanatus*	USA
Fusarium verticillioides	*Allium cepa*	USA
	A. porrum	Switzerland
	C. chinense	USA
	H. vulgare	USA
	Lathyrus sp.	Spain
	Linum sp.	USA
	M. charantia	Thailand
	O. sativa	Philippines, USA
	S. lycopersicum	USA
	T. aestivum	Australia
	Z. mays	Brazil, Chile, Mexico, Philippines, Thailand, USA
Myrothecium vereacaria	*M. charantia*	Thailand
Nigrospora oryzae	*Cucumis melo*	USA
	M. charantia	Thailand
Phoma cucurbitacearum	*M. charantia*	Thailand
P. exigua	*M. charantia*	Thailand
P. herbarum	*M. charantia*	Thailand
P. sorghina	*M. charantia*	Thailand
	O. sativa	Philippines, USA
	Zea mays	Brazil
Diaporthe sp.	*M. charantia*	Thailand
Puccinia helianthi	*Helianthus annuus*	Netherlands
Tilletia barclayana	*O. sativa*	USA
Verticillium albo atrum	*Brassica oleracea* var. *capitata*	Chile, Netherlands
	B. oleracea var. *botrytis*	Netherlands
Viruses		
▲*Arabis mosaic virus*	*Glycine max*♣	USA
Bean common mosaic virus	*G. max*♣	USA
**Bean pod mottle virus*	*G. max*	USA
Bean yellow mosaic virus	*G. max*	USA
* *Cherry leaf roll virus*	*G. max*	USA
Cowpea mild mottle virus	*G. max*	USA
Cowpea mosaic virus	*G. max*	USA
Grapevine fan leaf virus	*G. max*♣	USA
**High plains virus*	*Zea mays*	Chile
**Maize chlorotic mottle virus*	*Z. mays*	Chile
**Peanut stunt virus*	*G. max*	USA
**Raspberry ringspot virus*	*G. max*	USA
Southern bean mosaic virus	*G. max*♣	USA
Soybean mosaic virus	*G. max*	USA
Tobacco ringspot virus	*G. max*♣	USA
Tomato black ring virus	*G. max*♣	USA
**Tomato ringspot virus*	*G. max*	USA
Weeds		
●*Bromus secalinus*	*H. vulgare*	USA
●*E. crus-pavonis*	*H. vulgare*	Switzerland
●*Galium aparine*	*Coriandrum sativum*	Russia
**Phalaris paradoxa*	*H. vulgare*	USA
●*Polygonum lapathifolium*	*H. vulgare*	USA
**Sorghum almum*	*H. vulgare*	USA
●*Bromus secalinus*	*H. vulgare*	USA

●Pest regulated under PQ Order, 2003; *Pest not yet reported from India; ♣Pest present in India but not recorded on the host on which intercepted; ♣Virus present in India but not recorded on the host on which intercepted; ▲Virus present in India on rose with restricted distribution in H.P.

harvest from only healthy plants of different accessions was released to the indenters. The interceptions are presented in Table 3.1.

3.1.5 PEQ inspections at indenter's site

A total of 22 post-entry quarantine inspections of various crops consisting of 36,939 samples of maize (4,834), faba bean (471), wheat (21,901), tomato (15), rice (63), bitter gourd (100), lentil (2,157), grass pea (362), barley (5,123), soybean (442), cucumber (3), chickpea (1350), hot pepper (90) and cauliflower (64) imported from various countries were carried out at various indenters' sites during 2020 (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 during 2020

IQ No.	Country	Crop	Samples	Indentor	Date	Scientist(s)
158/2019	Netherlands	*C. annuum*	53	Syngenta India Ltd, Aurangabad	Jan. 20, 2020	VC Chalam
144/2019	Netherlands	*C. annuum*	1			
212/2019	Thailand	*C. annuum*	4			
260/2019	Thailand	*C. annuum*	3			
230/2019	USA	*Glycine max*	319	NABI, Mohali	Jan 30, 2020	VC Chalam, AK Maurya
288/2018	USA	*Zea mays*	370	Sayaji Seeds Ltd, Ahmadabad	Feb. 5, 2020	VC Chalam, K Gupta
304/2019	Mexico	*Triticum aestivum*	686	ITC Pvt Ltd, Sehore, MP	Feb. 21, 2020	VC Chalam, T Boopathi, P Kumar
357/2019	Mexico	*T. aestivum*	59			
368/2019	Mexico	*T. aestivum*	278			
318/2019	Lebanon	*T. aestivum*	2471	ICARDA, Amlaha, MP	Feb. 22, 2020	VC Chalam, T Boopathi, P Kumar
319/2019	Lebanon	*T. aestivum*	564			
335/2019	Lebanon	*T. aestivum*	976			
320/2019	Lebanon	*Hordeum vulgare*	2400			
337/2019	Lebanon	*H. vulgare*	2251			
322/2019	Lebanon	*Lathyrus sativus*	326			
323/2019	Lebanon	*Cicer arietinum*	1350			
324/2019	Lebanon	*Lens culinaris*	2157			
321/2019	Lebanon	*Vicia faba*	471	ICAR-NBPGR, New Delhi	Feb. 25, 2020	VC Chalam, SP Singh, BH Gawade, P Kumar
362/2019	Mexico	*T. aestivum*	3210	Mahyco Pvt Ltd, Jalna	Feb. 25, 2020	J Akhtar, AK Maurya
363/2019	Mexico	*T. aestivum*				
307/219	Mexico	*T. aestivum*	1448	Krishidhan Pvt Ltd, Jalna	Feb. 26, 2020	J Akhtar, AK Maurya

IQ No.	Country	Crop	Samples	Indentor	Date	Scientist(s)
303/2019	Mexico	*T. aestivum*	817	Suraj Crop Science, Sabarkantha	Feb. 29, 2020	J Akhtar, T Boopathi
338/2019	USA	*H. vulgare*	472	Anheusar Busch Inbev, Alwar	Feb. 29, 2020	MC Singh, SP Singh
33/2018	Brazil	*Z. mays*	11	Syngnta India Ltd., Hyderabad	Mar. 2, 2020	VC Chalam, J Akhtar
365/2018 366/2018 367/2018	Chile	*Z. mays*	47			
63/2019	Philippines	*Z. mays*	87			
151/2019 249/2019 265/2019 276/2019 277/2019	Thailand	*Z. mays*	4747			
124/2018	USA	*G. max*	123	ICAR-NBPGR RS, Hyderabad	Mar. 3, 2020	VC Chalam, J Akhtar
299/2019 367/2019	Mexico	*T. aestivum*	2775	Ankur Seeds, Nagpur	Mar. 4, 2020	K Gupta, Z Khan
301/2019 302/2019 369/2019	Mexico	*T. aestivum*	1848	JK Agri Seed, Jaipur	Mar. 5, 2020	Pardeep Kumar, DS Meena
417/2019 524/2019	Mexico	*T. aestivum*	1679	Bioseeds Pvt Ltd., Ludhiana	Mar. 6, 2020	M Shekhar, BH Gawade
297/2019 348/2019 396/2019	Bulgaria	*T. aestivum*	802	ICAR-IARI, New Delhi	Mar. 12, 2020	VC Chalam, M Shekhar
297/2019	Mexico	*T. aestivum*	4229	Nuziveedu Seeds Ltd. Karnal	Mar. 12, 2020	MC Singh, SP Singh, Z Khan, Pooja Kumari
358/2019	Mexico	*T. aestivum*	59	Bioseeds Pvt. Ltd., Alwar	Mar. 16, 2020	MC Singh, SP Singh
24/ 2020	Taiwan	*Momordica charantia*	100	Ankur Seeds, Nagpur	Aug 11, 2020	J Akhtar, R Kiran
183/ 2019	Colombia	*Oryza sativa*	63	Savanna Seeds Pvt Ltd. Gurugram	Sep. 15, 2020	BH Gawade, P Kumar
264/ 2019	Brazil					
384/2019	Thailand	*Capsicum annuum*	29	Syngenta India Ltd., Aurangabad	Oct 9, 2020	VC Chalam, J Akhtar, Z Khan, BH Gawade, P Kumar
91/2020	USA					
30/2020	Netherland	*Cucucmis sativus*	03			
102/2020	Thailand	*Solanum lycopersicum*	15			
86/2020	Netherlands	*B. oleracea* var. botrytis	64	M/s Syngenta India Ltd., Karnal	Nov 28, 2020	SC Dubey, J Akhtar, BR Meena

3.2 Export quarantine

A total 1,344 samples of crops comprising *Gossypium hirsutum* (4), *Lablab purpureus* (50), *Oryza sativa* (590) and *Triticum aestivum* (700) were exported to Burkina Faso, Ghana, Niger, Mali, Kenya, Uganda, Namibia, Senegal, Bangladesh, Bolivia, USA, Columbia, Laguna and Philippines. Out of 1,344 exported samples, 54 were X-rayed and all found free from any hidden infestation. Nineteen samples of *Triticum aestivum* were found infested by *Rhizopertha dominica*. All 19 insect infested samples were salvaged by fumigation using aluminium phosphide (Phosphine @ 2 g per cubic metre for 72 hrs). Additionally, nineteen samples of various crops found infected with fungal pathogens, *Bipolaris sorokiniana* and *B. tetramera* in wheat from Karnal, Haryana and *Bipolaris oryzae,Fusarium graminearum*, *F. oxysporum*, *F. semitectum*, *F. verticillioides, Nigrospora oryzae*, *Phoma sorghina* in rice from Telangana and *Tilletia barclayana* and *Ustilaginoidea virens* from Punjab. Prophylactic treatment with fumigation was given to 681 samples.Two sample of wheat intended for export to Bangladesh and Bolivia were found contaminated with *Phalaris minor* and *Melilotus indica,* respectively. One sample of rice meant for export to USA was found contaminated with *Echinochloa crus-galli*. A total of 18 phytosanitary certificates were issued.

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

A total 6,273 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 511 samples were found infested by various insect-pests. A total of 326 samples were found infected with nematodes from eleven different states / UT of the India.Visual/ stereoscopic examination resulted in detection of fugal (87) and viral (1) pathogens in germplasm samples which included purple stain (*Cercospora kikuchii*) in 2 soybean samples from Delhi (1) and Chhattisgarh (1) and downy mildew (*Peronospora manshurica*) from Uttarakhand (1); 5 samples of rice infected with *T. barclayana* from Assam (2), Delhi (1), Odisha (1) and Telangana (1) and false smut (*Ustilagenoidea virens*) in 75 samples from Assam (45), Odisha (19) and Delhi (11); wheat infected with *T. indica* from Haryana (3) and *Echinochloa esculenta* infected with *Ustilago crameri* from Uttarakhand (1). Viral symptoms included one sample of split seed coat in pea from Odisha. Out of 87 samples infected with fungal pathogens, 10 samples including 5 samples of rice infected with *T. barclayana*, 3 samples of wheat infected with *T. indica*, 1 sample each of soybean due to *P. manshurica* and barnyard millet due to *U. crameri* were rejected. Whereas, blotter test revealed detection and identification of many seed-borne fungi/ bacteria in 178 accessions of various crop germplasm. The important fungi detected include *Alternaria brassicicola*, *Bipolarisoryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsici*, *Fusarium oxysporum*, *Fusarium solani*, *Macrophomina phaseolina*, *Phomaexigua*, *Rhizoctonia solani*, *Verticillium albo-atrum* and the details of pathogens detected are given in Table 3.

A total of 18 samples accessions of indigenously collected seed material and multiplied material at various centres were found contaminated with 06 types of weed seeds and all these samples were salvaged by mechanical cleaning. The details of pests detected are given in Table 3.3.

A total 1,763 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 236 samples were found infested while visual infestation of insect-pests was recorded in 275 samples. A total 511

Table 3.3: Pests detected in material meant for pest free conservation

Pests	Host	Source/Collection site
Insects		
Acanthoscelides obtectus	*Phaseolus vulgaris*	Himachal Pradesh
Bruchus lentis	*Lens culinaris*	Madhya Pradesh, Odisha, Uttrakhand
Bruchus pisorum	*Pisum sativum*	Himachal Pradesh, Odisha,Uttrakhand
Cadra cautella	*Helianthus annuus*	Punjab
Callosobruchus cajanus	*Cajanus cajan*	Bihar, Gujarat, Maharashtra, Tamil Nadu, Telangana
Callosobruchus chinensis	*Cajanus cajan*	Telangana
	Cicer arietinum	Bihar
	Glycine max	New Delhi
	Hibiscus sabdariffa	Telengana
	Lathyrus sativus	New Delhi
	Vigna unguiculata	Telangana
Callosobruchus maculatus	*Abelmoschus esculentus*	New Delhi
	Cajanus cajan	Telangana, Maharashtra
	Macrotyloma uniflorum	Telangana
	Phaseolus vulgaris	Jammu and Kashmir,Uttrakhand
	Vigna mungo	Telangana, Maharashtra
	Vigna radiata	Telangana, Maharashtra
	Vigna unguiculata	Uttar Pradesh, Maharashtra
Callosobruchus phaseoli	*Phaseolus vulgaris*	Himachal Pradesh, Sikkim
Caryedon serratus	*Arachis hypogea*	Gujarat
Immature stages of bruchid	*Abelmoschus esculentus*	New Delhi
	Asparagus officinalis	Himachal Pradesh
	Cajanus cajan	Bihar, Jharkhand, Maharashtra, Odisha
	Cicer arietinum	Odisha
	Lablab purpureus	Madhya Pradesh
	Lens culinaris	New Delhi, Uttar Pradesh
	Mucuna pruriens	Karnataka
	Phaseolus vulgaris	Himachal Pradesh
	Pisum sativum	New Delhi
	Vigna mungo	Andhra Pradesh
	Vigna radiata	Odisha, Andhra Pradesh, Jammu and Kashmir
	Vigna unguiculata	Jammu and Kashmir
	V. unguiculata var. *sesquipedalis*	Maharashtra
Lasioderma serricorne	*Lablab purpureus*	Odisha
	Foeniculum vulgare	Rajasthan
Pectinophora gossypiella	*Gossypium hirsutum*	Andhra Pradesh, Punjab, Tamil Nadu
Rhizopertha dominica	*Avena fatua*	Haryana, Punjab
	Oryza sativa	Andhra Pradesh, Assam, Gujarat, New Delhi, Odisha, Punjab, Tamil Nadu, Telangana, Uttrakhand
	Sorghum bicolor	Uttrakhand
	Triticum aestivum	Haryana
	T. durum	Maharashtra
	V. unguiculata	Rajasthan
	Zea mays	New Delhi
Sitophilus oryzae	*Oryza sativa*	Assam, Nagaland, Maharashtra, New Delhi
	Sorghum bicolor	Jharkhand
	Triticum aestivum	Maharashtra, New Delhi
	Zea mays	Jammu and Kashmir, Jharkhand, New Delhi, Punjab
Sitophilus zeamais	*Hordeum vulgare*	New Delhi
	Oryza sativa	Sikkim
	Zea mays	Sikkim
Sitotroga cerealella	*Avenafatua*	Punjab
	Coixlacryma-jobi	Nagaland
	Hordeum vulgare	Himachal Pradesh

Pests	Host	Source/Collection site
	Oryza sativa	Andhra Pradesh, Assam, Gujarat, Maharashtra, Nagaland, New Delhi, Odisha, Sikkim, Tamil Nadu, Telangana, Tripura, Uttrakhand,West Bengal,
	Sorghum bicolor	Kerala
	Triticum aestivum	New Delhi
	Zea mays	Jammu and Kashmir, New Delhi, Punjab, Sikkim
Spermophagous albofaciatus	*Abelmoschus esculentus*	Maharashtra
Tribolium castanium	*Avena fatua*	Haryana, Punjab
	Benincasa hispida	New Delhi
	Foeniculum vulgare	Rajasthan
	Glycine max	Chattisgarh
	Gossypium hirsutum	Maharashtra, Karnataka
	Luffa aegyptica	New Delhi
	Oryza sativa	Chattisgarh, Gujarat, New Delhi, Odisha, Sikkim
	Sesamum indicum	Kerala
	Triticum aestivum	New Delhi
Pathogens		
Alternaria alternaria	*Sorghum bicolor*	Uttar Pradesh
A. brassicae	*Brassica juncea*	Punjab
A. padwickii	*Oryza sativa*	Assam
Ascochyta sp.	*Diplocyclos palmatus*	Uttar Pradesh
Bipolaris cynodontis	*Setaria italica*	Telangana
B. maydis	*Zea mays*	Bihar, Sikkim
B. oryzae	*O. sativa*	Assam, Odisha
B. sorghicola	*Pennisetum glaucum*	Rajasthan
B. sorokiniana	*Triticum durum*	Haryana
B. tetramera	*O. sativa*	Odisha
Botryodiplodia theobromae	*Capsicum annuum*	Maharashtra
Botrytis cinerea	*Callistephus chinensis*	Karnataka
Cercospora kikuchii	*Glycine max*	Chhattisgarh, Madhya Pradesh
Cercospora sp.	*S. bicolor*	Chhattisgarh, Nagaland
Colletotrichum capsici	*Cajanus cajan*	Maharashtra
	C. annuum	Madhya Pradesh, Maharashtra
	Phaseolus vulgaris	Delhi
C. gloeosporioides	*D. palmatus*	Uttar Pradesh
Fusarium graminearum	*O. sativa*	Delhi
F. oxysporum	*Abelmoschus esculentus*	Maharashtra
	Cicer arietinum	Maharashtra
	Cucumis sp.	Thrissur
	Hibiscus sp.	Delhi
	Momordica charantia	Punjab, Kerala
	S. bicolor	Telangana
	Trichosanthes sp.	Delhi
F. semitectum	*Amarnathus* sp.	Nagaland
	Benincasa hispida	Delhi
	O. sativa	Delhi
	S. bicolor	Uttar Pradesh
F. solani	*Cucumis melo*	Delhi
	S. bicolor	Telangana
F. torulla	*Vigna mungo*	Telangana
F. verticillioides	*B. hispida*	Jharkhand
	C. annuum	Madhya Pradesh
	Cucumis sp.	Thrissur
	Eleusine coracana	Uttar Pradesh

Pests	Host	Source/Collection site
	Foeniculum vulgare	Rajasthan
	M. charantia	Thrissur
	O. sativa	Assam, Delhi, Odisha
	Seasamum sp.	Delhi
	S. italica	Telangana
	S. bicolor	Telangana
	T. durum	Haryana
	Z. mays	Bihar, Haryana, Karnataka
Macrophomina phaseolina	*S. bicolor*	Telangana
	Vigna mungo	Telangana
Nigrospora oryzae	*O. sativa*	Telangana
Peronospora manshurica	*G. max*	Uttarakhand
Phoma exigua	*Luffa aegyptiaca*	Delhi
	Lagenaria siceraria	Delhi
P. sorghina	*B. hispida*	Jharkhand
	C. cajan	Maharashtra
	O. sativa	Nagaland, Odisha, Telangana
	S. bicolor	Gujarat
Phoma sp.	*D. palmatus*	Uttar Pradesh
	Trichosanthes tricuspidata	Uttar Pradesh
Diaporthe sp.	*Luffa* sp.	Delhi
	C. annuum	Madhya Pradesh
D. phaseolorum	*Luffa* sp.	Uttar Pradesh
D. phaseolorum	*Oroxylum indicum*	Assam
Puccinia carthami	*Carthamus tintorius*	Karnataka
Rhizoctonia solani	*C. cajan*	Maharashtra
Tilletia barclayana	*O. sativa*	Assam, Odisha, Telangana
T. indica	*T. aestivum*	Haryana
Ustilaginiodea virens	*O. sativa*	Assam, Odisha
Ustilago cameri	*Echinochloa esculenta*	Uttrakhand
Verticillium albo-atrum	*C. annuum*	Karnataka
	Cucumis sp.	Kerala
	Disscorea betophylia	Kerala
	Solanum viarum	Uttar Pradesh
Xanthomomas campestris pv. *campestris*	*B. oleracea* var. *botrytis*	Delhi
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andaman and Nicobar Islands, Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Kerala, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal
Weeds		
Echinichloa colona	*Cucumis sativus*	Karnataka
	O. sativa	New Delhi
Echinichloa crus-galli	*O. sativa*	Telangana
	O. sativa	AN
	Fagopyrum esculentum	New Delhi
	O. sativa	New Delhi
Phalaris minor	*Linum usitatisimum,*	UP
	T. aestivum	Haryana
	T. aestivum	Chhatishgarh
	Lens culinaris	New Delhi
Sonchus arvensis	*O. sativa*	Odisha
Vicia hirsuta	*Brassica juncea*	New Delhi
Vicia sativa	*Linum usitatisimum*	New Delhi

samples were found infested by various insect-pests. The insect pests detected are given in Table 2. Out of total 511 infested samples, 429 were salvaged by X-ray radiography (202), cold treatment (195) and mechanically (32) while 82 samples could not be salvaged hence rejected. A total of 326 samples were found infected with nematodes from eleven different states / UT of the India.

In addition, 107 cryo-preserved samples or for cryo-preservation were received from TCCU for seed health testing of which 7 samples were found infected with different fungi and all were salvaged.. A toal 67 samples were X-rayed to detect any hidden infestation of insect pests and all were found free from any hidden infestation.

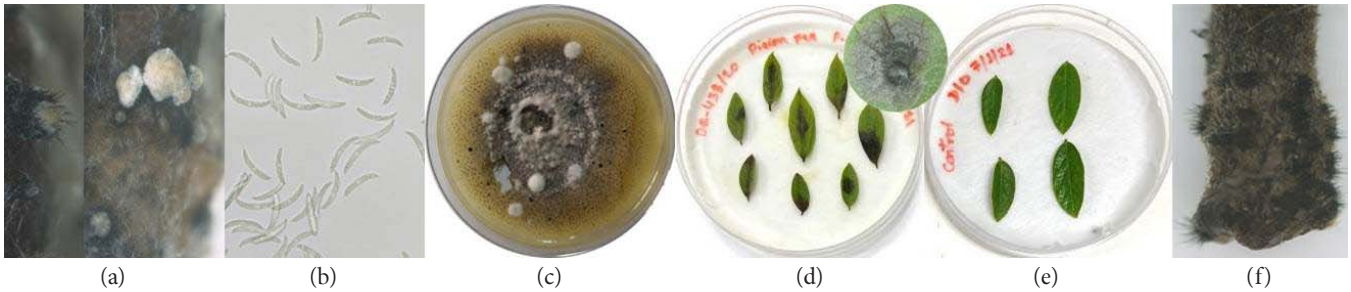
3.4 Detection of viruses in *In-vitro* cultures of germplasm meant for conservation

Thirty samples of *in vitro* cultures of *Fragaria vesca* were tested for four associated viruses *viz*., arabis mosaic virus (ArMV), raspberry bushy dwarf virus (RBDV), strawberry mild yellow edge virus (SMYEV) and raspberry ringspot virus (RpRSV) using DAS-ELISA. Out of thirty samples tested, it was found that 100% cultures were free from ArMV, RBDV and SMYEV and 90% cultures were free from RpRSV. Post-cryotherapy, 30 plants generated out of 60 cryopreserved shoot tips were tested by DAS-ELISA and representative samples by RT-PCR for RpRSV. Success rate of cryotherapy was 96.67% for elimination of RpRSV.

3.5 Supportive research

3.5.1 Pigeon pea - a new host record of *Colletotrichum capsici*

During seed health testing, several sub-epidermal fruiting bodies called acervuli containing thick black setae and dirty white conidial mass were observed on seed of pigeon pea accession no. IC323202 under stereo microscope with infection of 30.0 per cent. Microscopy revealed that conidia were sickle shaped, hyaline, fusoid with tapering end measuring 15-27 x 2-5 µm dimension. Based on morphological characteristic features, the fungus was morphologically identified as *Colletotrichum capsici*(Syd.) Butler &Bisby. The fungus was aseptically transferred from infected seed to PDA plates incubated at 27±1°C and to obtained pure culture. Later, pathogenicity was proved on pigeon pea leaves (cv. P-992) using detached leaf and stem technique. For the pathogenicity, the surface sterilized healthy leaves keeping adaxial (upper) side up and stems were placed on moistened blotter sheets (3-layer) in Petri plate (110 mm). The conidial suspension ($1x10^6$ conidia mL^{-1}) was prepared in distilled sterilized water test, spot inoculated @ 10 µl conidial suspension per spot using micropipette and uninoculated leaves served as control, all the plates after covering with lid having moistened blotter sheets (3-layer) were incubated at 27±1°C and observed daily. After three days of incubation, symptoms started appearing as necrotic lesions and on 4^{th}-6^{th} day, subepidermal acervuli were observed under stereo microscope



(a) (b) (c) (d) (e) (f)

Fig. 3.4. Growth and morphology of *Colletotrichum capsici* (a-c) and pathogenicity on pigeon pea (d-f)

on inoculated leaves and stems, while the control plates remained healthy (Fig. 3.4). Thereafter, microscopic observation revealed conidia with morphology similar to that of original culture.

3.5.2 Biogenic synthesis of silver nanoparticles and study of its antibacterial activity

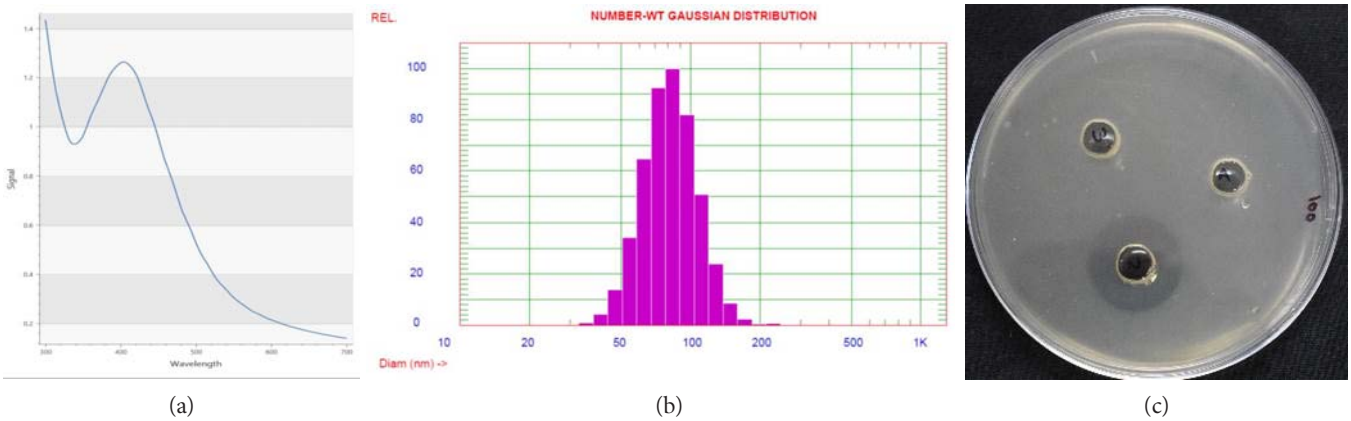
Silver nanoparticles (AgNPs) were synthesized using extract of *Fusarium oxysporum* as a reducing agent. The mycelium of *F. oxysporum* was grown in Potato Dextrose Broth medium in 100 ml flask for 7 days at 27±1°C, harvested by filtration and washed thrice with sterilized distilled water. The washed mycelium was re-suspended into 100 mL sterilized distilled water and incubated at 27±1°C for 2 days. Again, mycelium was harvested by filtration and culture filtrate was treated with 1.5 mM silver nitrate solution for 7 days. Appearance of dark brown colour of culture filtrate indicated the formation of silver nanoparticles. Further, AgNPs were characterized with the help of dual beam UV-Visible spectrophotometer by scanning the absorbance spectra at 300–700 nm range of wavelength and the peak was formed at ~405 nm (Fig. 3.5a). Using particle sizing system, mean diameter of particle was measured 84.3 nm (Fig. 3.5b). The antibacterial activity of AgNPs was investigated against *Xanthomonas campestris* pv. *campestris* using agar well diffusion assay method at the rate of 25, 50, 75 and 100 µL AgNPs. After incubation at 27±1°C for 24 h, the diameter of inhibition zone was recorded maximum (18 mm) at 100 µL concentration of AgNPs (Fig. 3.5c).

3.5.3 Phenotyping of *Brassica* germplasm against Sclerotinia rot

Screening of *Brassica* germplasm against Sclerotinia rot (*Sclerotinia sclerotiorum*) resulted in stem rot incidence up to 95.00 per cent, whereas, lesion length up to 55.20 cm. Artificial inoculation resulted in identification of few promising accessions such as EC20167, IC265495, IC341170, etc. which could be utilized as source of resistance in varietal improvement programme.

3.5.4 Standardization of mass culturing technique for continuous rearing of *Callosobruchus chinensis* based on life table and population parameters

C. chinensis was cultured on three pulses (green gram, lentil and cowpea) under laboratory conditions (27±1°C temperature with a 70±1% RH). Among the different pulses tested, cowpea was found to be an appropriate host for the continuous rearing of *C. chinensis* in laboratory conditions throughout the year. *C. chinensis*



(a) (b) (c)

Fig. 3.5. UV-Vis absorption spectrum of AgNPs (a), Particle size analysis of AgNPs based on Gaussian distribution (b), Antibacterial activity (zone of inhibition) of AgNPs against *X. campestris* pv. *campestris* (c)

showed comparatively more fecundity, shorter developmental period and longer female longevity on cowpea than green gram and lentil. The relative growth rate (RGR) for *C. chinensis* was 0.101±0.006 mg/d. The increase in the finite growth rate, the intrinsic rate of increase, and the net reproduction rate showed a faster increase in the *C. chinensis* population on cowpea than green gram and lentil. The overlapping life stages in the life expectancy, survival rate and reproductive results of *C. chinensis* on cowpea, green gram and lentil were noted; this universal pattern is important for inclusion in the assessment of life table parameters. The adult pre-reproduction period (APRP), and total pre-reproduction period (TPRP) of female counted from birth were 0.00 d and 26.87 d on green gram, 0.43 d and 25.86 d on lentil, 0.00 d and 23.76 d, respectively (Table 3.4). The number of oviposition days (O_d) and the eggs per oviposition day (E_d) were respectively, 4.73 d and 11.14 d on green gram, 0.00 d and 8.67 d on lentil, and 4.88 d and 11.69 d on cowpea. The number of eggs laid by a reproductive female (F_r) of *C. chinensis*were 52.73 on green gram, 43.36 on lentil, and 57.06 on cowpea. The doubling time (D_t) of *C. chinensis* were 6.65 d on green gram, 7.02 d on lentil, and 5.56 on cowpea. The estimated values for the intrinsic rate of increase (r), the finite rate of increase ($ë$), the net rate of reproduction (R_0), the gross reproduction rate (GRR) and the mean time of generation (T) for all individuals were 0.1042 d^{-1}, 1.1098 d^{-1}, 19.775 eggs/individual, 33.05 eggs/individual and 28.643 d on green gram, 0.0986 d^{-1}, 1.1036 d^{-1}, 15.175 eggs/individual, 25.96 eggs/individual and 27.568 d on lentil, and 0.1246 d^{-1}, 1.1327 d^{-1}, 24.250 eggs/individual, 31.70 eggs/individual and 25.589 d on cowpea, respectively. In cohorts, the female proportion was 0.375 on green gram, 0.350 on lentil, and 0.425 on cowpea.

3.5.5 Identification of resistance sources for *Callosobruchus chinensis* in green gram germplasm

The insects are restricted in their seed sample selection by no-choice method. This method is extensively used in screening of genotypes under laboratory conditions for resistance against *C. chinensis*. Growth index and biological parameters of *C. chinensis*in selected accessions under force choice test were presented (Table 3.5). Germplasm were categorized as highly resistant (2 germplasm), resistant (4 germplasm), moderately resistant (7 germplasm), moderately susceptible (2 germplasm), susceptible (3 germplasm) and

Table 3.4: Average (± standard error) of the adult pre-reproduction period of female adult (APRP), total pre-reproduction period of female counted from birth (TPRP), oviposition days (O_d), female adult fecundity and the doubling time (D_t) of *Callosobruchus chinensis* fed on green gram, lentil and cowpea

Parameters	Average ± standard error		
	Green gram	Lentil	Cowpea
APRP (day)	0.00±0.00	0.43±0.14	0.00±0.00
TPRP (day)	26.87±0.41	25.86±0.54	23.76± 0.37
Oviposition days (O_d) (day)	4.73±0.12	5.00±0.00	4.88±0.12
Eggs per oviposition day (E_d) (eggs/day)	11.14±1.18	8.67±0.94	11.69±1.06
Fecundity (F_r) (eggs/reproductive female)	52.73±3.90	43.36±1.35	57.06±1.99
Daily maximum fecundity (no.)	43	28	36
The maximum total fecundity (no.)	82	51	69

Table 3.5: Reaction of green gram germplasm to *Callosobruchus chinensis* on the basis of force choice test

Category	Susceptibility index (based on growth index)	Number of green gram germplasm
Highly resistant	<0.040	2 (EC920900, IC616161)
Resistant	0.041–0.050	4 (IC616111, IC616247, IC616258, IC616138)
Moderately resistant	0.051–0.060	7 (IC616156, IC623911, IC616188, IC616150, IC616125, IC616122, IC616124)
Moderately susceptible	0.061–0.070	2 (IC616157, IC616144)
Susceptible	0.071– 0.080	3 (IC616127, IC616268, IC616116)
Highly susceptible	>0.081	2 (EC862601, EC920903)
Total	-	**20**

highly susceptible (2 germplasm) based on growth index.

3.5.6 Screening of pulse germplasm for root-knot nematode

A total of 913 accessions of various pulse crops, *viz*., cowpea (177), lentil (166), chickpea (283), pea (103), rice-bean (184), moth-bean (140) were evaluated for resistant source to a species of root-knot nematode, *Meloidogyne incognita* in pots with artificial inoculation. Based on number of root-galls induced by nematode and its reproduction factor, only one accession of pea (EC2173) found resistant with less than 10 root-galls per root system. Rest of the accessions of mentioned crops were susceptible to highly susceptible with variable galls ranging from 30 to more than 100 galls per root system.

Fig. 3.6. Variation in host reaction in resistant and susceptible accessions of pea

3.5.7 Host-specificity in biological control of weeds using insects

The phenomenon of plant-insect interaction in biological control of weeds using insect was studied. Biological control of weeds by insects, whether native species or introduced ones, involves a complex of interacting morphological, biochemical, phenological and other factors in both host-plant and bio-control agent. Host-specificity is the most essential requirement for an insect to be used as a weed control agent. While an insect initially locates its preferred host-plant by responding to various orientation stimuli, eventually it selects and remains on the plant for feeding and breeding by reacting more intimately to one or more of the various factors mentioned above. Oviposition habit and nutritional suitability of the plant for growth and reproduction are important criteria in determining insect-plant association. Apart from climate, biotic factors such as parasites, predators and pathogenic organisms, as well as biochemical and phenological changes in host-plant vulnerability are among the major causes that affect the control value of insect enemies of weeds.

3.5.8 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 containment/ quarantine facility for transgenic planting material (DBT) component 1 (till September 26, 2020) national programme for quarantine and GM diagnostics of genetically engineered plant material (w.e.f September 27, 2020)

With the approval of RCGM 24 samples of imported transgenic planting material were received for quarantine clearance comprising of *Gossypium hirsutum* (23) from France for Bioseed Research India, Hyderabad and *Zea mays* (1) from USA for Monsanto Holding Pvt. Ltd., Bengaluru. All the samples were processed for quarantine clearance and released to the indenters.

Cotton seeds were found infected with bacterium. The infected samples were salvaged antibiotic treatment with streptocyclin @100ppm.

Seeds of transgenic *Gossypium hirsutum* (23) from France were grown in the containment facility for 45 days for detection of seed-transmitted pests not detectable in the laboratory tests. On the basis of observations at regular intervals suspected leaf samples were tested in the laboratory for the presence of various pests. The plants were uprooted after 45 days of growing in the Containment Facility. These were disposed off in the presence of members of Institutional Biosafety Committee (IBSC) of ICAR-NBPGR as per biosafety guidelines of DBT.

All the imported transgenic lines were tested to ensure the absence of embryogenesis deactivator gene by PCR with primers specific to the *cre-lox* system. Plasmid cloned with *cre* sequence was used as positive control. In PCR amplification of *cre* sequence, the amplicon of 1031 bp size was amplified only in positive plasmid sample while, no amplicon of corresponding size was observed in any of these transgenic samples ensuring the absence of embryogenesis deactivator gene.

One post-entry quarantine inspection was undertaken for *G. hirsutum* (virtual) grown at Bioseed Research India, Hyderabad. The crops were visually inspected for symptoms of pests/ diseases. Suspected infected leaf and soil samples were tested and were found to be free from exotic fungi, bacteria, viruses, nematodes and insect pests.

Major pests which may accompany *G. hirsutum* from France and *Z. mays* from USA and not yet reported from India were listed by studying the available literature.

Reverse-transcription-polymerase chain reaction (RT-PCR)-based diagnostics were developed for viruses *viz.*, raspberry ringspot virus and bean pod mottle virus.

3.6.2 Characterisation of genetic resources: 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) (DBT)

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

Sowing of 500 accessions of rice landraces for pot screening against sheath blight (*Rhizoctonia solani*) resulted in germination and

establishment of 207 accessions only. Artificial inoculation using typha-based mycelial bits resulted in infection of 123 accessions, where average lesion length ranged from 0.96 to 7 cm and incubation period ranged from 3 to 6 days. Further, result revealed that 27 accessions (acc. nos. 371, 379, 412, 448, 451, 454, 470 & 476, 354, 356, 364, 370, 375, 376, 403, 405, 406, 407, 413, 422, 426, 446, 452, 462, 469, 472 & 479) took 4 days or lesser incubation period and 31 (acc. nos. 350, 351, 358, 361, 363, 366, 367, 368, 373, 374, 377, 404, 408, 411, 414, 420, 421, 427, 428, 449, 456, 460, 468, 471, 473, 474, 477, 478, 480, 481 & 482) were recorded with incubation period of 5 days. Whereas, 23 accessions (acc. nos. 352, 353, 355, 357, 359,360, 378, 380, 381, 409, 410,417, 418, 419, 423, 424, 425, 450, 453, 457, 458, 461 & 475) were recorded with incubation period of 6 days.

3.6.3 Development of DNA barcode and multiplex PCR based diagnostics for detection of nationally important seed borne fungal pathogens of major pulse crops for safe exchange and conservation (DBT)

3.6.3.1 Development of multiplex PCR based detection of *Ascochyta rabiei, Sclerotinia sclerotiorum, Athelia rolfsii* and *Fusarium oxysporum* f. sp. *ciceris* infecting major grain legumes

Sensitivities of earlier developed markers were tested using conventional and real time PCR. All markers proved to be highly sensitive with detection limit ranging from 10 ng to 0.001 ng genomic DNA using conventional PCR, whereas, 1 ng to 0.0001 ng using real time PCR. Four sets of multiplex PCR assays were developed for detection of both *Cercospora canescense* (OBCC5aF&R) and *Pseudo cercospora cruenta* (BPC24LSF&R and ELSS11NPbF); *Rhizoctonia solani* (BRS17cITSF&R) and *Macrophomina phaseolina* (BMP13LSF&R); *Alternaria alternata* (BAA1TEF&R) and *A. tenuissima* (BAT3BTF&R) and for four different fungal plant pathogens namely, *Ascochyta rabiei* (BAR5TEF&R), *Sclerotinia sclerotiorum* (BSS21aLSF&R) and *Athelia rolfsii* (BSR19aSSF&R) and *Fusarium oxysporum* f. sp. *ciceris* (FOCox1F&3R) simultaneously (Fig. 3.7).

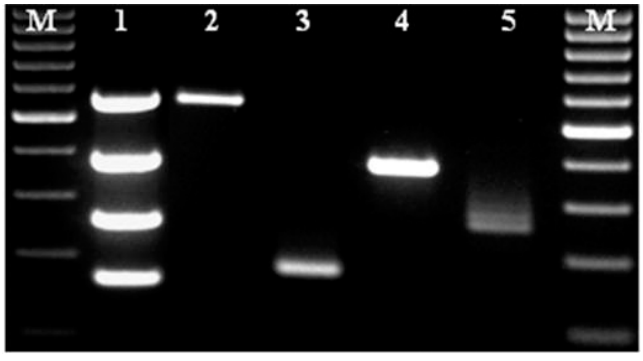


Fig. 3.7. Amplification obtained in multiplex and individual PCR using BAR5TEF&R+BSS21aLS&R +BSR19aSS F&R+BFCCOX1F&3R marker. Lane M-100 bp ladder, 1- multiplex of *A. rabiei* +*S. sclerotiorum* + *A. rolfsii* + *F. oxysporum* f. sp. *ciceris* (*Foc*), 2- *A. rabiei* (565 bp), 3- *F. oxysporum* f. sp. *ciceris* (150 bp), 4- *S. sclerotiorum* (380 bp), 5- *A. rolfsii* (254 bp).

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

3.6.4.1 Field screening of sesame against dry root rot under natural field conditions

Out of 4,095 accessions of sesame screened under natural condition, 53 accessions were reported as resistant (grade 3), 163 accessions as moderately resistant (grade 5), 241 accessions as susceptible (grade 7), whereas, 121 accessions were reported as highly susceptible (grade 9) (Fig. 3.8). The fungus isolated from typical dry root rot symptomatic plants was identified morphologically as *Rhizoctonia bataticola* (syn. *Macrophomina phasiolina*) and more than 40

isolates of *R. bataticola* representing different geographical locations were purified after routine isolation and maintained on PDA slants for diversity analysis.

Fig. 3.8. Field view showing characteristic symptoms on sesame plant under natural field conditions

3.6.4.2 Screening of sesame germplasm against phyllody disease caused by Phytoplasma

A total of 4,824 accessions of sesame germplasm have been evaluated against phytoplasma under field conditions. Association of phyllody with phytoplasma has been confirmed using nested PCR. A total of 2,552 accessions were found free from phyllody. 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. Along with 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 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 yellow mosaic disease

A total of 3,720 accessions of cowpea were screened against yellow mosaic disease under natural field conditions. A total of 2,718 accessions were found highly resistant and were free from symptoms. A total of 99 accessions

were found to be highly susceptible to yellow mosaic disease.

3.6.5.3 Screening of germplasm against *Bean common mosaic virus*

A total of 85 cowpea germplasm accessions were screened against BCMV in field conditions followed by artificial inoculation under controlled conditions along with susceptible check and resistant check. Electron microscopy, Direct Antigen Coating-Enzyme-linked Immunosorbent Assay (DAC-ELISA) and Reverse-transcription Polymerase Chain Reaction (RT-PCR) were used for confirming the presence/absence of BCMV. Electron microscopy (EM) revealed the flexuous rod viral particles of 725 nm in infected leaves. RT-PCR protocol has been standardized with newly designed three primer sets (BCMV1, BCMV2 and BCMV3. The amplified PCR products were sequenced and the PCR products showed 92.75%, 90.68% % and 92.5% nucleotide similarity with BCMV. The primer pair of BCMV 2 was selected for further use as the location of amplified region in the genome is matching with the coat protein geneof BCMV and 90.68% nucleotide similarity with BCMV as potyviruses are recommended to be detected targeting coat protein gene. The specificity of primer set BCMV 2 was validated *in silico* against the NCBI database and *in vivo* against infected plant positive controls of panel consisting potyviruses and are known to infect cowpea. No cross reactivity was observed during specificity tests against a panel that included BCMNV, BYMV, CABMV, SMV and PeMoV. The assay is sensitive, detecting as little as 0.14 ng/µl.

Among the 85 accessions screened for resistance to BCMV under natural field conditions and after artificial inoculation, 24 accessions were immune, 31 were highly resistant, 25 were resistant, five were moderately resistant to BCMV. Immune accessions did not show symptoms and no viral particles were observed in 24 accessions. DAC-ELISA and RT-PCR confirmed the absence of BCMV in 24 immune accessions. DAC-ELISA of embryo and seed coat of 85 accessions revealed that out of 24 immune accessions, four accessions *viz*., IC 16966, IC 201097, IC 338860 and IC 325928 showed presence of BCMV in seed coat. Therefore, these four accessions are also not immune. Hence, 20 accessions (IC199699, IC199701, IC202791, IC202814, IC202823, IC202837, IC202926, IC214751, IC249591, IC249593, IC257407, IC259072, IC259083, IC336763, IC336836, IC338832, IC353315, IC421900, IC433465 and IC433466) are immune to BCMV. Accessions from all the states/ union territories showed varied amount of resistance to BCMV.

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

PGR/DPQ-BUR-DEL-01.01 Detection and identification of fungi and bacteria in quarantine and supportive research **(SC Dubey,** Meena Shekhar (till June 30, 2020), Jameel Akhtar**,** Pardeep Kumar, Raj Kiran, Bharat Raj Meena (w.e.f. August 24, 2020), *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, T Boopathi (till August 6, 2020), *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 (**SP Singh,** Meena Shekhar (till June 30, 2020), Kavita Gupta, Jameel Akhtar, T Boopathi (till August 6, 2020), Bharat H. Gawade, Pardeep Kumar, Raj Kiran, Pooja Kumari, Bharat Raj Meena (w.e.f August 24, 2020), *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 **(Jameel Akhtar,** SC Dubey, V Celia Chalam, Meena Shekhar (till June 30, 2020), Kavita Gupta, MC Singh, SP Singh, Zakaullah Khan, T Boopathi (till August 6, 2020), Bharat H Gawade, Pardeep Kumar, Raj Kiran, Pooja Kumari, Bharat Raj Meena (w.e.f. August 24, 2020) Veena Gupta, Sushil Pandey, *AK Maurya, DS Meena, Smita LenkaI)*

4 DIVISION OF GERMPLASM EVALUATION

Summary: During 2020, a total of 25,980 accessions of various agri-horticultural crops were characterised/evaluated/regenerated/multiplied. Evaluation of different crops for their high yield potential helps in identification of high value germplasm resources which can aid in increasing the food production (SDG 2.3) and there by income of farmers, end poverty and increase the availability of food (SDG 1 and SDG 2). Wheat (1780 acc.), maize (302), barley corset (688 acc.), soybean (500 acc.), brassica (1293 acc.), sesame (4895 acc.), linseed (2634 acc.), pea (3054 acc.) wild lathyrus (20 acc.), ricebean (1872 acc.), cowpea (3720 acc.) and buckwheat (80 acc.) were raised for characterisation and evaluation for agronomic traits. Germplasm resources having tolerance to different abiotic and biotic stresses generate the resilience against vulnerable situations and aids in achieving SDG 1.5. A total of 940 accessions of different crops viz. brassica, urdbean, cowpea, maize, brinjal, chilli, and capsicum were evaluated for crop specific biotic stresses while a total of 593 accessions belonging to wheat, barley, and lentil were evaluated for abiotic stresses. Identification of germplasm resources in different food crops for nutritionally important traits such as protein and oil quality and their use can markedly improve nutritional status of population and aid in eliminating all forms of malnutrition (SDG 2.2). A total of 1991 accessions belonging to rice, maize, wheat, buckwheat, millets, horse gram, black gram, green gram, brassica, linseed, sesame, turmeric, ber, persimmon, vegetable amaranth, and *Bacopa monnieri* were evaluated for different nutrients and phytochemicals. Under CRP on Agro-biodiversity-PGR Component-II a total of 1618 accessions comprising wheat (812 acc.) okra (506 acc.) and chickpea (300 acc.) were evaluated at AICR centres/hotspots for quality traits, abiotic and biotic stresses. Germplasm Field Day on Linseed was organised at NBPGR farm, IARI on 25 February, 2020. A total of 8170 accessions of various crops were supplied to 79 indenters for use in crop improvement programmes.

4.1 Germplasm characterization

4.1.1 Characterization and evaluation of wheat and maize germplasm

A total of 1,780 wheat accessions comprising *T. aestivum* (361), *T. durum* (1574), *T. dicoccum* (312 acc.), *T. sphaerococcum* (35) were grown for characterization and evaluation at ICAR-NBPGR experimental farm, Issapur in Augmented Block Design using ten checks *viz.* HD-2967, WR-544, HD-3086, C-306, DWR-1006, UAS-415, UAS-428, DDK-1025, DDK-1029, HW-1093. There was good range of

Fig. 4.1. Erect plant type and spike variability in *T. sphaerococcum* germplasm

variability in the different species of wheat germplasm. *T. sphaerococcum,* known as Indian dwarf wheat was studied for morphological, biochemical and molecular characteristics. Good variability was observed for various morphological and quality parameters. *T. sphaerococcum* germplasm had mostly erect plant type, parallel spikes, scur type awns, dark green leaves, high protein content (>15%) and low sedimentation value (<48). Days to 75% spike emergence varied from 93-120 days, spike length from 4 - 13 cm and 100 grain weight from 26.05-45.55. Based on CAAT box- derived polymorphism (CBDP) markers, *T. sphaerococcum* accessions were grouped into three classes comprising 22, 9 and 4 genotypes (Fig. 4.2). During the *kharif* 2020 a total of 302 maize accessions were grown for characterization and evaluation purpose.

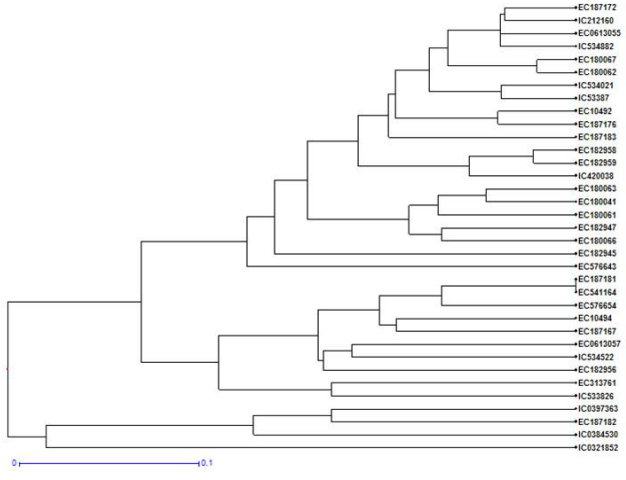


Fig. 4.2. Dendrogram showing genetic relationship among *T. sphaerococcum* accessions using CBDP markers

4.1.2 Validation of barley core set

Barley core set of 688 accessions was validated for agro-morphological and phenological traits for second consecutive year. The core set was developed based on data analysis of 7,400 accessions of barley germplasm using CoreHunter3 software [maximising both average entry-to-nearest-entry distance (EN) and average accession-to-nearest-entry distance

Fig. 4.3. Field view of Barley core set at Issapur farm, NBPGR

Fig. 4.4. Promising trait specific barley germplasm *viz.* two-rowed ear (a: IC0542206), early maturity (b: EC0578711), early spike emergence and early maturity (c: IC0138119).

(AN) with equal weightage (1:1)]. Trait specific promising accessions identified over the years 2016-2020 in barley are listed in Table 4.1.

4.1.3 Germplasm evaluation of soybean- a new initiative at ICAR-NBPGR, New Delhi

During *Kharif* 2020, characterization and evaluation of 500 soybean accessions (including 377 exotic collections from USDA-ARS, USA and 123 accessions of indigenous origin) was done. Appreciable genetic variability was observed for different agro-morphological traits (Table 4.2). Eight accessions showed high potential for the resistance against YMV resistance under Delhi conditions as none of these accessions was affected by YMV despite

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

Crop	Traits	Accessions
Triticum aestivum	Days to heading (< 86)	IC144915, IC118745, IC336751, IC335761
	Grains per spike (> 80)	EC0597859, IC547637, IC252653, IC539315, IC531862, IC 582706, IC401976, IC296727, IC252620, IC138601
	1000 grain weight (>58g)	IC335761, EC578152, IC539313, IC599622 IC539315
T. durum	Days to heading (< 89)	EC299155, IC542695, IC111805, IC128382, IC416329, IC47507, IC535208, IC535772, IC547663, IC335923
	Grains per spike (> 83)	IC445425, IC533698, EC426644, IC111820, EC276761, EC277170, EC444963, IC533699, EC276887, IC335620
	1000 grain weight (>58g)	IC335772, IC296483, EC299082, IC464099, IC543401, IC614989, IC277753, IC252569, IC138347, IC265313
T. dicoccum	Days to heading (< 98)	IC47548, IC28603, IC28604, IC534567, IC118763, EC006912, EC577904, IC534134, IC47035, IC47037
	Grains per spike (> 56)	IC47022B, IC535118, IC252504, IC113725, IC402020, IC535087, EC577410, EC11074, IC416358
	1000 grain weight (>52g)	IC28603, IC535086, EC578115, IC138896-A, IC112083, IC535094, EC011074, EC577398, IC47021, IC212164
T. sphaeroccum	Days to heading (< 96)	EC10494, EC10494, EC10492, IC53387, EC613057, EC187172
	Grains per spike (> 62)	IC384530, EC180067, IC420038, EC187182, EC182959
	1000 grain weight (>38g)	EC576654, ADP19/101, IC534882, EC187167, EC182947
Hordeum vulgare	Days to spike emergence (<70 days)	IC0138110, IC0138116, EC0578946, IC0137999, EC0578711, EC0362267, IC0138115, IC0073644, IC0073636
	Days to maturity (<125 days)	EC0408420, EC0667420, IC0138109, IC0138119, IC0138120, IC0138121, IC0617171, IC0533053, IC0073644
	Dwarf Plant height (<75 cm)	EC667491, IC0144824
	Spike length (>12 cm)	IC0533203, EC578292, IC0026558
	100-grain weight (>5.5 g)	IC0405269, IC0551372, EC0520242, IC0138120, IC0138111, IC0542197, IC0138066, IC0542196, IC303066
Maize	Days to 50% tasselling	IC624765, IC624766, IC624767, IC283431 (<43.00)
	ears/plant	KG/VK/SKT-50, KG/VK/SKT-146, KG/VK/SKT-222, EC568224, RSR/RB-19/14, KG/VK/SKT-120, KG/VK/SKT-148, KG/VK/SKT-151, IC253987, IC253990, IC260186, IC296393, IC625156, IC625161, RSR/NSP-55, RSR/NSP-64, RSR/NSP-18/5 (>2.00)
	Plant height (dwarf)	KG/VK/SKT-149, KG/VK/SKT-106, IC624767, RS/NSP-19, IC624766, IC130688(<99.00cm)
	Plant height (tall)	RSR/NSP-18/4, DPS/OPD-18/34, RSR/NSP-18/24, KC/5/1-66, RPH-43, EC477378, IC296393, IC625161(>211 cm)
	Ear length	RPH-72, IC254023, RPH-67, IC925090, IC568296, IC625141 (>15.07cm)
	Ear width	RSR/RB-19/56, KG/VK/SKT-120, RSR/RB-19/53, KG/VK/SKT-50, KG/VK/SKT-106, IC254010, EC477378, KG/VK/SKT-151, IC253975, IC254023, IC253990, AD-16/MISC/2, IC625161, RSR/NSP-64 (>3.80cm)
	Kernels/row	IC254023, IC283431, IC925090, IC625141, IC568296, RPH-67, RPH-99, RPH-83, RPH-102, IC625161, IC625599 (>29.00)

high disease pressure in field. Twenty-six lines were found to be early flowering types. Eleven accessions were devoid of pubescence on their pods that may serve as an important trait for the breeders and other stakeholders for table purpose i.e., salad and vegetable purposes. The crop samples of 13 accessions showing profuse podding and YMV resistance along with

Fig. 4.5. A field view of soybean crop

Fig. 4.6. Soybean variability for various morphological traits *viz.* profuse podding (A, B), single plant without any symptom of YMV(C), complete row with no symptom of YMV (D), variability in leaf (E) and pod shape and size (F), seed color variation in accessions (G)

different growth habit were also collected and deposited in NHCP (National Herbarium of Cultivated Crops) of ICAR-NBPGR, New Delhi.

4.1.4 Characterization and evaluation of *Brassica* germplasm

Total 1,293 accessions of brassica germplasm evaluated for agro-morphological traits during *Rabi* 2019-20. Validation of selected trait specific superior germplasm accessions of brassica based on data from two consecutive cropping years and at 3 locations (RS, Jodhpur, RBL CAU, Jhansi, SKNU, Jobner) was also done. In rapeseed mustard promising accession for different agro-morphological traits are listed in Table 4.2.

Fig. 4.7. Promising accessions of rapeseed mustard and *B. carinata* for important economic traits

Fig. 4.8. *Brassica carinata* accessions with short height and early flowering respectively

4.1.5 Characterization and evaluation of Sesame germplasm

Total 4,895 accessions of sesame were characterized at 5 different agro-climatic zones (ICAR-NBPGR, New Delhi; PAU, Ludhiana; PC Unit, Jabalpur; TNAU, RS, Vridhachalam; AU, Jodhpur) during 2020 and 696 accessions were validated for different agro-morphological traits.

Fig. 4.9. Promising germplasm of sesame for important economic traits

The promising accessions identified are listed table.

4.1.6 Characterization and preliminary evaluation of linseed (*Linum usitatissimum* L.) germplasm

Entire collection of linseed germplasm (2,634 accessions) conserved in National Gene Bank was sown for second consecutive year for characterization, evaluation and validation of agronomically important traits in an Augmented Block Design (ABD) at ICAR-NBPGR farm, IARI, New Delhi (Fig. 4.10). Broad variability was recorded in plant height, flower colour, flower shape, corolla aestivation, capsule size and seed colour. Coefficient of variation was high for the traits such as plant height, corolla size, number of primary branches/plant, number of capsules/plant and seed yield/plant. Entire linseed germplasm was categorized into different morphotypes: *Oil type* (2,416 acc. with bushy or semi-erect growth habit, more branching and plant height ranging between 40-70 cm), *Fibre type/dual purpose* (218 acc. with erect growth habit, less no. of primary branches and plant height ranging between 70-105 cm). Trait specific promising accessions identified in the year 2018-19 were validated at ICAR-NBPGR, New Delhi and RS-Akola during the year 2019-20 for the traits of economic importance mentioned in Table 4.2.

Fig. 4.10. Field view of linseed germplasm at NBPGR farm, IARI, New Delhi

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

Crop	Traits	Accessions
Rapeseed mustard	Dwarf type (<95 cm plant height)	IC422028 (65), IC343199 (71 cm), EC766127 (70.06), IC347947 (73.63), IC491641 (75.2), IC491251(89.33)
	Main shoot length (>95 cm)	IC266810 (125 cm), IC491068 (116cm), IC317528 (112cm), IC491196 (110 cm), EC765810 (104 cm), IC426385 (98 cm)
	Early maturing (<98days)	IC343199 (95), IC570302 (95) IC589691 (96), EC766320 (96), IC426386 (96), IC266266 (98), IC426394 (98)
	No. of silique on main branch (>81)	EC367885 (170.4), IC491077 (112), IC266810 (92), EC765810 (84)
	Seeds/siliqua (>30)	IC426322 (29), EC634284 (42), EC634281 (41), EC766136 (29)
B. carrinata	Short height	IC491745 (180 cm)
	Early flowering	IC 555891 (53 days after sowing)
Sesame	Early maturity	IC0430435, IC0430471, IC0281642, IC0598797, IC0598798
	Capsule/nod (6)	EC204373, IC131788, IC131788, IC205312, IC0204118
	No. of capsule/plant	IC500789 (195), IC232271 (194), IC23309 (157), IC500847 (153)
	Locule no./capsule (>15)	IC132042 (22), IC132182 (20), IC0201121(18), IC205064 (18), IC205015 (18), IC204639 (16), IC43144-1 (16); IC132182 (20), IC204639 (16)
	No. of seeds/capsule (>66)	IC41945 (96), IC500996 (66), IC500944 (66)
	Monoculm	IC0205632, IC20531
	Non shattering type	EC334978
	Stem & Capsule hairiness	IC279373, EC0376994, IC0140270
	Determinate type	EC370992, IC0430458, IC0500322

Crop	Traits	Accessions
Linseed	Days to 50% flowering (<60 days)	IC0096511, IC0096496, EC0012538, IC0267547, IC0096611, IC0096648, IC0118906, IC0096627, IC0096554
	Early maturity (<125 days)	IC0096490, IC0621688, IC0526058, IC0526102, IC0385333, IC0585314, IC0584773, IC0629090, IC0620658
	Tall plant height (>100 cm)	EC0718830, EC0718842, IC0526021, IC0526030, EC0718824, IC0499135, EC0041481, IC0526017
	Number of capsules/ plant (>400)	IC0498567, IC0498598, IC0053298, IC0385336, IC0498706; IC0267690, IC0498876
	Seed yield/plant (>15 g)	IC0498794, IC0498736, IC0385336, IC0498744, IC0498706, IC0053298, IC0498548, IC0499134
	Thousand seed weight (>10 g)	IC0096548, IC0585317, IC0585296, IC0525906, IC0096529, EC0041601-A, IC0054949, IC0499027
Soyabean	YMV resistance	EC1037917, IC993165, IC993174, IC993201, IC993229, EC1037845, EC1037827, IC993181
	Table purpose type	EC1037550, EC1037608, EC1037649, EC1037672, EC1037676, EC1037749, EC1037831, EC1037846, IC993184
	Pod profuseness	EC1037536, EC1037564, EC1037591, EC1037592, EC1037608, EC1037650, EC1037656, EC1037688, EC1037689

4.1.7 Characterization of pea germplasm

A total of 3,054 germplasm accessions (2,395 indigenous and 659 exotic) of pea characterized for agro-morphological descriptor traits at ICAR-NBPGR, Issapur farm, New Delhi during *Rabi* 2019-2020. 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 (Fig. 4.11). Promising accessions were selected for further validation.

Fig. 4.11. Highlights of phenotypic variability for morphological traits in pea

4.1.8 Characterization of wild species of *Lathyrus*

Twenty accessions of the genus *Lathyrus* comprising of *L. sativus*, *L. cicera*, *L. aphaca* and

Fig. 4.12. Pod variability of wild species of *Lathyrus* (Up to down: *L. aphaca*; *L. cicera*; *L. sativus* and *L. odoratus*)

L. odoratus were grown at ICAR-NBPGR experimental field, New Delhi during the crop season of 2019–2020 for characterization and agro-morphological evaluation. The results indicated a wide variation for qualitative and quantitative traits in studied *Lathyrus* accessions. Among the species, *L. aphaca* exhibited late maturing, and *L. odoratus* had early maturity. The average value of hundred seed weight was highest in *L. sativus* followed by *L. cicera* and *L. odoratus* while lowest value was recorded for *L. aphaca*.

4.1.9 Multi-flowering lentil germplasm with fascinated stem

A unique multi-flowering germplasm accession with fasciated stem, IC241473, in cultivated lentil (*Lens culinaris* Medik.), forming up to 16 flowers per peduncle at multiple flowering node was identified during characterization of entire lentil accessions of National genebank, ICAR-NBPGR, New Delhi (Fig. 4.13). The multi-flowering expression was validated over the years and locations. This unique and novel germplasm accession can be utilized for genetic studies to identify the locus regulating the multi-flowering trait in lentil and its association with environmental factors.

Fig. 4.13.

4.1.10 Characterization of ricebean germplasm for important agro-morphological traits

During the season *Kharif*, 2020 ricebean germplasm (1,872 acc.) was agro-morphologically characterized in augmented block design using four check varieties at ICAR-NBPGR, Issapur Farm, New Delhi. In this characterization traits such as hypocotyl colour, seed colour, days to 50% flowering, days to 80% maturity, terminal leaf length (cm), terminal leaf width (cm), no. of branched/plant, stem diameter (mm), pod length (cm) and 100 seed wt (g) were recorded. A good range of variability was observed for flowering, maturity, seed colour and seed weight. Some of the promising accessions for various traits are listed in Table 4.3.

Fig. 4.14. Partial field view of ricebean field at Issapur Farm, ICAR-NBPGR

4.1.11 Characterization, evaluation and documentation of vegetable, fruits and ornamental crops germplasm

Accessions IC356187, UHFP-90-2, IC317547 and EC598608 of pea were found early than the

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

Crop	Traits	Promising accessions
Pea	Early flowering	IC296119, IC276596, IC276597, IC276598, IC0209092, IC0255412, IC356187, IC317547, EC598608
	High number of seeds/ pod (>9)	EC0398595, IC0276603, EC0013055, EC0015322, EC0008532, EC0015299, EC598609, IC427145, EC395899, EC387624, EC269301, IC346094, P-2452
	Long pod	EC395899, IC427145, P-2452
	Multiflowers/ inflorescence	P-3300
	Higher number of pods/plant	EC269586, EC269578, EC257335
	100 seed weight (>50g)	IC415499, EC598574, EC387634
	Dark green pod	EC598856
	Edible pods & green peas	P-2452
	Powdery mildew resistance	IC411725, IC415499, IC566240, EC865919, EC269586
	Unique plant type with waxiness	IC0220286
	Unique seed morphotype with extended funiculus	EC0414478
	Erect at maturity	EC0865944, EC0865945, EC0865968, EC0865970, EC0865984, IC0220402
Ricebean	Stem diameter (cm)	IC350127 (14.3), IC342234 (13.7), IC342578 (12.4), IC342230 (12.2), IC564852 (12.2), IC564868 (12.1)
	Pod length (cm)	EC18565 (10), IC599886 (9.7), IC554726 (9.5), IC554725 (9.5)
	Seeds per pod	IC5.521048 (9.3), IC573512 (9), IC551706 (9), IC551659 (9)
Cowpea	Early flowering (<35 days)	EC723684, IC548860, IC353315, EC738126, EC723880
	Early Maturity, Erect type, upright podding	EC244108, EC244109, EC244116, EC517137
	High Protein content (27.5%)	EC170579-B
	100 seed weight (>28 g)	IC202779, IC202774, 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

check varieties (Arkel and Kashi Udaiy). Pea accessions EC269586, EC269578 and EC257335 were recorded with higher number of pods per plant, EC269301, EC387624, EC269301, IC346094 for number of seed /pod and IC415499, EC598574 and EC387634 for 100 seed weight (g). Pea accession P-5452 was found to bear dual purpose pods, of which the whole fresh pod can be used either as salad or in cooking and also the fresh shelled peas can be used as green peas. A total of 80 accessions of buckwheat were characterized and evaluated for important agro-morphological traits along with 4 check varieties (PRB-1, Himpriya, VL-7 and Shimla B-1) in augmented block design.

Table 4.4: List of promising accessions for important agro-morphological traits in vegetables, fruits and ornamental crops

Crop	Trait	Accession
Chilli	Earliness	EC772729, EC772772, EC772772-1
	>5 flowers per inflorescence	EC769386, EC769427, EC772705
	Paprika type	EC772739, EC7727297, EC692287
	Heat tolerance	EC772769
Buckwheat	Days to flowering	IC16552, IC37279, IC361131, IC361194
	Days to maturity	IC37279, IC 47929, IC16552, IC24300
	Plant height (cm)	IC26600, IC18045, IC329201, IC37279
	No of inflorescence/ plant	IC341664, IC361131, IC361194, IC49666
	Seed yield/plant (g)	IC341674, EC216635, EC323723, IC412837
	1000 seed weight (g)	EC216635, EC323723, IC341674, EC125940

4.2 Germplasm evaluation for biotic stresses

4.2.1 Screening of *Brassica* germplasm against white rust

Accessions *viz*. EC766164, EC766230 of *Brassica juncea*; IC20167 (*B. rapa*) and accessions *viz*. EC206641, EC206642, EC206651, IC341170, IC555891 of *B. carinata* showed complete resistant reaction at cotyledonary and true leaf stages against Delhi and Pantnagar isolates of white rust. While, IC508401, IC508406 and IC605224 of *Lepidium* sp. showed completely resistant reaction against Delhi isolate in field conditions. Accessions identified from preliminary screening were also validated against 10 isolates of *Albugo candida* collected from different states of the country at National Phytotron Facility, ICAR-IARI, New Delhi. EC206642 showed white rust resistance against 10 isolates, IC265495 and EC206641 against 8 isolates and EC766315 for 5 isolates.

4.2.2 Validation of tolerant germplasm in different *Brassica* species

In *B. juncea* EC766064, EC766061, EC766275, EC766136, EC766316, EC634291, IC261764 were found rust resistant, IC341164 in *B. chinensis* was found resistant to rust and *alternaria blight* and IC372259 and IC298022 were resistant to rust. In *B. juncea rugosa* IC369360 and IC399888 showed rust resistance.

4.2.3 Screening of urdbean germplasm against MYMV disease

A set of 295 urdbean germplasm accessions identified from preliminary screening was tested against *MYMV* disease in augumented block design at ICAR-NBPGR Experimental farm, New Area. Infector row cum susceptible checks of CO-5 and LBG 752 was planted in a regular interval of five rows for better pathogen spread. Disease severity was estimated by ratio of no. of leaves having disease symptoms and total number of leaves per plant. Three plants data per accessions was recorded. Promising accessions identified with no disease symptoms were IC530638, IC472032, IC519911, IC421981, IC471999, IC530460, IC519934, IC530625, IC519918, IC471975, IC530626.

4.2.4 Screening of cowpea against rot disease

Based on screening of diverse cowpea germplasm for rot resistance under natural conditions, a set of promising accessions (EC724153, EC724157, EC724160, EC738126, EC101970, EC724876 and EC724895) were identified. Selected accessions were validated at ICAR-NBPGR, New Delhi; RS-Jodhpur and UAS-Dharwad under artificial conditions.

Fig. 4.15. Response of cowpea accessions to artificial inoculation

Table 4.5: List of promising accessions for biotic stress resistance in vegetable crops

Crop	Accession	Trait
Chilli	EC769427, EC915026, EC769434, EC773729, EC771555, EC915030, EC772739, EC772732, EC920855, EC787119, EC894551, EC790590 (*C. tovari*), EC771556, EC773729, EC771550	Resistant to ChilLCD
	EC769427, EC769397, IC570408, EC915055, EC772732, IC-570408-1EC787126 (*Capsicum baccatum*) EC790590 (*C. tovari*)	Resistant to anthracnose
	EC772769	Heat tolerance
Pea	IC411725, IC415499, IC566240, EC865919, EC269586	Powdery mildew resistance

4.2.5 Screening of maize germplasm for resistance against maydis leaf blight

A total of 100 elite maize lines along with susceptible checks were evaluated at Delhi during *kharif* 2020 under artificially created epiphytotic conditions for identifying promising germplasm for resistance against maydis leaf blight (MLB) [*Cochliobolus heterostrophus* (Drechsler) Drechslerr]. Out of 100 lines, 25 lines (DML-1575, DML-1815, DML-1288, DML-1413, DML-1611, DML-1390, DML-1479, DML-1879, DML-1414, DML-1473-1, DML-196, DML-1837, DML-1352, DML-1545, DML-1851, DML-1278, DML-1909-1, DML-1897, DML-1634, DML-1117, DML-1828, DML-1834, DML-1835, DML-416, DML-212-1) were found resistant (Score dH 3.0 on 1-9 scale) to MLB.

4.2.6 Screening of brinjal germplasm against fruit and shoot borer

A total of 15 accessions of *Solanum incanum* were evaluated for brinjal fruit and shoot borer in two replications. The percent fruit infestations ranged from 6.6-14.5. A total of 8 accessions *viz*. IC531754-A, IC421594, IC541208-A, IC620612, IC531767-A, IC253957, IC253963-A, IC539833-A were found resistant (<10% fruit infestations) as compared check Pusa Purple Long (23.8%). Brinjal F_2 population of 4 F_1 crosses namely, Pusa Shyamla x IC253952, Pusa Shyamla x IC539855, PPL x IC253952, PPL x IC539855 were also evaluated for brinjal fruit and shoot borer.

4.2.7 Screening of chilli germplasm and its wild relative sagainst ChiLCD

A total of 250 accessions of chilli were evaluated and screened for agro-morphological characters and biotic stresses (Chilli Leaf Curl Disease) under natural epiphytotic conditions during *Kharif* 2020 at ICAR-NBPGR, IARI, New area farm. Accessions *viz*., EC769427, EC771556, EC771557, EC790579, EC772795, EC915026, EC769376, EC759958, EC769434, EC927383, EC769434, EC773729 and EC771555, EC915030 showed tolerant/resistant

reaction to Chilli leaf Curl Disease (ChiLCD) as no disease symptom was observed during 2020-21. Accessions EC769427, EC771556, EC771556-1, EC7905791, EC769377, EC772775 and EC771555 of *Capsicum annuum* and EC790590 of *C. tovari* were found completely free of ChiLCD infection under high disease pressure of naturally available whiteflies as the study location falls under hot spot area for ChiLCD for three consecutive years i.e., 2018, 2019 and 2020. Three accessions EC769427, EC773729 and EC771550 were found resistant to Chilli leaf curl disease under natural epiphytotic conditions at two locations i.e. New Delhi and Jobner (Jaipur). Accessions EC769427, EC771556-1, EC7905791, EC773729, EC771550. EC771555 and EC790590 were also found resistant even under challenge inoculation for virus strains of ToLCNDV (pre-dominant virus) done in collaboration with Division of Plant Pathology, ICAR-IARI, New Delhi.

Resistance reaction of EC769427 under challenge inoculation with the virus strains of ToLCNDV

Susceptible reaction of Pusa Jawala under challenge inoculation with the virus strains of ToLCNDV

Fig. 4.16. Host reaction of chilli accessions to TOLCNDY

4.2.8 *In vitro* screening of promising accessions of *Capsicum* spp. against anthracnose (*Colletotrichum capsici*)

In vitro screening of 60 promising accessions of *Capsicum* spp. against anthracnose (*Colletotrichum capsici*) was carried out under controlled environmental conditions using detached leaf inoculation technique at Division of Plant Quarantine, ICRA-NBGR, New Delhi. Preliminary phenotyping of accessions resulted in varying level of disease index whereas, no infection was observed in resistant accessions. Out of 60 accessions tested, eight accessions, namely EC787126 (*Capsicum baccatum*), EC769427, EC790590 (*C. tovari*), EC769397, IC570408, EC915055, EC772732 and IC570408-1 of (*Capsicum annuum*)were identified as resistant sources where no lesions were developed and only one accession IC570408-2 was recorded as moderately resistant.

4.3 Germplasm evaluation for abiotic stresses

4.3.1 Multi-location evaluation of wheat mini-core against drought stress under NICRA project

Under NICRA project, a set of diverse wheat panel of 224 accessions were grown for evaluation against drought stress at ICAR-NBPGR, Issapur, ICAR-NBPGR Regional Station, Jodhpur and JNKVV, Powarkheda in Augmented Block Design under normal sown and rainfed condition using checks HD-2967, C-306, Raj-3765, WR-544, HD-3086. Observations were recorded for twelve agro-morphological and physiological traits. Promising germplasm were identified under drought stress condition for traits namely, grain yield: IC252786, IC443766, IC290195, IC296383, EC578153, IC542076, IC266852, IC309875, IC554661, IC35715, IC335778 (>436.00); thousand grain weight: EC 249887, IC539313, IC28872, IC35715, IC290186, IC464099, IC282300, IC309879, EC578134, EC217835 (>55.51); Mean NDVI: IC531969, EC 11360, IC 535800, EC339611 (>0.67).

4.3.2 Evaluation of wheat germplasm for root architecture traits

A set of 140 wheat accessions, a mini-core subset was evaluated for root architectural traits

in collaboration with ICAR-National Institute of Plant Biotechnology under controlled condition as pot screening in growth chamber and under field condition. The wheat germplasm represented wide variability for root system architectural traits and shoot traits. Based on Principal Component Analysis, first three PC explained 57.07% of the variation. The maximum contribution for the PC1 came from variability in Root Shoot Dry Weight Ratio under field condition (RSDWR_F) and Shoot Dry Weight under controlled condition (SDW_C) followed by Total Root Size (TRS), Seminal Root Number (SRN) and Second Order Lateral Root Number (SOLRN). These traits were most influential to the phenotypic variations, and the traits contributing to PC2 were Root Dry Weight under Field Condition (RDW_F), Root Shoot Dry Weight Ratio under field condition (RSDWR_F), Specific Root Length under Field Condition (SRL_F), Average Diameter (AD), Shoot Length (SL_C), Lateral Root Density (LRD). Donors for multiple traits such as, EC426644 (for MRP, FOLRN, RLD, TRS, FOL, RSDWR and SOL); IC82425A (donor for SOLRN, LRS, RDW); IC128151(C306) (for MRP, FOLRN, LRD) andIC446633 (donor for NRA, RDW, SDW, RSDWR) are recommended as parental lines for improvement of respective RSA traits in wheat breeding.

4.3.3 Evaluation of barley germplasm for salt stress tolerance

A diverse set of 112 barley accessions including barley mini-core was screened under optimum as well as 200 mM NaCl for evaluation of salt stress tolerance at seedling stage traits based on the traits such as germination, coleoptile length, biomass and root system architecture. Based on PCA, all the 112 barley accessions could be categorized into five major groups, with group I being, in general, high salt tolerant, group II being salt tolerant, group III being slightly-medium salt tolerant (moderate), group IV being salt sensitive and group V being highly salt sensitive. Accessions EC0105938, EC0578267, IC0074279, IC0542151, EC0578761, IC0533057, IC0113056, IC0445798, EC0578289 were identified as high salt tolerant. A panel of 28 accessions consisting of high salt tolerant, moderate and susceptible was constituted for pot evaluation. This panel of 28 accessions was evaluated for salt stress in pot house using physiological traits (RWC, MSI, Chlorophyll fluorescence, chlorophyll concentration index, canopy temperature, Na^+/K^+ uptake) along with yield and its attributes. Selected accessions from this set will be used for sequence variation analysis to identify potential SNP haplotypes of abiotic stress responsive genes associated with salt tolerance in barley.

4.3.4 Evaluation of lentil germplasm for drought tolerance

A set of 117 lentil lines along with two checks (FLIP-96-51 and JL3) was screened for the study of Root Sytem Architecture (RSA) in lentil at seedling stage with respect to drought tolerance. A pot experiment at 25% field capacity and 80% field capacity was carried out in completely randomized design. Experiment was conducted twice independently. All the samples were exposed to drought for three weeks. Seedling survival (SS) along with the biomass (BM) was recorded. Total Root Length (TRL), Root Volume (RV), Total Project Area (TPA), Total Surface Area (TSA) and Root Diameter (AVD) were recorded in all the samples. All the root traits showed genotype dependent variation, while, growth and survival noticed reduction in all the genotypes in response to stress. Mean TRL reduced under stress by 54.6 % among lentil lines compared to controls. Mean TPA reduced by 70.1 %, while TSA decreased by 64.56 % in studied accessions under stress. AVD increased in 18.48 % genotypes, while 9.24 % lines showed no significant change. RV decreased by 69.85 % in stress condition compared to non-stress. SS

ranged 20% to 100% among lentil genotypes in response to water stress. BM reduced remarkably under stress and mean reduction was 50 % among different lines. STI based on SS ranged from 0.19 - 1.0, while, STI based on dry weight, it ranged in between 0.09-1.00. Drought tolerant check FLIP-96-51 had STI (SS) 0.93 and STI (DW) 0.80, while STI (SS) and STI(DW) was 0.41 and 0.40, respectively. Based on both the index, 11 genotypes (IC559647, IC560032, IC560337, IC560051, IC560246, IC559769, IC559757, IC559744, IC559713, IC559696 and IC835822 were studied further for reproductive stage drought (Fig. 4.17).

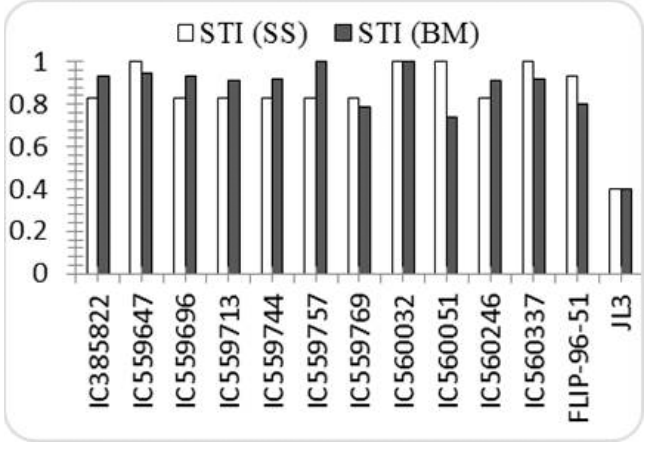


Fig. 4.17. Stress tolerance index (STI) based on seedling survival (SS) and biomass (BM) of drought tolerant lentil lines at seedling stage

Based on the above mentioned experiment, selected lentil lines were exposed to drought stress at the onset of flowering to study drought tolerance under terminal drought. Biomass and seed yield (SY) plant^{-1} was recorded at maturity. STI based on SY varied from 0.46 to 0.89 among lentil genotypes (Fig. 4.18). IC559744, IC560032, IC560051 and IC560246 had STI > 0.75 and were identified as drought tolerant, while IC385822, IC559647, IC559713, IC559757 and IC559769 were moderately tolerant to stress (0.75 > STI >0.50).

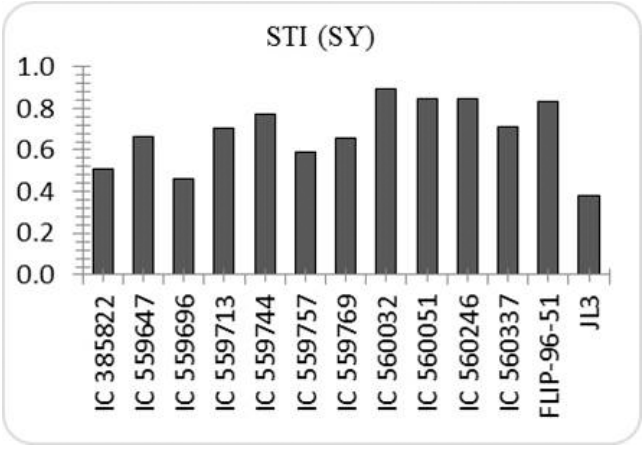


Fig. 14.18. Stress tolerance index (STI) based on seed yield plant^{-1} under terminal drought in lentil

4.4 Evaluation of germplasm for various biochemical parameters

Germplasm of different crops viz. rice (148 acc), maize (200 acc) wheat (100 acc), buckwheat (20 acc), millets (30 acc), horse gram (67 acc), black gram (136 acc), green gram (135 acc), brassica (100 acc), linseed (301 acc), sesame (180 acc), turmeric (236 acc), ber (34 acc), Persimmon (10 acc), vegetable amaranth (37 acc), *Fagopyrum* spp (152 acc) and *Bacopa monnieri* (30 acc) were evaluated for different nutrients and phytochemicals. Validation of trait-specific superior accessions was done for 62 accessions of linseed for oil content for third year (2019-20), eight accessions of wheat and five accessions of maize were validated for protein content.

4.4.1 Quality analysis of *Bacopa monnieri* germplasm

Bacopa monnieri commonly known as "Brahmi" has been used in Ayurvedic medicines for improving intelligence and memory. These pharmacological effects are attributed to presence of biologically active secondary metabolites bacosides. Germplasm of *Bacopa monnieri* (30 accessions) collected from different

Table 4.6: Details of germplasm analysed of various crops and superior accessions identified

Crop (Acc.)	Traits	Range	Average ±Stdev	Superior Acc.
Unpolished rice (48)	Protein (%)	8.38-10.5	9.21 ± 0.47	IC631733, 631730>9.5%
	Amylose (%)	8.35-23.6	19.3± 4.72	IC631733>23%
	Starch (%)	74.5-78.5	76.7 ±0.875	IC631735 <75%
	Phenols (%)	0.40-0.794	0.584 ± 0.08	IC631730 >0.75%
	Oil (%)	4.47-6.25	5.57 ± 0.33	IC631725, IC631736 >6%
Polished rice (100)	Amylose (%)	4.89-28.2	20.8± 5.32	IC7003, IC7128 < 8%IC007176, IC7373>28%
Horse gram (67)	Ash (%)	2.29-4.51	3.53 ± 0.432	IC22772, IC201115, IC22795>4%
	Protein (%)	20.9-26.7	23.9 ± 0.947	IC23482, IC256885, IC139512>26%
	Sugar (%)	0.859-5.95	3.31 ± 0.881	IC15735, IC426452>5%
	Phytate (%)	0.283-2.12	1.01 ± 0.445‘	IC19431<0.3%
	Phenols (% GAE)	0.338-0.846	0.561 ± 0.114	IC-89016, IC501564>0.8%
	FRAP (mg/100g GAE)	38.4-120	80.0 ±19.1	IC-625403, IC-426522, IC-501564> 115
Black gram(136)	Ash (%)	1.36-4.88	3.29 ± 0.628	IC419987, IC0423102, IC417775, IC321148>4%
	Protein (%)	23.3-28.0	26.2 ± 0.963	IC397859, IC0330874, IC331705, IC841031>27.8 %
	Sugar (%)	1.70-7.21	3.64 ± 1.28	IC548280, IC417775, IC485428, IC449270>6.5%
	Starch (%)	20.7-47.2	36.1 ± 4.32	IC436765, IC485420>45%
	Phenols (% GAE)	0.157-0.692	0.309 ± 0.074	IC485645, IC268228>0.5%
	FRAP (mg/100g GAE)	28.4-107	66.7 ± 20.5	IC248343, IC275909, IC369132>100
Green gram (135)	Ash (%)	2.45-4.04	3.39 ± 0.326	IC296113, PLM13, IC436735>4%
	Protein (%)	15.7-27.3	24.8 ± 2.05	IC354429, PLM524, IC565293, EC396396>27%
	Sugar (%)	2.18-6.55	3.48 ± 1.01	IC42102, IC148418, IC39552, IC39350>5.5%
	Starch (%)	35.6-42.9	39.2 ± 1.77	EC251768, EC251555, IC148396>42%
	Phenols (% GAE)	0.23-.378	0.290 ± 0.03	IC472057, IC39350, EC251555>0.35%
	FRAP (mg/100g GAE)	56.3-128	71.9 ± 11.2	IC39350, IC148402, IC447796, IC52079, EC 251808>80
Linseed (301)	Oil %	33.5-48.7	40.7±3.07	IC267690, IC510927, IC510930, EC718826, EC718826, EC718829, IC267673>47%
	Protein %	9.15-24.5	20.7±1.45	IC054983, EC718826, EC718834, EC718830, EC718847, EC718845, EC718829>23.5
Sesame (180)	Oil %	35.9-55.9	46.9±6.38	EC346656, EC346824, IC372575, IC43178-1, IC42999 >54.5%
	Protein %	12.6-27.2	22.4±2.36	EC346255, EC346419, EC346572, EC37064, IC383334, EC346683,EC891108 e”26%
Maize (200)	Oil %	1.7-8.58	5.08±1.45	IC77261, IC128762, IC550365, IC254039, IC283431, IC447215, IC526430, IC77124, IC315920>6.7%
	Protein %	7.66-18.5	12.1±1.78	IC77181, IC128792, IC109642, IC130762, IC562879, IC253986 >15.5%
	Sugar (%)	0.89-2.27	1.38±0.31	IC77126, IC538074, IC469894, IC128788, IC188792 >2%
	Test weight (gm)	7.41-35.3	19.9±4.9	IC254037, IC625178, IC627708, IC625597, IC625598 >28
	Specific gravity (g/cm^3)	0.5-3	1.78±0.41	IC556415, IC556396,IC253999, IC254003, IC254038, IC391315 >2

Crop (Acc.)	Traits	Range	Average ±Stdev	Superior Acc.
Turmeric (236)	Total Curcumin (%)	3.75-8.91	6.06 ± 1.10	IC22527, IC628732, IC628699 >8.5%
Ber fruits (34)	Edible (%)	71.1-100	88.9 ± 6.42	IC0625849, IC0625864 100%
	Ash (%)	0.22-1.56	0.70 ± 0.316	IC0625869, IC0625849 >1.5%
	Protein (%)	0.64-4.05	1.16 ± 0.743	IC0625849, IC0625864 >3.5%
	Sugar (%)	0.80-6.05	2.24 ± 1.07	IC0625852, IC0625873, IC0625863, IC0625855>4%
	Ascorbic acid (mg/100g)	27.0-138	80.8 ± 24.9	IC0625849, IC0625872, IC0625864>120
	Phenols (mg/100g GAE)	6.4 - 186	43.1 ± 48.4	IC0625864, IC0625849, IC0625869>160
	FRAP (mg/100g GAE)	22.1 - 387	97.9 ± 98	IC0625849, IC0625864, IC0625848>360
Persimmon fruit (11)	Moisture (%)	67.8-92.1	79.0 ± 6.06	
	Sugar (%)	0.901-12.3	7.17 ± 3.71	IC555292, EC452161>10%
	Ascorbic acid (mg/100g)	3.35-83.8	36.1 ± 27.7	IC349965, IC555292
	Total carotenoid(µg/g)	0.211-16.6	3.85 ± 6.11	IC349965 >15 µg/g
	Total Phenols (mg/100g GAE)	0.294-6.71	2.41 ± 2.04	EC552664, IC349965>6
	FRAP (mg/100g GAE)	0.082-15.5	5.34 ± 5.42	IC349965, EC552664>12
Vegetable Amaranth (37)	Oxalate (mg/100g) incooked leaves	2916-4455	3883	IC536649, IC469545, IC541407 < 3500
B. juncea (100 acc)	Oil content (%)	35.5-43.1%	39.1 ± 2.22	IC491161, IC426341, IC491358, IC491017, IC261709 > 42 check Rajat (40.2%), Luxmi (39.0%)
Validation of high oil linseed (62 acc)	Oil content (%)	38-44.3%	41.9± 1.25	EC0041735, IC0096488, EC0000538, IC0420772, IC0096494, IC0096514, IC0525904, IC0449071, IC0526058, IC0096704, IC0525953 >43 checks Kartika (41.79%), T397 (40.07%)
Maize (45 accessions)	Oil content (%)	2.23-5.22%	4.50 ± 0.51	IC624152, IC624171, IC624149, IC624159 >4.9 check HM-4 (3.5%)
Wheat (100 accessions)	Protein content (%)	7.58-14.9 %	12.6 ± 1.73	EC574390, IC252568, IC335732, EC463434, IC335712, IC252543, IC416089, IC28649, IC584159, IC252472, IC252509, IC138617, IC335761, IC539574>14.5%
Validation of high protein wheat	Protein content (%)	14.1-16.5%	15.5 ±0.85	IC296727, IC547637, EC217715, EC217659, EC217883, EC405359, EC473090 >14.5%
Validation of high protein maize	Protein content (%)	10.8-11.4	11.9 ±1.00	IC405278, IC624146, IC624151, IC624167 > 11%
Buckwheat (20 acc)	Resistant starch range (g/100g)	1.2-3.19	2.23 ± 0.53	IC329593, IC202226, IC313468>2.8%
Foxtail millet (10 acc)	Resistant starch range (g/100g)	0.24-0.90	0.63 ± 0.20	IC007863, IC007336, IC001337>0.8%
Barnyard millet (10 acc.)	Resistant starch range (g/100g)	0.32-1.6	0.95 ± 0.39	IC547313, IC547321 >1.35%
Prosomillet (10 acc)	Resistant starch range (g/100g)	1.01-1.44	1.16 ± 0.14	EC024124, EC24113 >1.35%

geographical regions from ten different states of India was evaluated for biochemical traits of total phenol content (7.90 -25.65 mg GAE/g); flavonoid (20.68 - 65.72 mg/g) and bacoside content (0.72 ± 0.07% to 3.36 ±0.02%). Promising accessions having high bacoside content were identified as IC554588, IC554586, IC353204 and IC342108.

4.4.2 Quality evaluation of *Fagopyrum* germplasm

152 accessions of *Fagopyrum* species germplasm consisting of *F. tataricum*, *F. esculentum* and *F. cymosum* were evaluated for biochemical quality traits: moisture content (6.98-11.34%); fat content (1.10- 3.68%); phenol content (5.78- 25.54 mg GAE /g); total flavonoid content (1.19- 4.39%); amylose content (10.32 -20.0 %); rutin content (0.01-2.88%) in seeds on dry weight basis. Maximum rutin content was found in *F. tataricum* germplasm seeds and promising accessions with high rutin content (> 2 %) were EC104036, EC278738, EC18173, IC14889, IC26583, EC18629 and IC42423.

4.4.3 Method development

NIRS based prediction model was developed for predicting protein, starch and beta-glucan content of barely. Coefficient of determination (R^2) of >0.7 and ratio of performance deviation (RPD) > 2 was obtained for all traits in model validation. Paired t-test of laboratory vs predicted value gave *p* value of >0.8, which signifies that the differences between the two values are not significant.

4.5 Interspecific hybridization for genetic base enhancement

4.5.1 Wide hybridization in Brassica

Crossing was done between previously identified rust resistant accession of *B. carrinata* and one of the *Brassica napus* variety GSL1 to

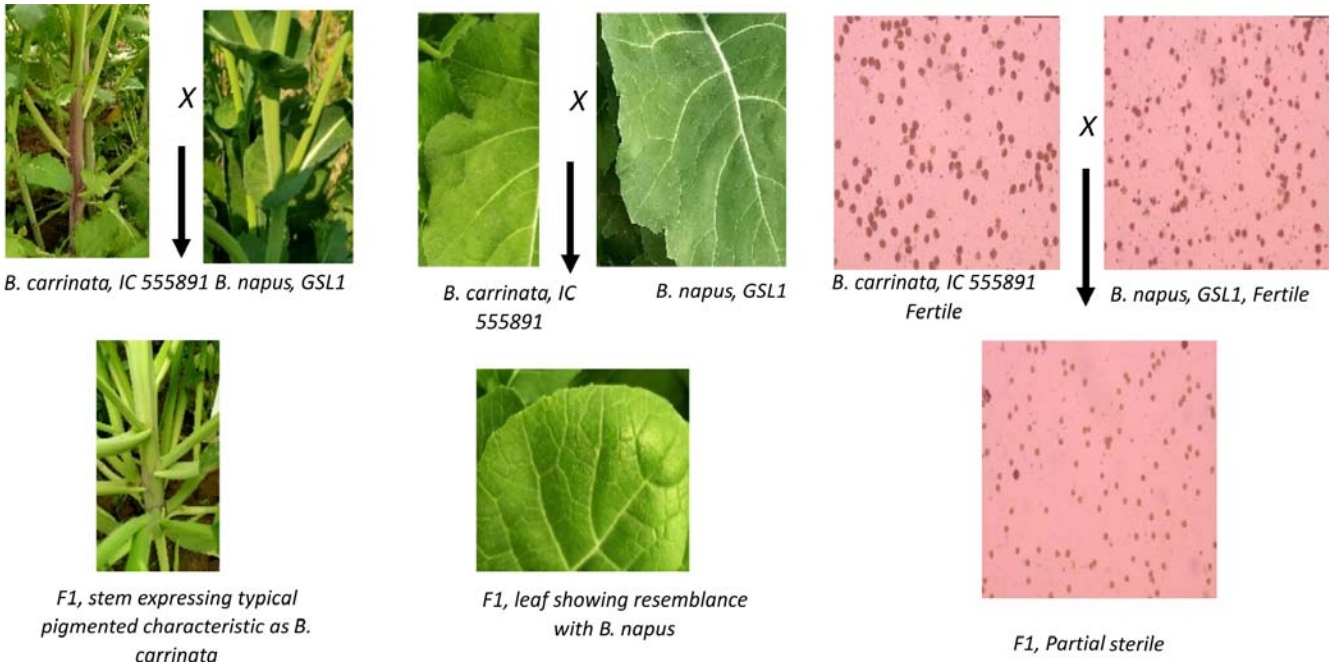


Fig. 4.19. Interspecific hybridization between Brassica carrinata and Brassica napus

generate genetic variability. The hybrids were rust resistant under field conditions and showed morphological characters that were intermediate between the two parents (Fig. 4.19). The F1 hybrid also showed partial sterility.

4.5.2 Wide hybridization in linseed

Augmentation of different wild linseed species viz. *Linum grandiflorum*, *Linumbienne, Linum lewisii* and *Linum perenne* was done (Fig. 4.20).

Fig. 4.20. Various wild linseed species

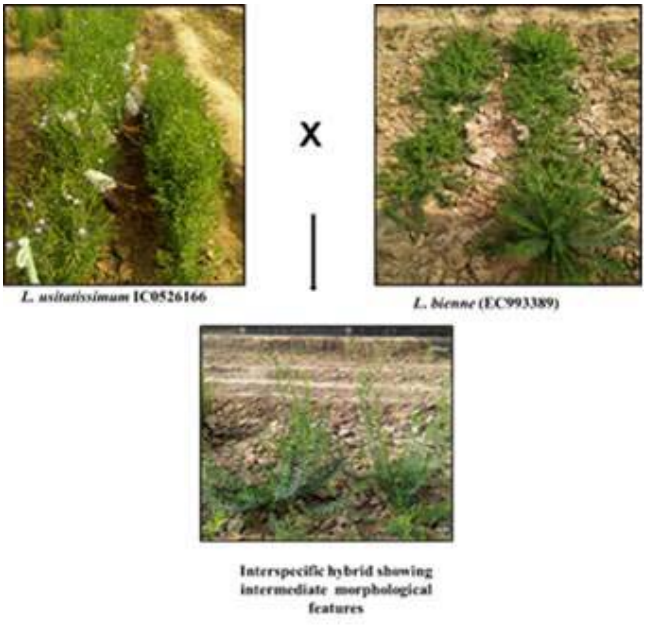


Fig. 4.21.

Interspecific hybridization with wild linseed species viz., *L. grandiflorum* and *L. bienne* was attempted to assess the crossability. Embryo rescue was done at different days after pollination and varying growth responses are being observed in the interspecific hybrids thus obtained. Interspecific hybrid between *Linum usitatissimum* and its wild relative *Linum bienne* could successfully be grown in the field conditions and is showing intermediate morphological features between the two parents (Fig. 4.21).

4.5.3 Interspecific hybridization in chilli

Interspecific hybridization is widely used for creating new germplasm and expanding genetic diversity in pepper. However, successful interspecific crosses were limited in most cases, due to cross incompatibility. To know the cross compatibility and introgress resistance genes for biotic stresses such as ChiLCD, anthracnose and agro-morphological traits like earliness, various interspecific crosses were attempted between *C. chacoense*, C. *frutescence* and *C. chinense*, *C. baccatum* var. *pendulum*, *Capsicum annuum*, *C. baccatum*, and *C. tovari*, respectively (Fig. 4.22). Successful interspecific crosses were obtained between *C. chacoense* (EC790579) x *C. baccatum* var. *pendulum* (EC772791), *C. chinense* (EC787141) x *C. annuum* (EC771555), *C. frutescence* (EC787119) x *C. annuum* (EC771555), *C. chinense* (EC787141) x C. *frutescence* (EC787119), *C. chinense* (EC787141) x *C. tovari* (EC790590), *C. tovari* (EC790590) x *C. annuum* (Kashi Anmol), *C. annuum* (Kashi Anmol) x *C. tovari* (EC790590), respectively.

Interspecific F_1 cross combination *C. tovari* (EC79059) x *C. annuum* (Kashi Anmol) had produced desirable erect plant type with profuse branching, flowering, small size green and highly pungent fruits and revealed resistance to ChiLCD. Whereas, interspecific F_1 cross combination between *C. chinense* (EC787141) x

Fig. 4.22. F_1 plants of interspecific cross combinations between *C. tovari* (EC790590) x *C. annuum* (Kashi Anmol) and *C. chinense* (EC787141) x *C. frutescence* (EC787119)

C. frutescence (EC787119) was found high yielding with medium size highly pungent fruits and also showed resistance to ChiLCD.

4.6 Achievements during *Rabi* 2019-20 under CRP-Agrobiodiversity

4.6.1 Evaluation of wheat germplasm

A total of 812 wheat accessions were evaluated during *Rabi* 2019-20 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 (522 acc.) from ICAR-NBPGR, Delhi was carried out at IIWBR, Karnal for protein content and sedimentation value. In addition, 12 high protein lines were evaluated for protein content, sedimentation value, grain hardness, iron and zinc. Identified promising accessions are given in Table 4.7.

4.6.2 Evaluation of okra germplasm against Okra yellow vein mosaic and okra enation leaf curl diseases

A total of 506 accessions of okra germplasm and 88 accessions of *Abelmoschus moschatus* ssp *moschatus* were evaluated at IIVR, Varanasi; PAU, Ludhiana and ICAR-NBPGR, New Delhi for Okra yellow vein mosaic and okra enation leaf curl diseases. Four accessions of okra *A moschatus* ssp *moschatus viz*. EC360794, EC360586, EC361171, EC360830 were found highly resistant to Okra yellow vein mosaic disease and resistant to okra enation leaf curl disease, leaf hopper and white fly.

4.6.3 Evaluation of chickpea germplasm for biotic and abiotic stress

300 accessions of chickpea selected from previous field screenings were evaluated against ascochyta blight, botrytis grey mold, fusarium wilt, dry root rot and drought for validation. The screening was done in hotspot locations/artificial

Table 4.7: Promising/validated accessions identified for various traits

Traits	Locations	Promising accessions
Wheat		
Karnal bunt	PAU, Ludhiana IIWBR, Karnnal	IC574388, IC240801, IC531862, IC111787, IC532019, IC531062, IC539317, EC414149, EC76005, EC578152, EC573974, IC443766, EC178071-691, IC252794, IC402042, IC252954, IC530077, IC539314, IC531524, IC542051, IC375938, IC543373 (based on 2018-19 and 2019-20)
Powdery Mildew	IARI-RS, Wellington &CSKHPKV, Palampur	IC0381124, IC0427157, IC0393915, IC0355870, IC0047939, IC0398115, IC0079012, IC0329445, IC0598656, IC0316103, IC0382658, IC0553123, IC0553111, IC0589278, IC0107378 (Score=0)IInd year- ECO612495, ECO675842, ECO582301, ECO598378, ECO98264, IC252928, IC542645 (Resistance at seedling as well as adult stage)
Loose smut	VPKAS, Almora	EC 463396, EC 576941, IC 531062, IC 535257, IC 533610, EC 609338, EC 575981, IC 401925, IC 252928, EC 414149, EC 577595, IC 375938, IC 531524, IC 383670, EC 6903, IC 252419, IC 534949, IC 75208, IC 335998, EC 575971
Spot blotch	BHU, Varanasi	IC0397821, IC0279880, IC0279885, IC0328890, IC0467773, IC0467775, IC0467776, IC0467777, IC0467781, IC0467786, IC0336647, IC0582720, IC0319811, IC0329348, IC0398278, IC0345690 (DD Score at 3 stages <13)
Salinity tolerance	CSSRI, Karnal	Validated entries (Two years): IC0445425, IC0128150, IC0531524, IC0542051, IC0128280 EC339611, EC6903, IC0075221, IC0346064, IC-0138909-B, EC0597864, EC0595177, EC0582359, EC0595181, EC0595260Validated entries (Three years): IC303067, IC443633, IC527448 and IC35163
Quality traits	IIWBR, Karnal	EC0598211, EC0595283, EC0529969, EC0530161, EC0530162, EC0529878, EC0520980, EC0530041, EC0613051, EC0598295, EC0529942 (>16%)
Protein content		Validated entries (Four years): IC296727, IC547637, IC112060 (>15%)
Sedimentation value	IIWBR, Karnal	EC0635808, EC0595303, EC0597897, EC0595274, EC0520960, EC0520981, EC0520985, EC0529932, EC0529933, EC0529934, EC0529951, EC0529960, EC0529943 (>70)
Chickpea		
Drought tolerance	RARI, Durgapura	IC244324 (ave. root length 32.2 cm, root weight 4.75 g, yield/plant 26.5 g)
Dry root rot	RARI, Durgapura	IC255447, IC299163, IC275775, IC276272, IC272642, IC244651, IC244371, IC24484, IC244241-1, IC486999, IC486965, IC468853, IC408259, IC83959, IC269439, IC305593, IC512067, IC56780, IC209235, IC244324, IC486895, IC305498, EC442006, IC41651, IC487344, IC32767654, IC487243, IC486999 (less than 10% mortality)
Ascochyta blight	PAU, Ludhiana	IC275447, EC267301, IC248147 (disease severity score = 3), IC297322 (disease severity score = 4), resistant check PB-5 (disease severity score = 4)
Botrytis grey mold	PAU, Ludhiana	IC209231, IC468782, IC209237 (ave. disease severity score of 6.5)
Fusarium wilt (race 3)	JNKVV, Jabalpur	EC24608, IC487464, EC555508, EC442698, IC298990, IC486922, IC272642m EC555589, EC267285 (Plant mortality % <10)
Fusarium wilt (race 2)	IIPR, Kanpur	IC244324 (Plant mortality % <10) IC275775, IC468839, IC269439, IC275448 (Plant mortality % <20)
Collar rot resistance	(JNKVV, Jabalpur)	IC486922, IC487243, EC538501, IC209236, EC382350, IC244245, ICC4520, ICC5949, IC552250, ICC6025, ICC3234 (Plant mortality % <10)

field sick plots of these pathogens. The locations were PAU, Ludhiana (Ascochyta blight & Botrytis Grey Mold), ICAR-IIPR, Kanpur (*Fusarium* wilt), JNKVV, Jabalpur (*Fusarium* wilt), dry root rot and drought (RARI, Durgapura) (Fig. 4.23). Promising accessions identified for these traits are listed in Table 4.7.

Fig. 4.23. Field view of drought screening plot at RARI, Durgapura

4.7 Germplasm supply and seed multiplication

4.7.1 Germplasm supply

During 2020, a total of 8,170 accesssions of various crops, *viz*. wheat (2,049), brassica (1,327), linseed (2,962), sesame (580), pulses (978), barley (119), brinjal (39), okra (30) and bottle gourd (86) were supplied to 79 indenters belonging to ICAR institutes, SAUs and other research organisations engaged in crop improvement programmes.

4.7.2 Seed multiplication

- A total of 500 accessions of barley were multiplied and conserved under medium term storage facility of national gene bank.
- 2,612 accessions of linseed germplasm were multiplied through single plant seed from previous year and conserved in medium term storage.
- Seed multiplication of trait specific mungbean germplasm viz. IC39582, LGG460, Sona mung, Chait mung, IC148537, IC121220, IC546274, IC118998, IC548275 and IC39352 was done for distribution.

Research Programme (Code: Title, **Programme Leader**)
PGR/GEV-BUR-DEL-01.00 Characterization, evaluation and documentation of genetic resources of agri-horticultural crops (**Ashok Kumar**)
Research Projects (Code: Title, **PI**, Co-PIs and *Associates*)
PGR/GEV-BUR-DEL-01.01 Characterization, evaluation and documentation of wheat, barley and triticale germplasm (**Jyoti Kumari**, Sandeep Kumar, Sundeep Kumar, Vikender Kaur, Ruchi Bansal, SK Kaushik and Pardeep Kumar and *YS Rathi*)
PGR/GEV-BUR-DEL-01.02 Characterization, evaluation and documentation of maize germplasm (**Ashok Kumar**, Jyoti Kumari, Vinay Mahajan, Ishwar Singh, K S Hooda and *RK Sharma*)
PGR/GEV-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 (up to 31.03.2020) and *Babu Ram*)
PGR/GEV-BUR-DEL-01.04 Characterization, evaluation, and documentation of oilseeds germplasm (**Rashmi Yadav**, Sandeep Kumar, RK Gautam, Vijay Singh Meena, Vikender Kaur, Mamta Singh, Jameel Akhtar, Sapna and *BL Meena*)
PGR/GEV-BUR-DEL-01.05 Characterization, evaluation and documentation of vegetable and ornamental crop germplasm (**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/GEV-BUR-DEL-01.06 Biochemical evaluation of field and vegetable crops germplasm (Rakesh Bhardwaj, Sandeep Kumar, Manjusha Verma, Vijay Singh Meena, Sapna, Nand Lal Meena)
PGR/GEV-BUR-DEL-01.07 Characterization and evaluation of medicinal and aromatic plants germplasm (**Archana P Raina,** Ashok Kumar, Ishwar Singh, KP Mahapatra (w.e.f. 06.01.2020), Rakesh Singh, RC Misra (w.e.f. 05.08.2020) and *BS Panwar*)
PGR/GEV-BUR-DEL-01.09 Evaluation for abiotic tolerance in field crops germplasm stress (**Ruchi Bansal**, Vikender Kaur, Jyoti Kumari, Rashmi Yadav, Gayacharan, Kuldeep Tripathi, Mamta Singh, MC Yadav and Nand Lal Meena)
PGR/GEV-BUR-DEL-01.10 Characterization of wild species and pre-breeding in selected crops (**Vinod Kumar,** 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/GEV-BUR-DEL-01.11 Characterization, evaluation and documentation of underutilized crops germplasm (**SK Kaushik**, KK Gangopadhyay, Ishwar Singh, Sandeep Kumar, Rahul Chandora, Mohar Singh, SB Choudhary, Mamta Arya, Vartika Srivastava and Anuradha Agrawal)
PGR/GEV-BUR-DEL-01.12 Application of statistical techniques in management of information on plant genetic resources (Hanuman Lal **Raiger**)

5 DIVISION OF GENOMIC RESOURCES

Summary: The mandated activity of DNA fingerprinting service for requirement for CVRC were carried out for one hundred and two (102) samples of 19 agri-horticultural crops. Novel Simple Sequence Repeat markers were developed in cardamomum (250,571) and ridged gourd (2593) through low coverage whole genome sequencing. Genetic diversity studies in cowpea germplasm from konkan area and 2496 sesame accession were carried out using SSR markers and 45 diverse pigeonpea genotype using SNPs. Total 2893 accessions of Grain Amaranth were purified through selfing for core development using SNPs. SEM studies have been carried out to distinguish the two species of Sesamum viz. *Sesamum indicum* and *S. malabaricum* using seed surface characteristics. Screening for robust root system in Indian mustard under saline condition in control environment were carried out. Allele mining for PSTOL1 locus and screening of rice landraces at low phosphorus plot were carried out. Genome wide association study (GWAS) conducted using 68925 SNPs identified through GBS approach has helped identify 15 and 6 SNPs associated with flowering time (days to 5%, 50% and 95% flowering) and physiological maturity trait, respectively. GWAS was performed on an association panel of 135 diverse wheat genotypes and found of 42 reliable QTNs for 10 salt tolerance associated traits using SNPs. Transcriptome sequencing of developing grains of two rice bean accessions (bold pod and small pod) at different time intervals (i.e., 4 days and 7 days) was done. RNAseq analyses to identify 15 miR genes and its targets responsible for the innate nature of horsegram in drought tolerance were carried out. Through transcriptome studies in rice, the upregulation of *cpPdc* gene in rice leaves provide opportunity to develop C_2 rice that could help bypass photorespiration. Resolved identity of vegetable *Amaranthus* species complex using nuclear ITS sequence. A total of 2,677 depositions from 5 species are added to NGRR (National Genomic Resources Repository) DNA extraction protocols were optimized for GM detection of processed food derivatives.

5.1 DNA fingerprinting

One hundred and two (102) samples of 19 agri-horticultural crops, viz. grain amaranth, brinjal, chilli, cotton, fennel, fenugreek, French bean, hot pepper, lentil, little millet, maize, mustard, oats, okra, paddy, sorghum, soybean, tomato, walnut and wheat were DNA profiled during the period under report for various public and private sector organizations. The DNA profiling was mostly done using 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. 400044/- were also generated.

Table 5.1: Details of samples DNA finger printed during 2020

S. No.	Crop	Scientific name	No. of samples
1.	Amaranth	*Amaranthus sp.*	03
2.	Brinjal	*Solanum melongena*	04
3.	Chilli	*Capsicum annuum*	01
4.	Cotton	*Gossypium hirsutum*	22
5.	Fennel	*Foeniculum vulgare*	01
6.	Fenugreek	*Trigonella foenum-graecum*	01

S. No.	Crop	Scientific name	No. of samples
7.	French bean	*Phaseolus vulgaris*	04
8.	Hot pepper	*Capsicum frutescens*	06
9.	Lentil	*Lens culinaris*	02
10.	Little millet	*Panicum sumatrense*	02
11.	Maize	*Zea mays*	06
12.	Mustard	*Brassica oleracea*	05
13.	Oats	*Avena sativa*	01
14.	Okra	*Abelmoschus esculentus*	04
15.	Paddy	*Oryza sativa*	28
16.	Pea	*Pisum sativum*	01
17.	Sorghum	*Sorghum bicolor*	01
18.	Soybean	*Glycine max*	02
19.	Tomato	*Solanum lycopersicum*	06
20.	Walnut	*Juglans regia*	01
21.	Wheat	*Triticum aestivum*	01
	Total		**102**

5.2 Development of Novel SSR markers in small cardamom

Novel Simple Sequence Repeat markers were developed through low coverage sequencing. Two paired-end (PE) libraries were prepared and sequenced on HiSeq1000 (Illumina, San Diego, CA, USA) using 2 x 100bp paired end chemistry. The raw sequence reads were assembled by using CLC workbench. A total of 250,571 SSRs were identified from the assembled contigs using software SSR locator v.1. A total of 227,808 primers were designed from SSRs mined from the cardamom genome. For wet lab validation, a set of 52 SSR primers have been screened, of which 43 primers produced amplification of expected size. These have been validated in 96 accessions of cardamom and used for analyses of genetic diversity.

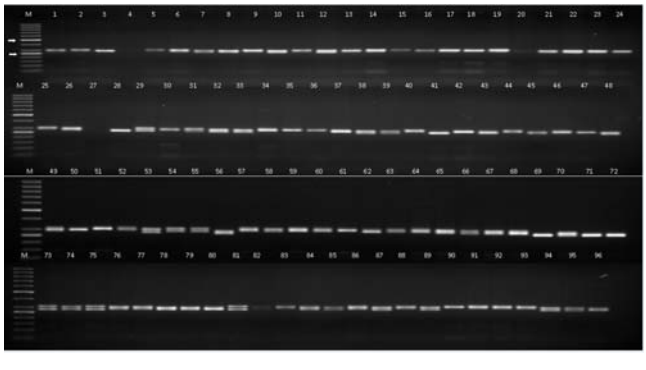


Fig. 5.1. Representative profile of amplification (96 cardamom accessions) at locus SSR_27

5.3 Development of SSR markers in ridged gourd

Novel Simple Sequence Repeat markers were developed from the ridged gourd 2593 SSR containing whole genome sequences. 89267 perfectly aligned chromosomal SSRs were predicted using MISA. Primers were designed using Primer3 and 362 primers were validated in ten ridged gourd germplasm and will be used for genetic diversity analysis and cultivar identification. (SDG 2.5)

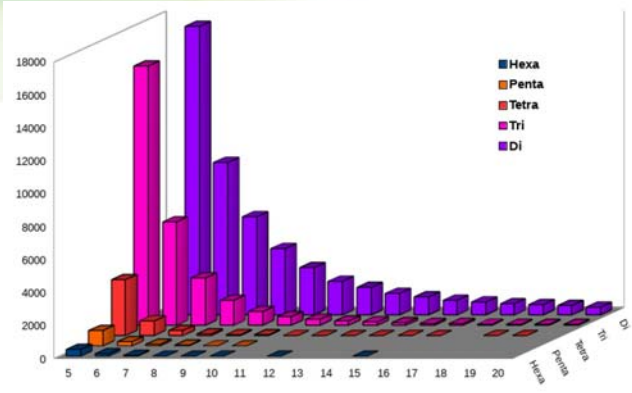


Fig. 5.2. Novel Simple Sequence Repeat markers of different types and length developed from ridged gourd whole genome sequencing?

5.4 Development of novel SSR markers in browntop millet through cross-species and cross-genera transferability

DNA was extracted from fifty-seven genotypes of browntop millet. For development of SSR markers for browntop millet (*Brachiaria ramosa* (L.) Stapf), sixty-nine SSR primer pairs [(source species are *B. brizantha*, *B. ruziziensis* and interspecific *Brachiaria* hybrid Mulato II (CIAT 36087) which was developed from crosses between the agamic complex species (*B. ruziziensis*, *B. decumbens*, *B. brizantha*)] with high PIC values were identified and synthesized. Out of 69 primer pairs tested in seven genotypes of browntop millet, 41 could be amplified. Similarly, 116 from foxtail millet and forty SSR primer pairs from finger millet were tested in seven genotypes of browntop millet and 36 and five SSR primer pairs could be transferred respectively. In total 82 SSR markers could be developed in browntop millet and will be used for molecular characterization of larger set of germplasm.

5.5 Genetic diversity of cowpea germplasm accessions from Konkan region of Maharashtra

Genetic diversity of the recently collected 12 germplasm accessions of cowpea through exploration in Konkan region of Maharashtra was studied along with five popular varieties of cowpea using SSR markers. 23 SSR primer pairs led amplification of total 80 alleles. Genetic relatedness of these 12 accessions with five popular cowpea varieties was studied with the help of population structure based on SSR data using a model-based programme STRUCTURE. The number of distinct populations was determined based on maximum Delta *K* value plotted against the K (K=1 to K=10) using 'Structure harvester' programme, Maximum delta K value was observed for K=2 (Fig. 5.3), therefore two distinct populations were considered for the 17 accessions. The bar plot clearly shows two populations with 11 of the recently collected accessions in population-I, whereas, population-II comprised all five varieties and one recently collected accessions (Fig. 5.3).

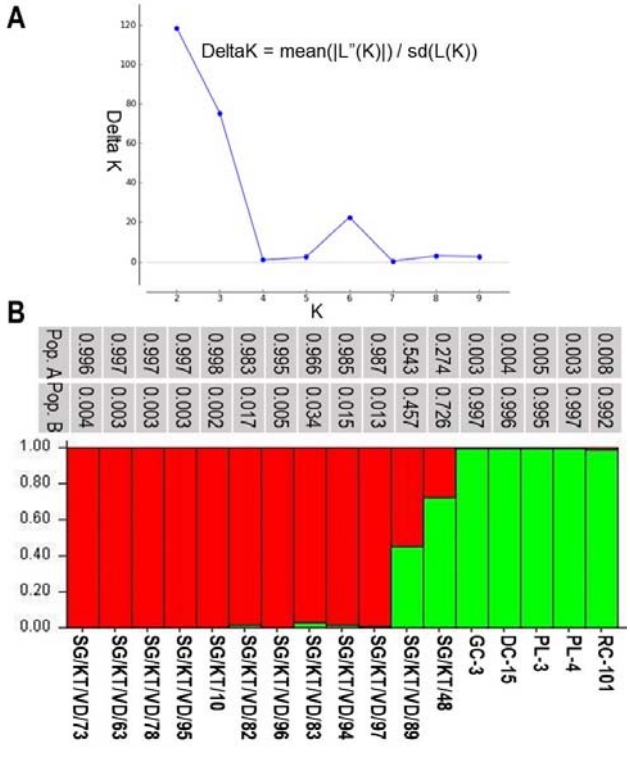


Fig. 5.3. Model based clustering of 12 recently collected cowpea accessions along with five varieties based on SSR data in STRUCTURE for K=2 populations

5.6 Genetic diversity studies in Sesame

The polymorphism in 2496 sesame genotypes were assessed using the identified set of polymorphic SSR markers, reported earlier in sesame. Few selective sample profiles run on the 6% Polyacrylamide gels are shown here (Fig. 5.4).

5.7 Genetic diversity of Pigonpea germplasm

Pigeonpea is the second most important pulse legume crop for food and nutritional security of South Asia that requires accelerated breeding using high throughput genomic tools. Single nucleotide polymorphisms (SNPs) are highly suitable markers for this purpose because of their bi-allelic nature, reproducibility and high abundance in the genome. We have identified, mapped and published high density SNP map of 7,34,810 genome wide pigeonpea SNPs available with accession numbers PRJEB27956. More than 65 high yielding pigeonpea lines were either selected or developed through pre-breeding approaches. Uniqueness of these high yielding lines were tested using a pigeonpea 62 K SNP chip array 'CcSNPnks' for Affymetrix GeneTitan® platform developed in collaboration with NRCPB under Indo-Swiss collaboration in Biotechnology project. The array was designed after filtering 7,34,810 genic-SNPs identified from re-sequencing data of 45 diverse genotypes. It was used successfully for the analysis of genetic diversity and population structure of 50 pigeonpea lines developed at NBPGR (Fig. 5.5).

5.8 Characterisation of 2893 germplasm accessions of Grain Amaranth for Core development

The 2893 accessions of Grain Amaranth procured from Genebank were sown during Rabi 2019-2020 and purified seeds were developed using selfing (Fig. 5.6). The purified seeds were used for the DNA isolation and Core development. 50,000 unique SNP markers has been filtered out from 8.50 lakh SNP identified in Grain Amaranth. These markers has been tested and found suitable for SNP chip developement. SNP chip development work has been initiated.

5.9 Molecular Characterization of 96 diverse accessions of little millet with genic SSRs

DNA was extracted from 96 diverse accessions of little millet. These accessions represented nine states of India and showed wide variation with respect to days to 50% flowering and thousand grain weight. Molecular characterization was done with ten in house developed genic SSR markers. Out of ten, five genic SSRs were polymorphic (Fig. 5.7).

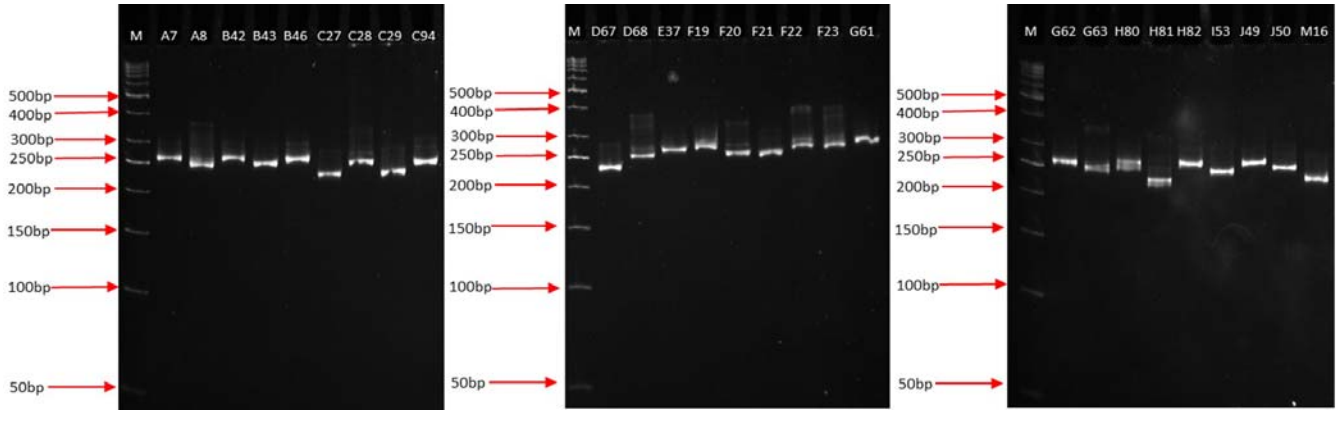


Fig. 5.4. Sample profile for 27 sesame genotypes using the primer *Si24*, M: 50bp marker

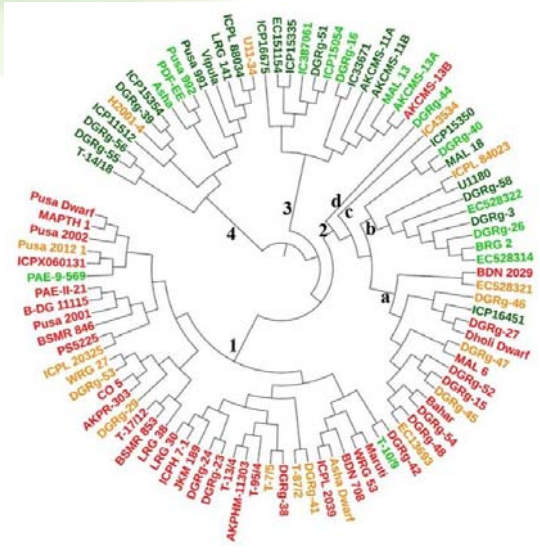


Fig. 5.5. Diversity tree of pigeonpea lines indicating unique pigoenpea lines developed at NBPGR

Fig. 5.6. Filed view for selfing and purification of Grain Amaranth

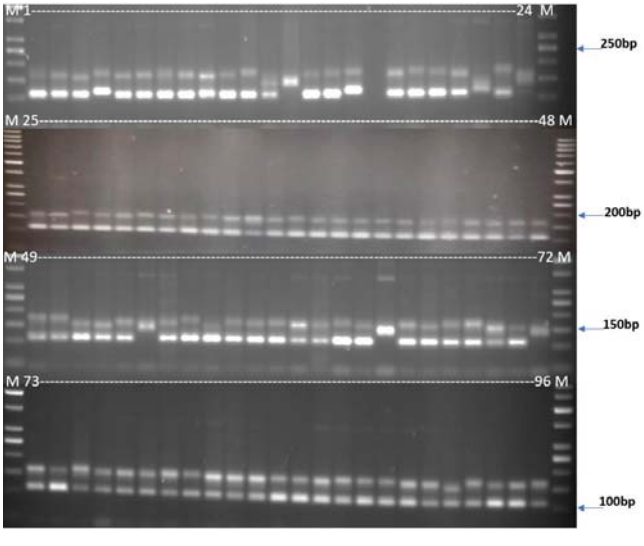


Fig. 5.7 Genotyping of 96 accessions of little millet with genic SSR LM 361

5.10 Sesame seed surface characteristics for species identification

The SEM studies have been carried out to distinguish the two species for the *Sesamum indicum* cv. Swetha (IC312565) and *S. malabaricum* (IC0635708) using seed surface characteristics (Fig. 5.8).

5.11 Screening for robust root system in Indian mustard (*Brassica juncea*)

Abiotic stresses (AS) such as extreme temperatures, soil salinity, drought and flood that affects the production and cultivation of agricultural crops. Among AS, soil salinity is one of them leading to major reduction in cultivated land area, crop productivity and quality. Oilseed brassica is grown all over India however, it dominates in western to central parts of North India (Rajasthan, Madhya Pradesh, Haryana and Uttar Pradesh). From aforementioned areas, it is being estimated that saline regions across India are the regions, which are mostly used for cultivation of Indian mustard. Therefore, it is important to identify better salt tolerant line to increase the production. It has been reported that brassica species respond differently at different growth stages to saline conditions. Mostly, it is the germination and seedling stage that are more affected than the adult stage. Considering above, is the saline tolerant genotypes at the seedling stage showing robust root phenotype were studied.

In order to select potential lines showing robust root phenotype under saline condition (EC~9 dS m^{-1}), large scale primary screening was conducted under controlled growth conditions. The identified potential/promising lines were then subjected to secondary screening under three different saline conditions (EC~9, 10 &11 dS m^{-1}) to check the consistency of phenotype. Following above analyses seeds of selected lines were sown in the field to collect seeds from

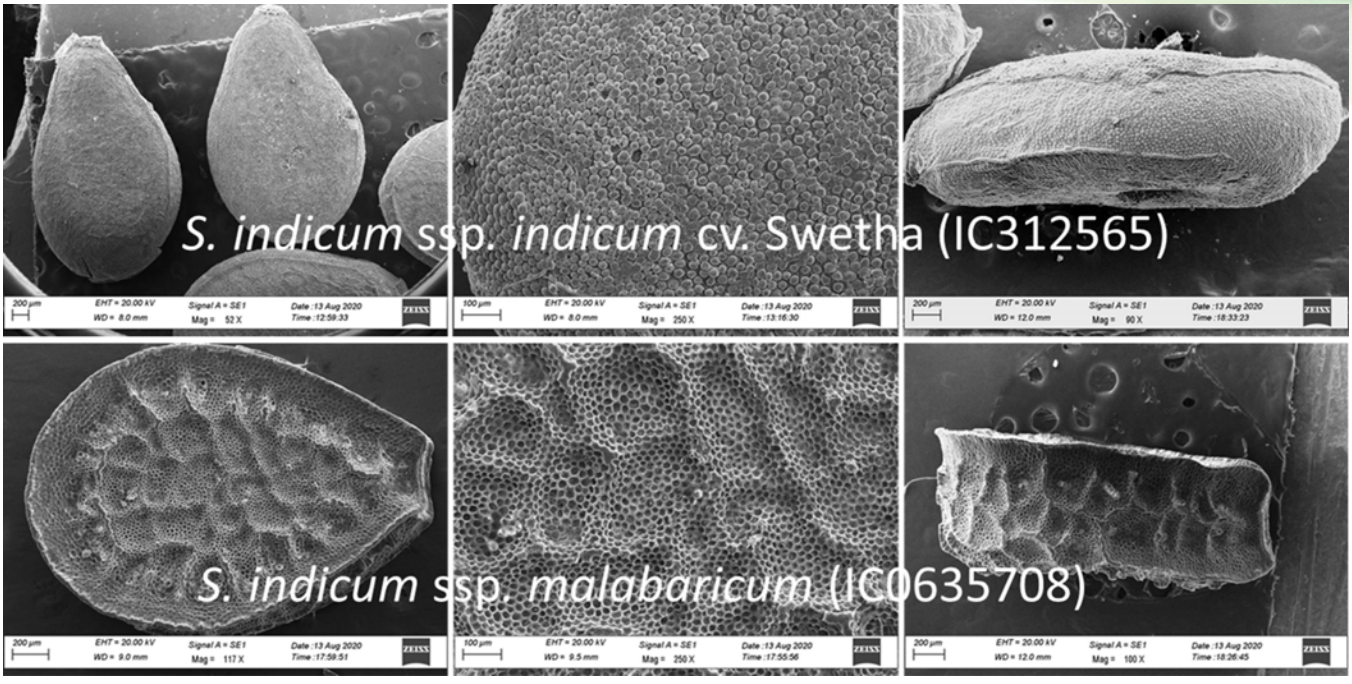


Fig. 5.8. SEM images distinguishing *Sesamum indicum* cv. Swetha (IC312565, top row) and *S. malabaricum* (IC0635708, bottom row)

individual plant progeny of each line. This was necessary as seeds of most of the germplasm, stored at Genebank of NBPGR, were often collected from population. The seeds collected from 5-6 progeny of each selected line were again subjected to testing under saline conditions in order to check genetic stability of trait i.e. robust root phenotype. In all the above screening, pictures of seedling were taken at 4th DAS (days after sowing) (Fig. 5.9). Image J (freely available software) was used to analyze seedlings for recording shoot and root length of seedlings. From above screening, involving over four thousand germplasm/accessions/varieties, we identified seven lines which were showing better root phenotype under saline conditions as compared to saline tolerant control lines. Such promising lines will be subjected to associative transcriptomic studies to unravel genetic factors controlling robust root phenotype under saline conditions.

5.12 QTL mapping for heat tolerance in the RIL population of wheat

The mapping population (275 RILs) along with two parents NIAW 34 (M) and Raj 4014 (F) were sown in the field as timely sown

Fig. 5.9. Seedlings of progenies (a, b and c) at fourth day after sowing of a promising germplasm line grown under saline condition (EC~10 dS m^{-1})

condition during *Rabi* 2019-2020 at NBPGR, New Delhi. A total of 14 traits were recorded during the cropping season under both timely and late sowing conditions. Molecular profiling data of 275 RIL population along with parents NIAW34/RAJ4014 has been generated using 35K Axiom SNP array. A linkage map has been developed (Fig. 5.10) for mapping the heat tolerance related traits.

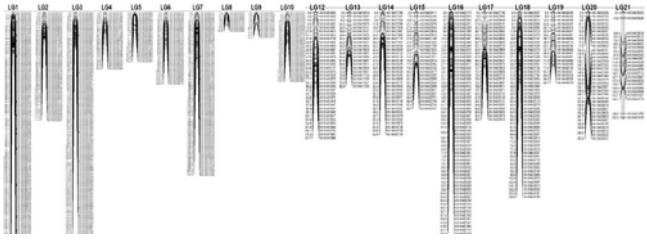


Fig. 5.10. Linkage map developed with 35K Axiom SNP array in RIL population (NIAW34/RAJ4014) of wheat

5.13 Allele mining for PSTOL1 locus and screening of rice landraces KMD 18/5 (IC636753), KMD 18/6 (IC636754) and 18/7 (IC629160) at low phosphorus plot

The PSTOL1 locus was mined in three local landraces [KMD 18/5 (IC636753), KMD 18/6 (IC 636754) and 18/7 (IC629160)]. The sequence alignment showed in-del and SNP at 1860bp and 1870bp respectively in comparison with Kasalath rice variety (P tolerant) (Fig. 5.11). Further these landraces were screened at low phosphorus plot in which phosphorus was not applied in the last 20 years at IIRR, Hyderabad. Among the three landraces, KMD 18/7 (IC629160) was very much early in flowering than other two landraces. The KMD18/7 (IC629160) having less panicle length (16cm) and a smaller number of productive tillers/plants. Among the landraces, KMD 18/6 (IC636754) performed better and recorded 4.29 g/plant grain yield followed by KMD 18/5 (IC636753) which recorded 3.5 g/plant and KMD 18/7 (IC629160) recorded 2.73 g/plant. Rasi being used as check was tolerant and recorded highest grain yield of 5.67g/plant whereas Kasalath recorded 4.07 g/plant. The landraces used in present study contains P-tolerant locus with some in-dels and SNPs was established after sequencing the PSTOL1 locus and field screening.

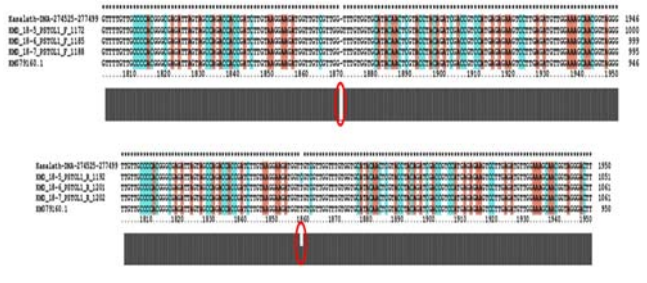


Fig. 5.11. PSTOL1 locus sequence aligment of three local land races alongwith with sequences of Kasalath rice variety (P tolarent)

5.14 Genomic resources for flowering and maturity time traits in linseed

In linseed, flowering time is an important trait as it enables plants to attain early maturity. In this context, 220 germplasm accessions have been evaluated in five environments over last three years (year 2017-18, 2018-19, 2019-20 at ICAR-NBPGR, New Delhi and year 2018-19 and 2019-20 at ICAR-NBPGR, RS Akola). Based on the five environment observations, superior trait specific accessions were identified for important traits. For early flowering four accessions were identified with days to 50% flowering (DF50%) <=60 days (EC0000526: 57.6 days, IC0096496:59.3 days, IC0096539: 58.7 days, IC0096637: 58.9 days, IC0523807: 58.9 days, IC0525939: 59.7 days, whereas, the best check T-397 recorded 75.4 days for DF50. Four accessions (IC0096496: 121.8 days, IC0096731: 123.8 days, IC0523807: 123.3 days and IC0525939: 121.5 days) were identified early for physiological maturity whereas the best check T-397 took 129.1 days to attain physiological maturity. Five accessions (EC0041720: 9.6 g, EC0041469: 9.8 g, IC0096488: 10.4 g, IC0096489: 10.6 g and EC0041700: 11.1 g) recorded high thousand seed weight (TSW) over best check Shekhar which showed TSW 7.8 g.

Based on flowering and maturity time a panel of 131 accessions constructed and genotyped using 68925 SNPs following genotyping by sequencing (GBS) approach. Genome wide association study was conducted using these SNPs. For three flowering traits (days to 5%, 50% and 95% flowering), total 15 SNPs were found associated at significance level of $p = 0.0001$ [–log(p) = 4.0 using Mixed Linear Model (MLM) for Delhi location (Fig. 5.12). For days to physiological maturity (DM), total six SNPs on chromosome 4, 10 and 13 were found significantly associated.

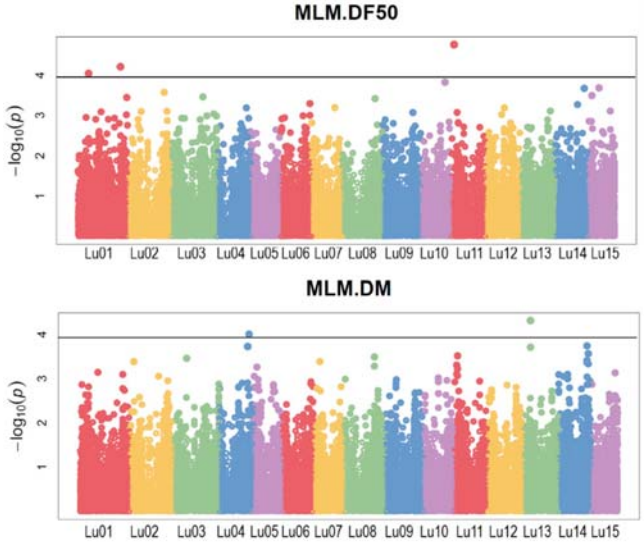


Fig. 5.12. Manhattan plots showing significant *p*-values (mixed linear model) for days to 50% flowering and maturity time for Delhi location during year 2019-20. Colors indicate different chromosomes while horizontal lines indicate a common significance level

Further in order to identify allelic variation in candidate genes for flowering time traits, EARLY IN SHORT DAYS 4 (ESD4) gene was PCR amplified, isolated and sequenced from two early and late linseed germplasm accessions (Fig. 5.13). Sequences analysis and alignment revealed a total of 10 SNPs. Four of the SNPs were in the coding region and six SNPs were from the intronic region of the gene. Two exonic SNPs (position- 39, 1921) and four intronic SNPs (1240, 2392, 2488, 2499) were able to distinguish early and late accessions (Table 5.1).

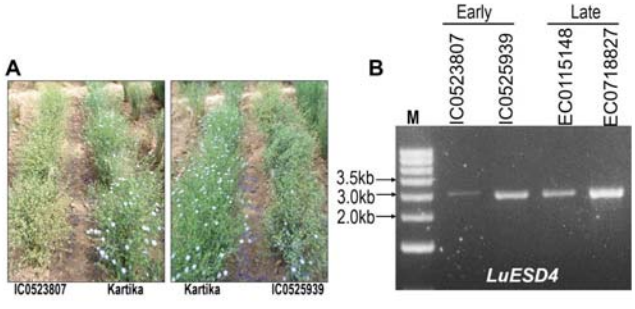


Fig. 5.13. A-Variation in flowering time of early accessions, IC0523807 and IC0525939 along with check variety Kartika. B- PCR amplification of LuESD4 gene from early and late flowering-maturing linseed accessions

5.15 Genome-wide association mapping of seedling stage salinity tolerance traits in wheat

GWAS was performed on an association panel of 135 diverse wheat genotypes for seedling stage traits using five multi-locus GWAS models. A

Table 5.1: SNP haplotype of EARLY IN SHORT DAYS 4 (ESD4) gene from early and late flowering-maturing linseed germplasm accessions. Nucleotides in green and red font color are from exonic and intronic regions, respectively

Haplotype		EARLY IN SHORT DAYS 4									
Nucleotide Position		39	241	612	1240	1813	1921	1990	2392	2488	2499
Ref. CDS-Bethune		A	C	G	T	C	A	G	T	T	G
Late	EC115148	G	G	C	C	A	C	C	A	C	C
	EC0718827	G	G	C	C	A	C	C	A	C	C
Early	IC0525939	A	G	C	T	A	A	C	T	T	G
	IC0523807	A	C	G	T	C	A	G	T	T	G

total of 42 reliable QTNs for 10 salt tolerance associated traits. Among these 42 reliable QTNs, 9, 17 and 16 QTNs were associated with physiological, biomass and shoot ionic traits respectively. Novel major QTNs were identified for chlorophyll content, shoot fresh weight, seedling total biomass, Na^+ and K^+ concentration and Na^+/K^+ ratio in shoots. Further, 10 major QTNs showed significant effect on the corresponding salt tolerance traits. The identified salt tolerance associated genomic regions contained genes encoding for K+ transporter, sucrose transporter and stress associated proteins.

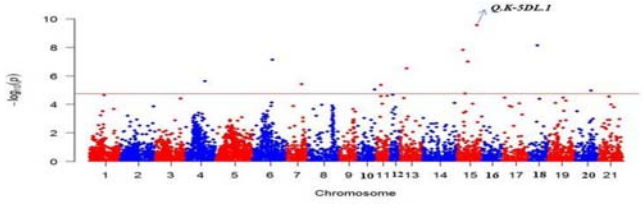


Fig. 5.14. Manhattan plot showing a strong marker association for shoot K^+ content on 5DL

5.16 Transcriptome analysis of developing seed stages of ricebean genotypes contrasting for seed size

The transcriptome sequencing of developing grains of two ricebean accessions (i.e., IC426787; bold pod and IC552985; small pod) at different time intervals (i.e., 4 days and 7 days) was done using Illumina *HiSeq 4000*. Differentially expressed genes (DEGs) analysis was performed for the pairwise comparison of twelve libraries (three biological replicates for each accession at two time points). When comparing the different time points, 6928 DEGs were identified for bold cultivar, whereas 14544 DEGs were identified for small cultivar (Fig. 5.15). The number of up-regulated genes were higher as compared to down-regulated genes in all different time points in both the cultivars except in the case of bold cultivars at different time intervals. The top 10 KEGG pathways include metabolic pathways, plant-pathogen interaction, oxidative phosphorylation, plant hormone signal transduction etc. Some KEGG pathways which are suggested to play an important role in the pod development process like plant hormone signalling (Auxin, cytokinin), cell cycle, glucose and galactose metabolism etc were also identified.

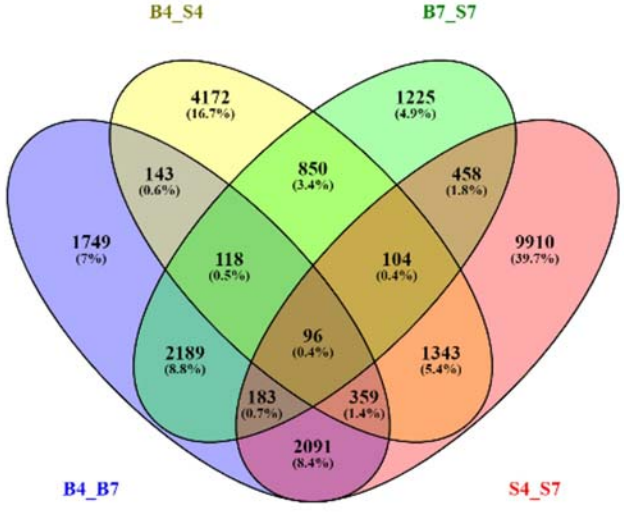


Fig. 5.15. Differentially expressed genes for the bold and small cultivar of rice bean at differentent timepoints (4 days and 7 days)

5.17 Moisture stress tolerance in Horsegram

A core of horsegram was developed earlier with multilocation trials conducted at four agro-climatic zones for two years during 2011 and 2012. From this comes a collection of 50 better performing accessions were selected. These 50 accessions were subjected to moisture stress trials and 20 accessions were filtered out as stress responsive accessions. From these 20 accessions contrasting two accessions were subjected to further RNAseq analyses to identify 15 miR genes and its targets responsible for the innate nature of horsegram in drought tolerance. These miR genes were confirmed to play a role by expression analyses and validation from other reported datasets. Synteny mapping revealed the presence of these miRs in all related crops and we could map them in Soybean (Fig. 5.16).

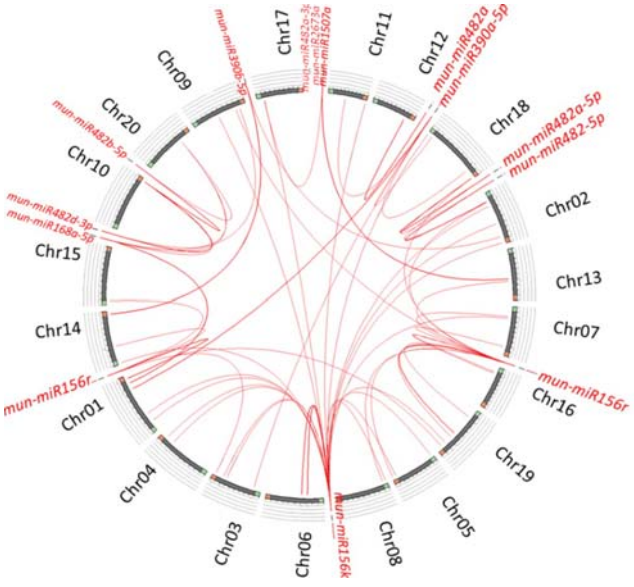


Fig. 5.16. Synteny map of identified novel mun-miRs in soybean

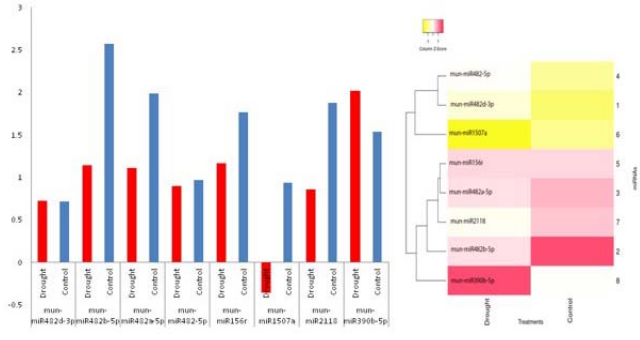


Fig. 5.17. Quantitative differential expression of identified stress responsive mun-miRs

5.18 Transcriptome-wide identification of WRKY TF in little millet (*Panicum sumatrense*)

WRKY transcription factors play a critical role in response to biotic and abiotic stresses. Keeping this in mind, the reference sequences of WRKY domain were downloaded from pfam database and fifty transcripts were identified as putative WRKY genes of little millet (LmWRKY). The multiple sequence alignment was used to construct phylogenetic tree along with WRKY genes of foxtail millet and finger millet. LmWRKY were found closely grouped with foxtail WRKY TFs. To further reveal the syntenic relationship between LmWRKYs and foxtail millet genome, the genomic database of foxtail millet was retrieved from NCBI genome database and collinearity between the LmWRKY and foxtail genome was established.The collinearity status of LmWRKYs with foxtail millet genome was graphically represented using CIRCOS model. The LmWRKY genes (for example LmWRKY2 and LmWRKY50, etc.) were considered as tendemly duplicated genes. Based on sequences similarity, the rest of LmWRKY genes showed relative chromosomal position in foxtail millet genome. More number of LmWRKY genes were mapped on chromosome number 2, 3 and 5 as compared to other chromosomes of foxtail millet.

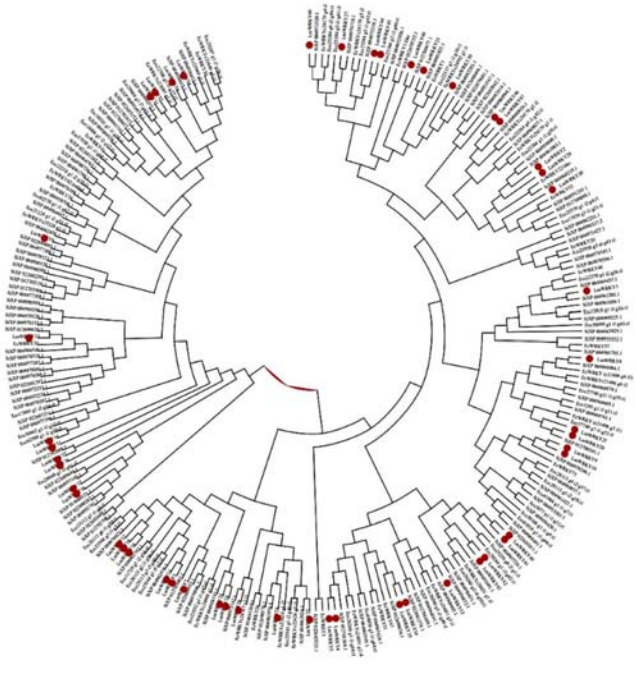


Fig. 5.18. Phylogenetic tree of little millet WRKY TF genes (LmWRKY) with WRKY genes of foxtail millet and finger millet (red dots: LmWRKY)

5.19 NIRS spectra-based diversity in little millet

A total of 1,598 accessions of little millet procured from NGB were scanned using NIR spectroscope for NIRS spectra acquisition. Based

on spectral data analysis 117 biochemically diverse set of little millet accessions were identified. These samples will be evaluated for different biochemical traits like total protein, total starch and total phenols and minerals etc. to develop NIRS prediction models.

5.20 Identification of trait specific accessions of little millet

A total of 1635 accessions were characterized at two locations viz. RS, Akola and Issapur Farm, New Delhi in 2018-19 and following trait specific accessions have been identified:

Potential little millet accessions with thousand grain weight (TGW) equal to and greater than 3.0 g IC0405086, IC0405124, IC0405078, IC0483303, IC0028422-X, IC0483040, IC0482808, IC0404919, IC0482988, IC0483133, IC0483042, IC0482852, IC0482980, IC0483302, IC0483072, IC0482907, IC0404913, IC0404924, IC0404929, IC0483129, IC0483478, IC0483063, IC0482989, IC0483068, IC0393399, IC0482851, IC0482850, IC0483345, IC0345046, IC0405074, IC0483062, IC0483113, IC0483157, IC0404934

Potential little millet accessions for days to 50% flowering IC0483105, IC0483198, IC0483399, IC0483457, IC0404946, IC0405001, IC0405008, IC0405140, IC0340160, IC0262990, IC0589819, IC0483450, IC0275070, IC0404944, IC0404988, IC0483164, IC0483328, IC0483329, IC0482793, IC0482827, IC0268168, IC0268171, IC0326687, IC0331802, IC0331803, IC0404965, IC0589887

5.21 Protein content variability in kodo millet

Protein content was estimated for 99 accessions of kodo millet from 12 states of India (Fig. 5.19). Protein content varied from 6.82 to 9.38% with a mean±stdev. of 8.42±0.472. The accessions showing more than 9% protein content are IC482607 (Uttar Pradesh), IC481762 (Tamil Nadu), IC481737 (Karnataka), IC482541 (Gujarat), IC88480 (Kerala), IC404569 (West Bengal), IC342543 (Chhattisgarh), IC41857 (Maharashtra), IC88479 (Kerala), IC481540 (Gujarat), IC88478 (Kerala). IC481762 showed high biomass (97.67g), straw yield (65.67g) and yield per plant (27.60g). IC482541 showed early maturity (96 days).

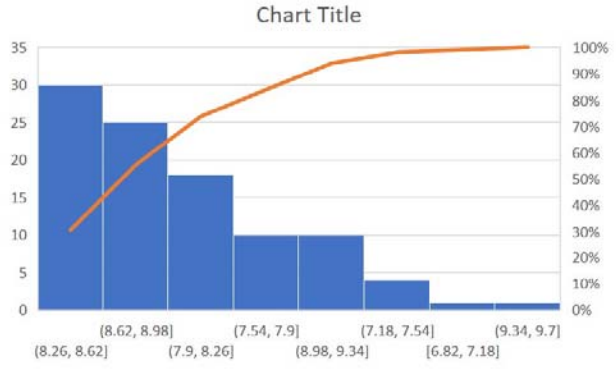


Fig. 5.19. Protein content variability in 99 accession of kodo millet

5.22 Potential strategies laid out to develop C_2 rice with high biomass – insights from transcriptome studies

The expression levels (in RPKM values) for genes of photorespiration, phosphoglycolate phosphatase (*cpPGLP*), glycolate oxidase (*pGOX*), glutamate:glyoxylate aminotransferase (*pGGT*), serine hydroxymethyltransferase (*mSHMT*), glycine decarboxylase (*mGDC*), glycerate kinase (*cpGLYK*), glutamine synthetase (*cpGS2*), glutamate synthase (*cpGOGAT*), serine:glyoxylate aminotransferase (*pSGT*), and hydroxypyruvate reductase (*pHPR*) were found to be significantly lower in developing grains (3-5 dpa), when compared to the leaves in all the three rice genotypes APO (EC734333), BAM4234 (EC497171), and CROSSA (IC575838). Additionally, the chloroplastic pyruvate dehydrogenase (*cpPdc*) gene expression was found to be significantly higher in developing grains than the leaves from the same dataset. Hence, with upregulated expression for *cpPdc* gene in rice leaves, it is potentially possible to develop C_2 rice (Fig. 5.20), that could help bypass

photorespiration, overcome metabolite toxicity from 2-PG and glyoxylate, and the carbon loss.

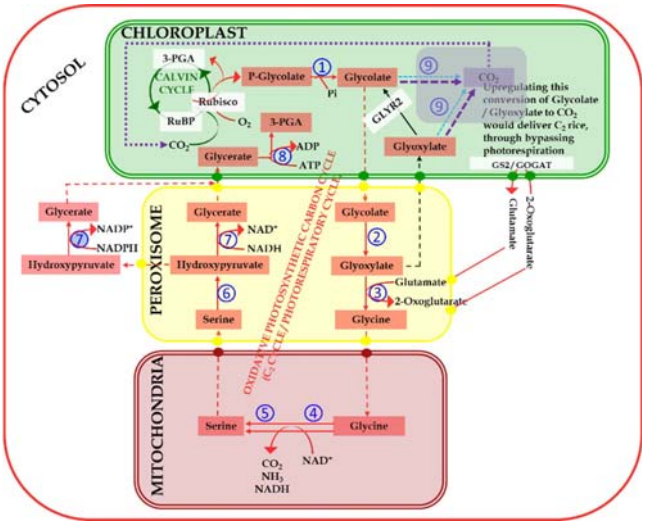


Fig. 5.20. Proposed strategy for C_2 rice with high biomass (purple). 1: cpPGP; 2: pGOX; 3: pGGT; 4: mSHMT; 5: mGDC; 6: pSGT; 7: pHPR, highlighted 7 in cytosol is cHPR; 8: cpGLYK; 9: cPDC; 3-PGA: 3-phosphoglycerate; GLYR2: glyoxylate reductase-2; GS2: glutamine synthetase; GOGAT: glutamate:oxoglutarate aminotransferase; Rubisco: ribulose-1,5-bisphosphate carboxylase/oxygenase; RuBP: ribulose-1,5-bisphosphate.

5.23 Molecular systematics in vegetable Amaranthus species complex

In the present study morphological, cytological and sequence of nuclear ITS (inter transcribed region) were used to identify and delineate 30 accessions of non-designated vegetables Amaranthus species from National Gene Bank of ICAR- NBPGR. In the present study after studying the diagnostic characters previously used to distinguish the species, the tepal morphology found to be prominent in identifying species holistically. The tepal shape and tip of tepal both provided weightage in terms of identifying these species. The lanceolate shape of tepal and acuminate tip belongs to the species *A. tricolor* whereas, the ovate shape and acute tip belongs to *A. blitum*. Even though the leaf color showed great range of variation, the reddish-purple leaves may not represent *A. blitum*. All the remaining variation like green, greenish yellow were common in both the species. The species *A. tricolor* and *A. blitum* accession showed same number of chromosomes. i.e 2n =34. An average 634 base pair for each accession were generated which includes ITS1, 5.8S and ITS 2. The *A. tricolor* accession which represented 24 accessions were having variable base pair count of 13 which is higher side for considering variation within the species. Similarly, *A. blitum* accessions also showed higher (14) base pair variation within the species. However, all the variation showed in both species were either singleton or missing base pairs which does not have any implication on species relationship and phylogenetic analysis. With the combined analysis of *A. tricolor* and *A. blitum*, the sequence alignment showed 8 parsimonious informative site which are the key site differentiate these two species. The ITS1 and ITS2 shared 4 site each of the parsimonious site. Among the plants, the ITS2

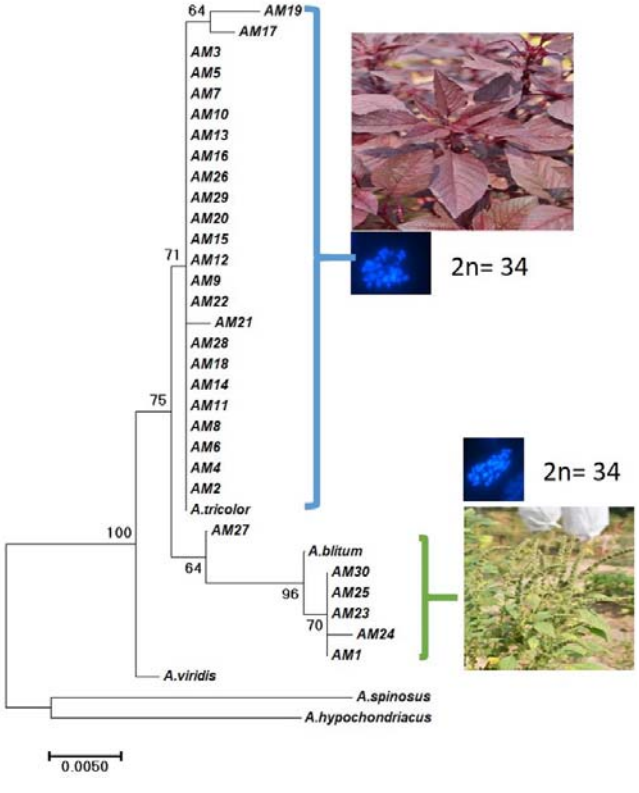


Fig. 5.21. NJ tree based on ITS sequence differentiating species of Amaranthus

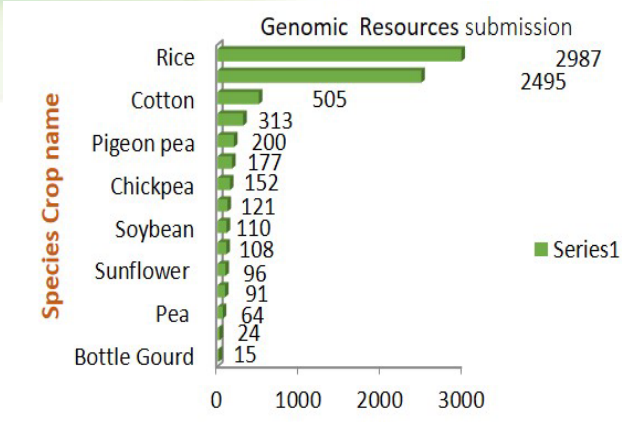


Fig. 5.22. National Genomic Resource Repository genomic resource conservation 9044 from 46 species as on 31.12.20. A total of 2,677 depositions from 5 species are added during Jan-Dec. 2020

is considered evolutionary important as it shows variation which are phylogenetically significant. The neighbor joining tree constructed based on Juke-Cantor substitution model showed clear cut grouping of *A. blitum* and *A.tricolor* accessions. The variant available in A. *tricolor* and *A. blitum* showed availability of taxonomic varieties in the species complex including some of the newly described species. The correlation of DNA barcode variation in varietal classification requires further morphometric analysis and more barcoding loci sequences. (Fig. 5.21).

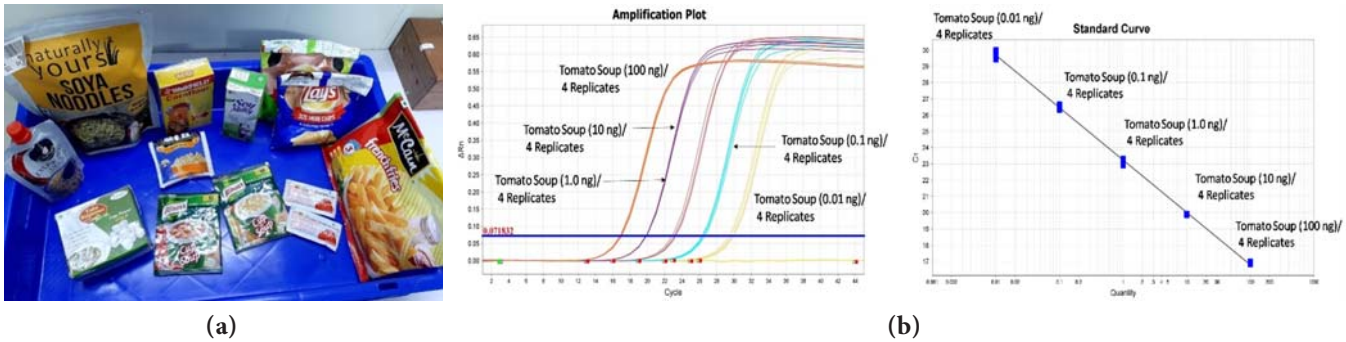
5.24 GM detection in processed food derivatives

Based on the GM events of crops such as canola, corn (maize), potato, soy approved in different countries, matrix for different food derivatives was identified (Fig. 23a). DNA extraction protocols were optimized using modified CTAB method or commercial kit. PCR amplifiability was confirmed using respective endogenous gene specific assays or/ and inhibition test (Fig. 23b) for different food matrices – Apple (juice, fruit seeds), Tomato (sauce, soup) and Maize (pop corn, baby corn), Soy (soy sticks, tofu). So far, DNA extraction protocols for >20 food derivatives have been standardized and amplifiability has been confirmed using respective taxon-specific real-time PCR/ inhibition tests.

GMO matrix for food crops (apple, canola, potato, tomato) was developed. Common screening targets were identified as P-35S, P-FMV, T-nos, aadA, nptII, pat, cry1Ab/Ac, ctp2-cp4epsps for GMO testing in derivatives of apple, canola, cotton, maize, potato, soybean, and tomato.

5.25 Molecular testing of imported transgenic planting material

The imported transgenic corn (event MON89034) from USA was tested for specific GM event using real-time PCR assay (Fig. 24a). The sample was also tested for ensuring absence of embryogenesis deactivator (*cre*) gene (terminator gene technology). The sample did not show the presence of terminator gene technology (Fig. 24b).



(a) (b)

Fig. 5.23. (a) Range of food derivatives selected for GM detection (b) Confirming amplifiability of DNA extract of tomato soup using real-time PCR and corresponding inhibition test

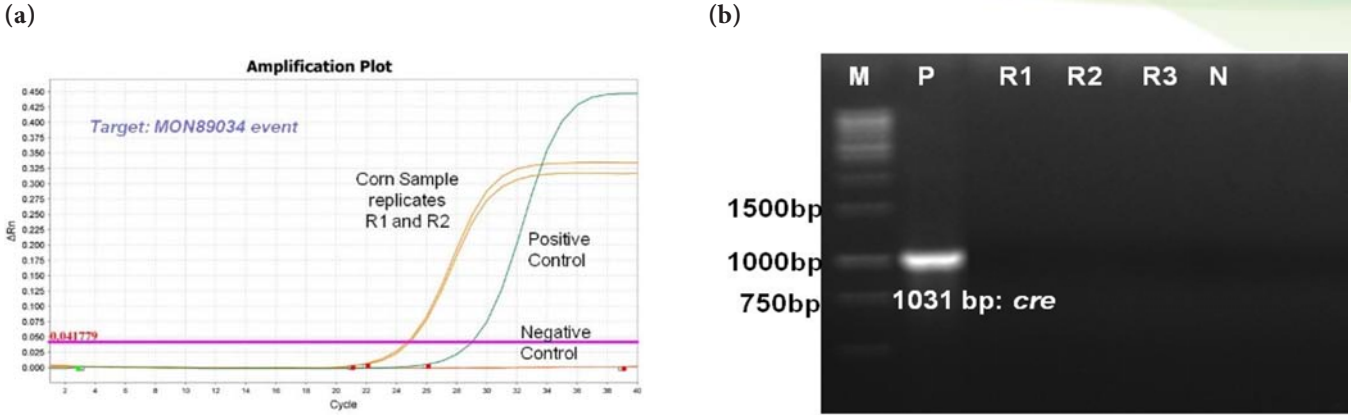


Fig. 5.24. Molecular testing of imported transgenic *Zea mays* (corn) – event MON89034 (a) Event-specific real-time PCR amplification profile in transgenic corn (R1, R2) (b) Ensuring absence of embryogenesis deactivator gene: R1-R3, three replicates of corn sample, PC: Positive control giving product of 1031 bp for *cre* gene, NC: Negative control, M: 1 kb DNA ladder

5.26 For quality assurance, participated in three Inter-laboratory Comparison Programs (ILCP) on real-time PCR-based GM detection organized by:

(i) NAWaL Analytical Laboratories, Hosur: The test samples (blind samples) of maize were tested for *P-FMV* promoter and cotton were tested for *P-35S*, *P-FMV*, *cry1Ac*, *pat*, *T-nos* and *Sah-7*.

(ii) Testex India Laboratories Pvt. Ltd., Mumbai: Five test samples were tested for *P-35S*, *P-FMV* promoters and *T-nos* terminator and three samples were tested for *cry1Ab/Ac*, *pat* and *otp-mepsps*.

(iii) Export Inspection Agency, Kochi: Five test samples were tested for *P-35S* and *T-nos* along with taxon-specific sequences for maize, rice and soy.

5.26.1 GMO testing of samples

GMO testing services were provided for 24 samples of 21 consignments of 2 crops (papaya, soybean) received from public or private sector on payment basis for checking the GM status

Table 5.2: Details of consignments received for GMO testing during 2020

Crop	No. of Consignments (Samples)	Source
Papaya	03 (03)	DPPQ&S, Plant Quarantine Station (PQS), Bengaluru (Karnataka)
	06 (06)	DPPQ&S, Regional PQS, Rangpuri, New Delhi
	01 (01)	DPPQ&S, PQS, Mumbai
	05 (07)	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)
	03 (04)	East West Seeds India Pvt. Ltd., Aurangabad (Through PQS, Mumbai)
Soybean	02 (02)	DPPQ&S, PQS, Mundra-Kutch (Gujarat)
	01 (01)	DPPQ&S, Regional PQS, Mangalore (Karnataka)
TOTAL	**21 (24)**	

(details are enclosed in Table 5.2). **(*Resource generation:* Rs 1, 43, 960).**

Technical support was provided for regulatory compliance (i) for checking adventitious presence of Roundup Ready trait in soybean (Source: USA), and (ii) for testing of UASD-78 *Bt* cotton event (Source: ICAR-National Institute of Plant Biotechnology, New Delhi/ International Crops Research Institute for the Semi-Arid Tropics, Patancheru)

5.26.2 Institutional Biosafety Committee (IBSC) meetings

1st and 2nd meetings of Reconstituted IBSC (virtual) were held on 26 May 2020, and 22 December 2020 respectively under the chairmanship of Director, ICAR-NBPGR to discuss the ongoing activities related to genetically engineered (GE) including GM detection.

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

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

Research Projects (Code & PI, Co-PIs and *Associates*)

PGR/GRD-BUR- DEL-01.01: Development of genomic tools for discovery and validation of genes of economic importance for enhancing the use of plant genetic resources of pulses, oilseeds and fibre crops (**Rajesh Kumar,** S Marla, J Radhamani, JK Yasin, DP Wankhede, Rashmi Yadav, S. Rajkumar, R Parimalan and *SK Singh*)

PGR/GRD-BUR- DEL-01.02: Development of genomic tools for enhanced utilization of cereals (**Rakesh Singh,** MC Yadav, Sundeep Kumar, AK Singh, R Parimalan and *Sheel Yadav*)

PGR/GRD-BUR- DEL-01.03: Development of genomic tools for enhanced utilization of millets (**Lalit Arya,** Monika Singh, Mamta Singh)

PGR/GRD-BUR- DEL-01.04: Development of genomic tools for enhanced utilization of horticultural crops (**AB Gaikwad,** M Verma, S Archak, K Joseph John and *Dikshant Gautam*)

PGR/GRD-BUR- DEL-01.05: Development of genomic tools for species delineation and genetic erosion studies in selected crops (**MC Yadav,** S Rajkumar, S Marla, J Radhamani, DR Pani, N Dixit and M Latha)

PGR/GRD-BUR- DEL-01.06: Establishment and maintenance of national genomic resources repository and bioinformatics facility (**S Marla,** MC Yadav, MK Rana, Lalit Arya, M Verma, Sundeep Kumar, S.RajKumar, Rajesh Kumar, AK Singh, JK Yasin, R Parimalan, Sheel Yadav, DP Wankhede, Monika Singh, Rekha Chaudhury and *SK Singh*)

PGR/GRD-BUR- DEL-01.07: Development of DNA based diagnostics for transgene detection and impact analyses of GM crops on plant biodiversity (**Gurinderjit Randhawa** and Monika Singh)

PGR/GRD-BUR- DEL-01.08: Development of unique identity system for cultivars and genetic stocks for IPR protection (**MK Rana,** AB Gaikwad, Rakesh Singh, Lalit Arya, M Verma, Sundeep Kumar, Rajesh Kumar, S Rajkumar, R Parimalan, AK Singh, Sheel Yadav, DP Wankhede, JK Yasin and *SK Singh*)

6 DIVISION OF GERMPLASM CONSERVATION

Summary: A total of 20616 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 9,057 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 448581. Of the conserved accessions, 4,649 were new and 4,408 accessions were received after regeneration. Monitoring of germination and seed quantity in conserved germplasm (5178 accessions) and distribution (64,034) for characterization/ evaluation/regeneration/research were the other priority activities. The germplasm supplied includes those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). The entire maize germplasm collection of National Genebank (11,642 accessions) has been grown at Regional Maize Research and Seed Production Centre of Indian Institute of Maize Research, located at Begusarai, Bihar, under the CRP (AB) programme to characterize and derive a core set for enhanced utilization. Rice landraces (12000) representing the entire rice growing areas of the country were characterized for their agro-morphological traits. To develop a predictive model for obtaining optimum seed germination in field during regeneration of conserved samples Hydrothermal Time (HTT) Modeling was done using repeated probit method and correlations have been developed for rice, wheat, maize, barley, finger millet, mung bean, pearl millet and onion. Quick viability testing protocol was standardized in *Maclura cochinchinensis*. Glutathione half cell redox potential were standardized in wheat, barley, onion and soybean as an alternative to seed viability monitoring through germination tests indicating its potential use as a biochemical predictor for seed viability.

Long-term storage (LTS) of seeds of various agri-horticultural crops in the National Genebank, (at -18^{0}C), and medium-term storage (MTS, at +4^{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, are the other important activities, to facilitate utilization of germplasm in crop improvement programmes.

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

A total of 20,616 germplasm accessions of various agri-horticultural crops were received for long-term conservation in the National Genebank, ; 9,057 accessions qualified for conservation as per the genebank standards and were conserved at –18±2^{0}C as base collections. Of the conserved accessions, 4,649 were new and 4,408 accessions were received after regeneration (table1). A total of 232 accessions were rejected during quarantine examination. Accessions which did not qualify the genebank standards in terms of seed quantity were stored in MTS and will be multiplied subsequently for further long-term conservation.

Among the new accessions added to the genebank, cereals (1439), legumes (679), vegetables (676), and oilseeds (587), comprised a major portion of germplasm followed by fibres (474), millets (325), medicinal aromatic plants (267), pseudo-cereals (80), forages (72) and spices & condiments (28). The total germlasm holdings in the National Genebank representing 2,014 species has increased to 448581 (including 10,771 trial material and 10,235 accessions of lentil and pigeonpea as safety duplicates). Accessions received after regeneration (8052) belonged to cereals (943), millets (1967), pulses (906), oilseeds (419), vegetables (39), medicinal and aromatic plants

Table 6.1: Status of germplasm holdings in the National Genebank (as on December 31, 2020)

Crop Groups/ Crop Name	No. of Accessions conserved during (1st January to 31st December 2020)			Total no. of Species	Present Status (As on 31st December 2020)
	Regenerated Acc.	New Accessions	New Species Added		
Cereals	943	1439	5	139	166285
Millets	1967	325	3	29	59739
Forages	0	72	5	203	7320
Pseudocereals	9	80	—	55	7833
Grain legumes	906	679	3	111	67499
Oilseeds	419	587	2	87	60942
Fibre	3	474	-	77	16220
Vegetables	39	676	5	218	27462
Fruits & Nuts	0	14	4	71	293
Medicinal & Aromatic plants	122	267	5	682	8392
Ornamental	0	5	1	122	670
Spices, Condiments and Flavour	0	28	—	28	3265
Agroforestry	0	3	1	192	1655
Duplicate safety Samples	0	0	—-	0	10235
Trial Material(Wheat,Barley)	0	0	——	0	10771
Total	4408	4649	34	2014	448581*

* The figure includes varieties proposed for release/ notification and genetic stocks

(122), and pseudo- cereals (9) crop groups (Table 6.1).

In addition, 906 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. The received accession comprised cereals (210), vegetables (24), grain legumes (29) and oilseeds (643).

6.2 Monitoring of germplasm

Germplasm conserved in the long-term storage condition for ≥10 years (5178 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.

6.3 Distribution of germplasm for characterization, regeneration and utilization

A total of 64,034 accessions were supplied for utilization by different stakeholders. Most of the accessions were distributed for research, regeneration, characterization (under CRP on Agro-biodiversity) and evaluation. The details are given in Table 6.3.

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

Crop	Numbers of accession tested for viability	Initial viability range (%)	Present viability range (%)	No. of accessions identified for regeneration
Paddy	1755	60-100	20-100	115
Wheat	385	85-100	80-100	0
Barley	620	90-100	90-100	6
Pea	200	85-100	85-100	-
Castor	50	85-100	80-100	3
Groundnut	220	95-100	85-100	nil
Linseed	112	90-100	85-100	nil
Safflower	100	92-100	85-100	4
Niger	354	85-100	75-100	28
Sunflower	100	85-100	80-100	6
Chilli	39	70-90	70-90	-
Pumpkin	177	70-90	70-90	5
Tomato	68	70-90	70-90	-
Okra	33	70-90	70-80	-
Medicinal crops	107	48-90 (hard)	70-100	-
Pseudo-cereals	69	100	90-100	-
Spices	71	70-100	80-100	-
Ornamentals	08	70-80	70-90	-
Cotton	236	65-100	48-100	150
Jute	145	85-100	60-100	66
Kenaf	94	85-100	60-100	94
Forage species	235	20-100	20-100	-
Total	9573			1250

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

Crops (no. of accessions)	Purpose	No. of accessions
Paddy (7904), Maize (11674), Sorghum (1285), Finger millet: (152), Foxtail millet: (11), Pigeon pea (1423)	CRP (AB)	22449
Paddy(15043), *Trifolium* sps..(597), Lucerne(229), Forage grasses (350)	Regeneration and/or evaluation	16219
Paddy (5581), Wheat(620), Lentil (194), Oats (1587), Safflower(6000), Niger (3000)	Multiplication / Characterization	16982
Paddy (319), Wheat(1175), *Lathyrus* (2812), Chickpea (87), French bean (11), Lentil (13), Sem (341), Urd bean (315), Mothbean (72), Cowpea (137), Horsegram (21), Mungbean (883), Pigeon pea (2), Cotton (140), Pumpkin(200), Okra(33), Chilli(318), Cauliflower (86), *Solanum* spp (149), Snake gourd(35), Tomato(129), Okra(33), Onion(1), Amaranth (962), Mehndi(14), Jobs tears(124), *Tecomella undulata* (11), *Dalbergia* (11)	Research	8384
	Total	64,034*

*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 enhance the security systems. Its 12 long-term storage (LTS) modules and four 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 and humidity (Fig. 6.1).

Fig. 6.1. Upgraded Long-Term storage modules are now state-of-the-art facility with AI enabled security systems

Convirm Service Technical Programme organised by Blue Star Engineering for the Genebank Technical staff (5-17th October, 2020) as a part of Genebank upgradation and modernisation (Fig. 6.2).

6.4.2 Technical Support to NAGS, Agricultural Universities and Agricultural Institutes

Technical know-how of low-cost conservation (MTS) and detailed layout drawing, for specifications of MTS for Department of Plant Breeding and Genetics, AAU, Jorhat, Assam was provided.

6.4.3 Management of MTS and LTS facilities

Routine activities include operation and maintenance of 12 Long Term Storage (LTS) and five Medium Term Storage (MTS) modules, to maintain the temperature (-20°C) for LTS Modules and (+4°C) for MTS Modules. Additionally, management of humidity level in LTS/MTS and maintenance of refrigeration system, seed dryers and other National Genebank facilities, is carried out round- the- clock to ensure safety of National Germplasm collections kept under Long-Term Storage in the Genebank.

6.5 Characterization of the Conserved Germplasm-(Relevant Aichi Biodiversity Target 2,6,7,14)

6.5.1 Large-scale characterization of rice landraces from NGB

12227 unique rice landraces representing the entire rice growing areas of the country (Fig. 6.3)

Fig. 6.2. Training programme for Genebank Technical staff

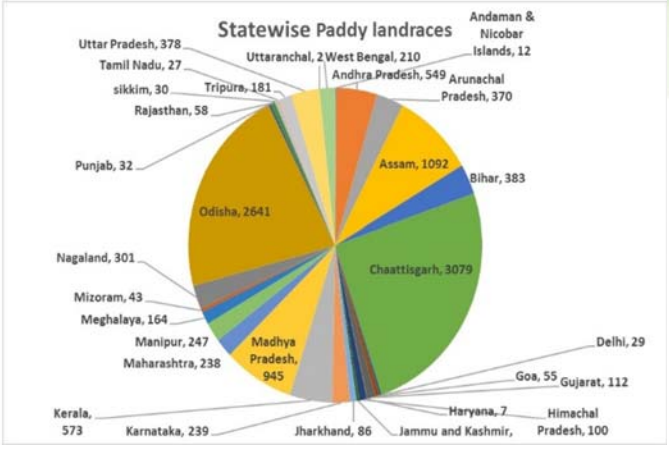


Fig. 6.3. Morphological characterisation of rice landraces conserved in National Genebank

were characterized for its agro-morphological traits. Broad variability was recorded for days to maturity, plant height, number of productive tillers, panicle length, leaf length and width, maturity and grain yield (Fig. 6.4). This set of accessions also exhibited large variation with respect to qualitative traits like seed colour, kernel colour, length/breadth ratio, aroma, threshability *etc*. (Fig. 6.5 & 6.6).

6.5.2 Mega characterization experiment of entire maize germplasm conserved in NGB

The entire maize germplasm collection of National Genebank (11,642 accessions) has been grown at Regional Maize Research and Seed Production Centre of Indian Institute of Maize Research, located at Begusarai, Bihar, under the

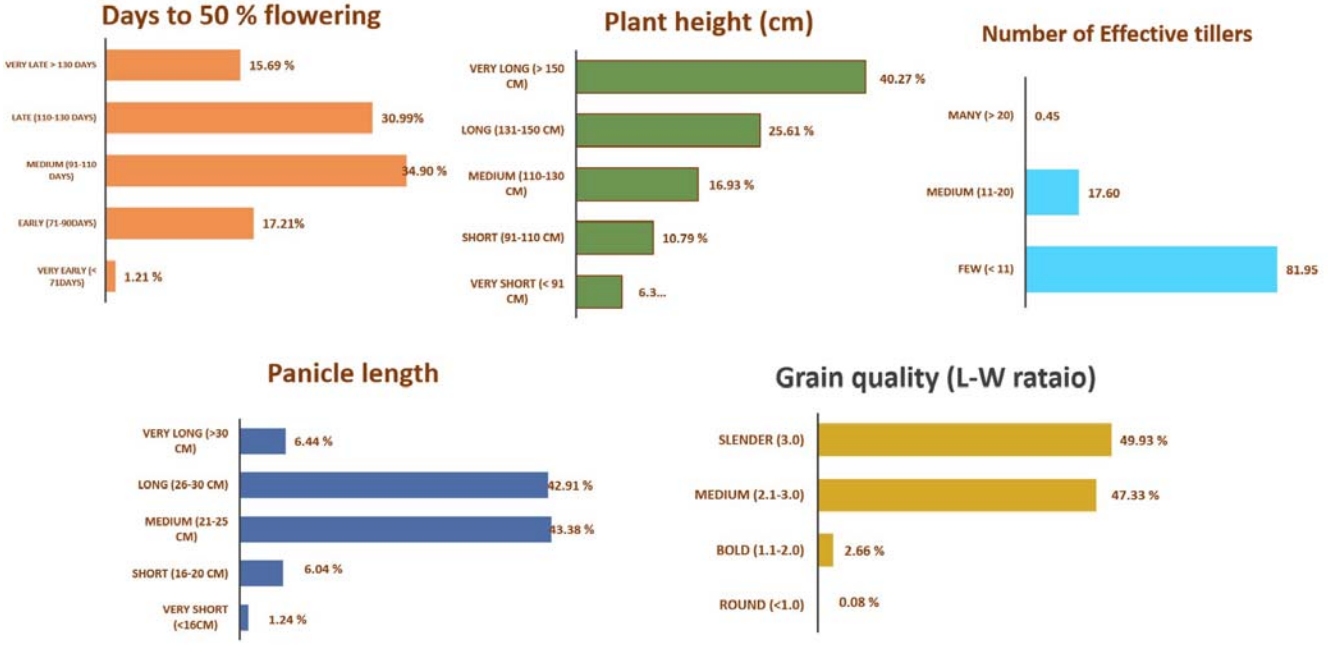


Fig. 6.4. Variation in Quantitative traits in rice landraces

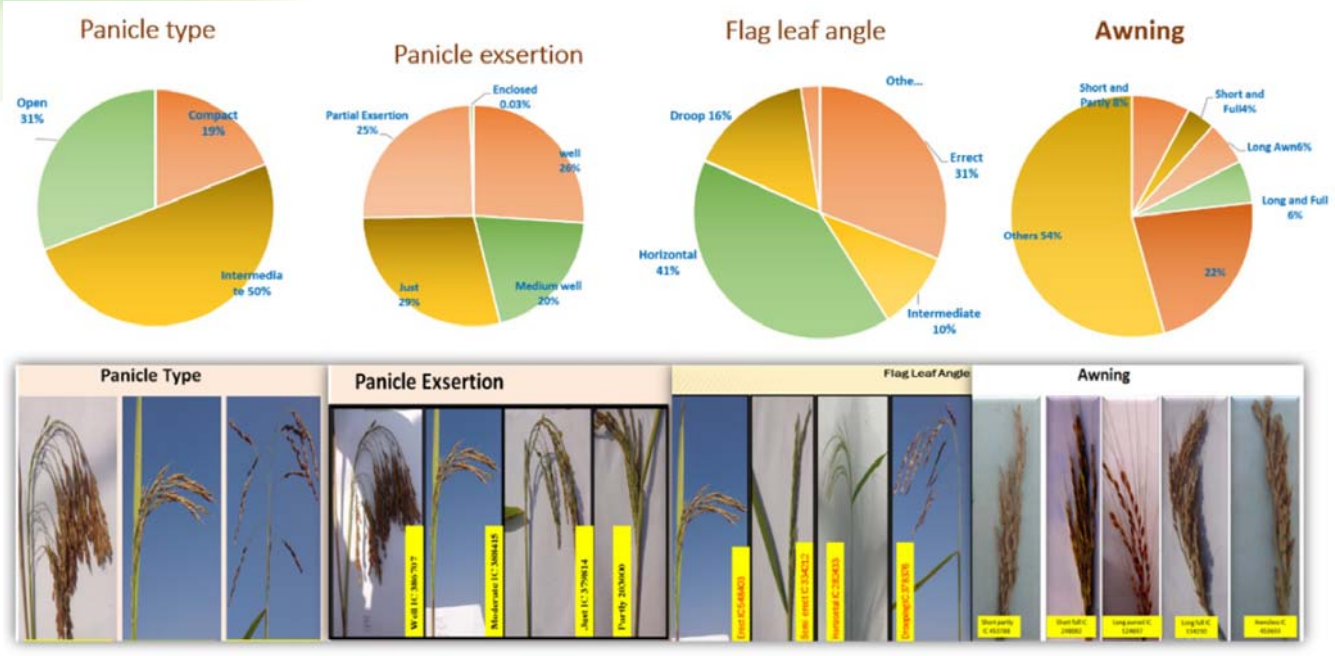


Fig. 6.5. Variation in Qualitative traits in rice landraces

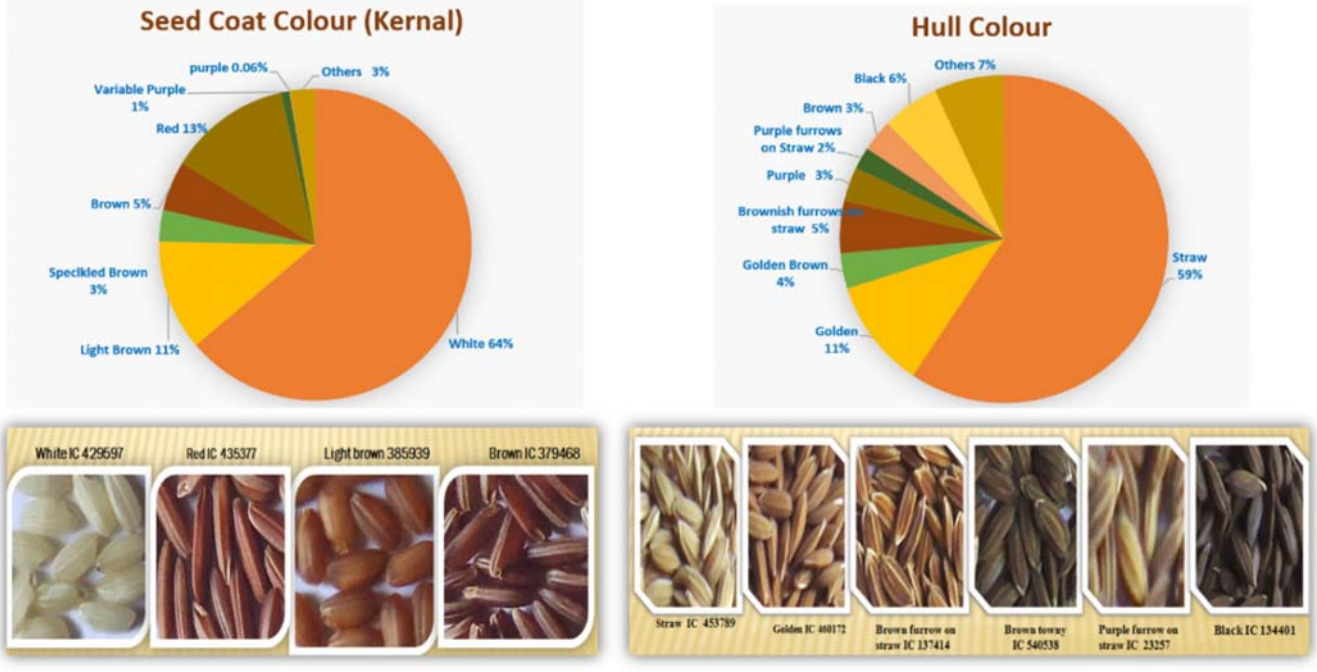


Fig. 6.6. Variation in seed traits of rice landraces

CRP (AB) programme, during *Rabi* 2020 (Fig. 6.7). The objective of the experiment is to characterize the entire germplasm and derive a core set for enhanced utilization. The accessions have been planted after categorizing them as per biological status and within each category, further stratification has been done based on source of collection. Data on more than 35 agro-morphological descriptors are being recorded.

Fig. 6.7. Field view of maize germplasm grown at IIMR-Begusarai, Bihar

6.6 Basic supportive research

6.6.1 Hydrothermal time (HTT) model of seed germination

To develop a predictive model for obtaining optimum seed germination in field during regeneration of conserved samples, data was generated for seven temperature and eight water potential combinations in rice, wheat, maize, barley, finger millet, mung bean, pearl millet and onion (Fig. 6.8). HTT modeling was done using repeated probit method and correlations have been developed.

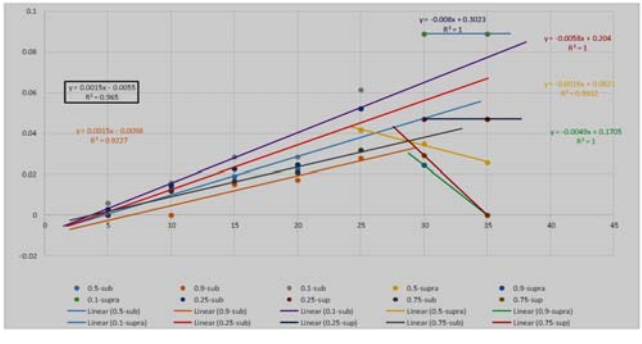


Fig. 6.8. Broken stick model for estimation of base, optimum and ceiling temperatures of seed radicle emergence

6.6.2 Glutathione half cell redox potential

As an alternative to seed viability monitoring through germination tests, efforts were made to standardize glutathione half-cell redox potential tests in wheat, barley, onion and soybean. Two varieties from each species were used for the experiment and redox equivalents were generated for 20 germination percentages in each. All the experiments were done in five replicates. -220mV to -180mV values of redox potential had seed samples above 80% viability (Fig. 6.9). This assay could effectively correlate a drop of 5% viability with a detectable difference in redox potential, thus indicating its potential use as a biochemical predictor for seed viability.

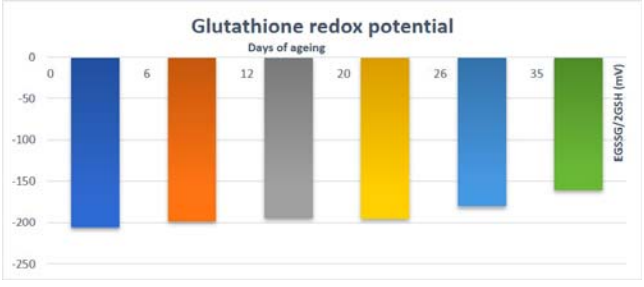


Fig. 6.9. Change in Glutathione redox potential values during artificial ageing of wheat seeds

6.6.3 Imbibition behaviour study of pea seeds with unique funiculus

To explore the role of funiculus in water uptake, intact seeds of uniform size and equal moisture content were subjected to three treatments (three replicates of 25 individual seeds for each

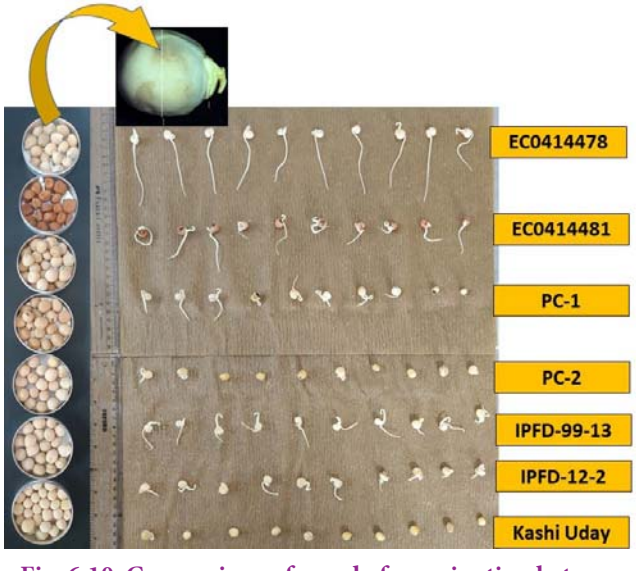


Fig. 6.10. Comparison of speed of germination between seed with unique hilum and normal pea seeds

treatments): (1) seeds with completely intact funiculus; (2) seeds with funiculus covered with varnish (three layers) and kept overnight for drying and (3) seeds with mechanically removed funiculus. Highest water uptake was observed in seeds with completely intact funiculus as compared to seeds with completely varnished funiculus and completely removed funiculus. When the reading was taken on the 4th day of sowing, the speed of germination was also superior in EC414478 as compared to all other accession used in the study (Fig. 6.10). Thus, EC414478 has faster rate of imbibition & germination, which indicates that funiculus may be facilitating enhanced water uptake in the EC0414478 accession.

6.6.4 Quick viability testing protocol standardized in *Maclura cochinchinensis*

For the standardization of viability testing and seed coat dormancy breaking protocol in *Maclura cochinchinensis* (Lour.) Corner, three temperatures (30, 35, and 40°C) with two concentrations of TTZ (0.5%, and 1.0%, with pH 7.0, prepared in distilled water) and three different durations of soaking in TTZ (1 h, 1.5 h, and 2 h) were attempted, using three replications of each treatment. Statistically significant result (correlated with actual seed germination) was obtained at 1% TTZ for 1 hr. at 30°C temperature (Fig. 6.11).

Fig. 6.11. TTZ stained viable embryo of *Maclura cochinchinensis* (Lour.) Corner

6.6.5 Identification of bold seeded ricebean accession

A bold seeded accession of ricebean germplasm, IC137150 with 100 seed weight (37.4 g) was identified and sent for evaluation and validation at three locations namely., ICAR-NBPGR, New Delhi and ICAR-NBPGR, RS, Shimla and Shillong, for validation.

6.7 Plant Germplasm Registration

Two Plant Germplasm Registration Committee (PGRC) meetings were conducted online through GRIS (Germplasm Registration Information System). The first meeting was held at ICAR-NBPGR, New Delhi on September 29, 2020 and second on December 21, 2020 under the Chairmanship of Dr AK Singh, DDG (CS) ICAR, New Delhi. Out of 253 proposals submitted, 123 were considered for registration. Finally, 117 proposals belonging to 61 species were approved for registration (Table 6.4). Some notable registered germplasm were: Rice with high zinc in grains, purple leaves and panicles; Rice highly tolerant to sheath blight; Wheat tolerant to drought stress; Barley highly resistant to stripe rust with high 1000 grain weight (47.5g). and low protein content (9.5%); Barley with low beta glucan content (<3.) and resistance to yellow rust; French bean resistant to white mold disease (*Sclerotinia sclerotiorum*); First CMS line in radish with higher heterosis for yield, root length and root weight; Castor with high ricinoelic acid and early maturity; Sugarcane with drought tolerance; Oil Palm with more number of bunches and slow vertical growth; Chrysanthemum with pink flower colour, flower diameter 9.94cm, plant height 100.97cm; Papaya tolerant to Papaya Ringspot Virus with yellow flesh; Wild diploid potato with wider genetic base highly resistant to late blight disease.

Kashi Kale-1 (IC0632940; INGR20035) a Collard green (*Brassica oleracea* var. *acephala*) germplasm first of its kind in the world that bolts, flowers and sets seeds during spring season. It does not require vernalization to stimulate/induce bolting and flowering. Fast growing and high leaf yield potential i.e. 45-50 t/ha.

IIHRG-7 (IC0620379; INGR20066) a Gladiolus (*Gladiolus hybrida*) germplasm with spike of variegated florets.

IIHRGO-1 (IC0632739; INGR20102) a Gerbera (*Gerbera jasmeonii*) germplasm with bright red and double type flowers.

M 81 (IC0628528; INGR20078) a Sunflower (*Helianthus annuus*) germplasm resistant to powdery mildew (PDS<10%).

CSIR-IHBT-CH-14-4 (IC635438; INGR20108) a Chrysanthemum (*Dendranthema grandiflora*) germplasm with pink flower.

Pune Selection-2 (IC0637024 ; INGR20113) a Papaya (*Carica papaya*) germplasm tolerant to Papaya Ringspot Virus and fruit with yellow flesh.

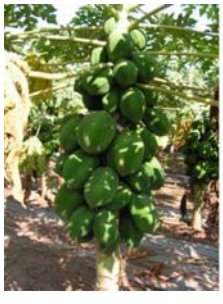


Table 6.4: Status of registered genetic stocks in the National Genebank (as on December 31, 2020)

Crop-group wise germplasm registered		
Crop group	**Current status**	**January 01, 2020-December 31, 2020**
Cereals and Pesudocereals	570	27
Millets	87	5
Fibre and Forages	120	1
Grain Legumes	163	12
Vegetables	95	11
Commercial Crops	107	7
M & AP and Spices	105	14
Ornamentals	80	18
Oilseeds	220	17
Fruits and Nuts	46	2
Tubers	42	3
Agro-forestry	8	-
Grand Total	**1643**	**117**

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, *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** 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**, Neeta Singh, Sherry Rachel Jacob and J Aravind)
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 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)
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 (PI-**Sherry Jacob**)

7 TISSUE CULTURE AND CRYOPRESERVATION UNIT

Summary: Cultures of 1,916 accessions of 149 plant species of different horticultural crops were conserved in the *In Vitro* Active Genebank (IVAG) at ambient and/or at low temperature, with subculture duration ranging from 2-24 months. A total of 11,906 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 30 new accessions were added to the IVAG and 35 accessions were added to *In Vitro* Base Genebank (IVBG). *In vitro* multiplication protocols were developed in *Artocarpus lakoocha* and *Garcinia gummi-gutta*, while slow growth conservation protocols were developed/ refined in *Allium albidum, Allium ramosum, Artocarpus lakoocha* and *Garcinia indica*. Varying degrees of success was achieved in cryopresevation experiments using vitrification, droplet vitrification and V- and D-cryoplate techniques. Maintenance of genetic integrity of cryopreserved plants was confirmed in *Bacopa monnieri* (using 39 ISSR markers), *Stevia rebaudiana* (using 40 SSR markers) and *Dioscorea deltoidea* (using 30 SSR and 39 ISSR markers). A total of 123 accessions were cryostored as seeds, embryonic axes and pollen at temperatures between -160°C to -180°C. Freezing and desiccation studies were carried out in 12 species and protocols for breaking seed dormancy were optimized in four species. Long-term seed conservation protocol was optimized in *Docynia indica*. *In vitro* pollen germination protocol was stadardized in *Zea mays and Z. mexicana*. The activities of TCCU comply with the SDG 2 and Aichi Targets 13 and 18.

7.1 Conservation of vegetatively propagated/ horticultural crops

7.1.1 Germplasm maintenance

A total of 1,916 accessions of different horticultural crops in the form of 36,600 *in vitro* cultures and/or *in vitro* cryopreserved meristems/ shoot-tips were conserved in the *In Vitro* Active Genebank (IVAG) or *In Vitro* Base Genebank (IVBG), respectively (Table 7.1). Cultures in IVAG are normally conserved at 25±2°C under 16 h photoperiod, and in some species, at low temperature (5-10°C, in dark). The average subculture period under these conditions varied from 4-24 months, depending on the species/ genotype and the conservation strategy employed.

7.1.2 Germplasm augmentation and addition

Germplasm augmented for its conservation in the IVAG/IVBG comprised of accessions *Allium sativum* L. from ICAR-DOGR, Pune (46) and National Horticultural Research and Development Foundation, New Delhi (2); *Trillium govanianum* (5); *Naregamia alata*, a rare medicinal plant, and *Sauropus androgynous*, a multivitamin plant, both collected from Karnataka (1 each); *Ipomoea batatas* (5 breeders' lines) and *Colocasia esculenta* var. *antiquorum* (32,) from ICAR-NBPGR RS, Hyderabad; *C. esculenta* from Bihar (1) and ICAR-NBPGR RS, Shillong (4 accessions). Some 30 suckers/floral buds of *Musa* cultivars/wild relatives were obtained from project network partners and ICAR-NBPGR regional stations during the year. In addition to these, CWR of ginger, namely, *Zingiber neesanum* (1) and *Z. wightianum* (1) and *Piper* spp. (5) from ICAR-NBPGR RS, Thrissur, *Z. zerumbet* (1) from Odisha, *Curcuma longa* (1) from Bihar, *Malus* and *Prunus* (21) from ICAR-CITH, Srinagar and 40 accessions of *Malus* from RS, Shimla, were augmented for conservation.

Table 7.1: Status of *in vitro* conserved germplasm in IVAG/IVBG (as on Dec. 31, 2020)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	No. of Accessions (% of total)	Major collections (no. of accessions)
Tropical fruits (banana)	2	16	9,000	443(23%)	*Musa* spp. (443)
Temperate and minor fruits (apple, apricot, blackberry, blueberry, pear, strawberry)	10	42	8,500	364(19%)	*Actinidia* spp. (11), *Aegle marmelos* (2), *Artocarpus lakoocha* (1), *Fragaria x ananasa* (81), *Malus domestica* (33), *Morus* spp. (61), *Prunus* spp. (15), *Pyrus communis* (73), *Rubus* spp. (62), *Vaccinium* spp. (21)
Tuber crops (sweet potato, taro, yam)	5	14	6,800	526(27%)	*Ipomoea batatas* (263), *Dioscorea* spp. (153), *Colocasia esculenta* (96), *Xanthosoma sagittifolium* (10) *Alocasia indica* (4)
Bulbous and other crops	4	13	4,000	171(9%)	*Allium* spp. (157), *Cicer microphyllum* (1), *Dahlia* sp. (6), *Gladiolus* sp. (7)
Medicinal and aromatic plants	30	40	4,000	185(10%)	*Coleus forskohlii* (14), *Plumbago zeylanica* (19), *Rauvolfia serpentina* (13), *Tylophora indica* (10), *Valeriana wallichii* (16)
Spices and industrial crops	8	24	4,300	227(12%)	*Curcuma* spp. (110), *Elettaria cardamomum* (5), *Humulus lupulus* (8), *Piper* spp. (7), *Simmondsia chinensis* (12), *Stevia rebaudiana* (1), *Vanila planifolia* (4), *Zingiber* spp. (80)
Total	59	149	36,600	1,916	

Based on the collections received, 30 accessions were added to the IVAG. These were *Artocarpus heterophyllus* (1), *Colocasia esculenta* var. *antiquorum* (6), *Curculigo orchioides* (1), *Dioscorea deltoidea* (5), *Ensete glaucum* (1), *Ipomaea batatas* (2), *Luffa tuberosa* (1), *Malus domestica* (1), *Musa acuminata* (1), *M. balbisiana* (1), *M. indandamanensis* (1), *M. velutina* (1), *M. itirenans* (1), *M. cheesmanii* (1), *M. puspanjaliae* (1), *Naregamia alata*. (1), *Pyrus communis* (1), *Prunus armeniaca* (1), *Rauvolfia serpentina* (1) and *Sauropus androgynous* (1). Initial *in vitro* establishment was achieved in a new species, *Trillium govanianum*.

7.1.3 *In vitro* cryobanking

Long-term conservation of medicinal plants by *in vitro* cryobanking of shoot-tips was continued in six accessions of *Bacopa monnieri*

Table 7.2: Status of germplasm cryobanked in the IVBG (as on Dec. 31, 2020)

S. No.	Species	Accessions added during 2020	No. of accessions in IVBG	Technique(s)	Explant (s)
1.	*Allium sativum*	0	132	V, DV	ST
2.	*A. chinense*	1	8	V, DV	ST
3.	*A. tuberosum*	0	4	V, DV	ST
4.	*A. hookeri*	0	2	V, DV	ST
5.	*A. albidum*	0	1	V, DV	ST
6.	*A. scorodoprasum*	0	1	V, DV	ST
7.	*A. fistulosum*	1	1	V, DV	ST
8.	*A. ramosum*	0	1	V, DV	ST
9.	*A. lineare*	0	1	DV	ST
10.	*Bacopa monnieri*	6	6	DV	ST
11.	*Colocasia esculenta*	1	1	DV	SM
12.	*Dioscorea deltoidea*	10	10	V	ST
13.	*D. bulbifera*	0	2	V	ST
14.	*Ensete glaucum*	1	2	AD	ZE
15.	*Fragaria xananassa*	0	1	ED	ST
16.	*Gentiana kurroo*	3	3	DV	ST
17.	*Musa* spp.	4	74	DV, V, AD	SM, ECS, ZE
18.	*M. acuminata*	1	7	DV	ZE, SM
19.	*M. balbisiana*	1	8	AD, DV	ZE, SM
20.	*M. indandamanensis*	1	2	AD	ZE
21.	*M. velutina*	1	2	AD	ZE
22.	*M. itirenans*	1	2	AD	ZE
23.	*M. cheesmanii*	1	2	AD	ZE
24.	*M. puspanjaliae*	1	3	AD	ZE
25.	*M. ornata*	0	1	AD	ZE
26.	*M. textilis*	0	1	DV	SM
27.	*Rubus hybrid*	0	6	ED	ST
28.	*Vaccinium ovatum*	0	7	ED	ST

(IC249250, IC375976, IC426442, IC353204, IC468878, IC342108), three accessions of *Gentiana kurroo* (IC266697, IC554589, IC612563), six accessions of *Dioscorea deltoidea* (IC527296, IC527297, IC527299, IC527300, IC527313, IC582604). Among the Alliums, *in vitro* cryobanking was done in four accessions of *A. chinense* (IC613375, IC627868, IC630346, IC634132) and one accession each of *A. fistulosum* (IC353541) and *A. lineare* (EC328492).

Cryobanking of *in vitro* derived shoot-tips was initiated in *Colocasia esculenta* (IC317585)

using the droplet vitrification protocol, with high rates of regeneration (80-90%). Similarly, cryobanking using the vitrification technique was initiated in four new accessions of the medicinal plant *D. deltoidea* (IC527303, IC527304, IC527307, IC527310). Eight accessions of CWR of banana (*M. acuminata, M. balbisiana, M. indandamanensis, M. velutina, M. itirenans, M. cheesmanii, M. puspanjaliae* and *Ensete glaucum)* were cryobanked as zygotic embryos, and one accession of *Fragaria* x *ananassa* (EC381255) using shoot tips.

7.1.4 Germplasm supply for utilization/ exchange

Three accessions of banana were supplied as *in vitro* cultures to ICAR-NRC for Banana, Trichy, for field evaluation. Shoot cultures of eight accessions each of *Centella asiatica* and *Plumbago zeylanica* were supplied to Delhi Technological University, Delhi, for research purpose. Seeds of neem (IC268566 and IC268588) retrived from cryogenebank were supplied to IIT, BHU, Varanasi.

7.2 Supportive Research

7.2.1 *In vitro* shoot multiplication/ micropropagation protocols

In vitro multiplication of medicinal plants : Experiments were initiated in *Naregamia alata* and *Podophyllum hexandrum* for *in vitro* multiplication/regeneration using nodal segments and shoot buds/leaf segments from seedlings, respectively. In *N. alata,* ~20% cultures multiple shoots (2-3 shoots) developed on MS medium supplemented with BAP and NAA. In *P. hexandrum*, sterilization protocol for aseptic germination of seeds was standardized and low germination (~20%) of seeds was observed. Using explants from the seedlings, experiments were initiated for *in vitro* multiplication. Shoot buds, induced using leaf explants (via callus) formed roots, however, the seedlings failed to grow further on various media tested (Fig. 7.1).

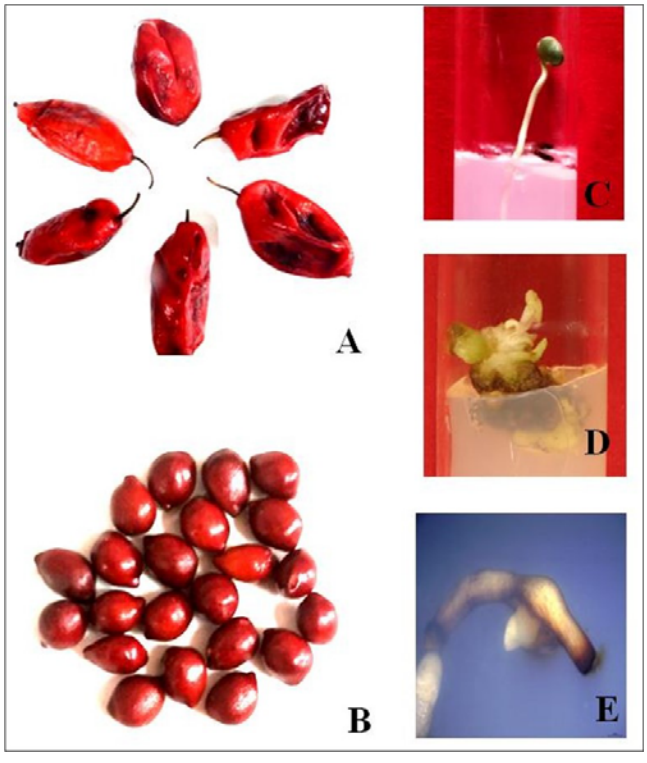


Fig. 7.1. *In vitro* multiplication of *Podophyllum hexandrum* Royle. (A) Fruits, (B) Seeds, (C) Seeds germinated *in vitro* (D) Shoot cultures (E) Shoot bud induction on *in vitro* root

In vitro establishment of Piper miniatum : Cultures were initiated from nodal explants of *P. miniatum* (AJJPN/19-116), a CWR of *P. nigrum*, collected from the Great Nicobar Biosphere Reserve in the Andaman and Nicobar Islands. Nodal explants surface sterilized with 0.2% bavistin for 10 min and 0.05% mercuric chloride for 3 min were cultured on MS medium supplemented different combinations of growth regulators, namely, BAP, Kn and NAA. Plantlets were successfully established *in vitro* and multiplied on MS + 0.44 µM BAP medium (Fig. 7.2).

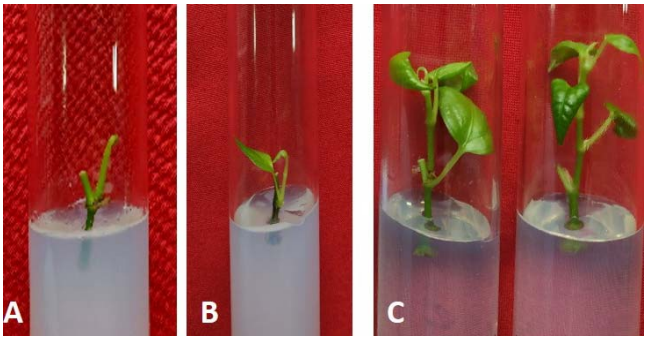


Fig. 7.2. *In vitro* establishment of *Piper miniatum*

In vitro aseptic culture establishment in Momordica dioica : Spine gourd/kankoda/kakora, a perennial dioecious cucurbitaceous climber, is a multipurpose plant, bearing fruits of high nutritional quality along with edible tubers. Preliminary experiments on aseptic culture establishment through pot-grown tubers were done. Protocol for surface sterilization of shoot-tip explants (from sprouted tubers) was standardized. *In vitro* cultures were established on MS medium supplemented with 0.8 µM BAP. Experiments are continued for refining the multiplication protocol *in vitro*.

***Shoot multiplication of Garcinia gummi-gutta*:** *Garcinia gummi-gutta* (family Clusiaceae), is a popularly used natural weight loss supplement, endemic to Western Ghats of India. Shoot multiplication medium was optimized in one accession (IC0638187) and 90% *in vitro* shoot induction from the cut seed portions were obtained on MS medium + 35.52 µM BAP + 1 µM NAA (Fig. 7.3). Maximum shoot multiplication (55±5 shoots/explant) was observed on 8.88 µM BAP and 2.68 µM NAA medium; higher BAP concentrations was found to be detrimental for shoot growth. Shoot elongation was achieved by transferring multiplied shoots to the MS + 0.2% charcoal medium.

***In vitro propagation of Artocarpus lakoocha* (IC612468):** For *in vitro* propagation using nodal explants (from *in vitro* shoots), MS medium supplemented with different concentrations of BAP (0, 0.2, 0.5, 1, 2 and 5 mg/L) and Meta-Topolin (MT) (0, 0.5, 1, 2 and 5 mg/L) was used to study their effect on growth. As compared to control, BAP and MT showed improvement in all the shoot growth parameters (Fig. 7.4) and BAP was superior than MT for shoot multiplication. No significant difference was observed on number of nodes using various concentrations of BAP and MT.

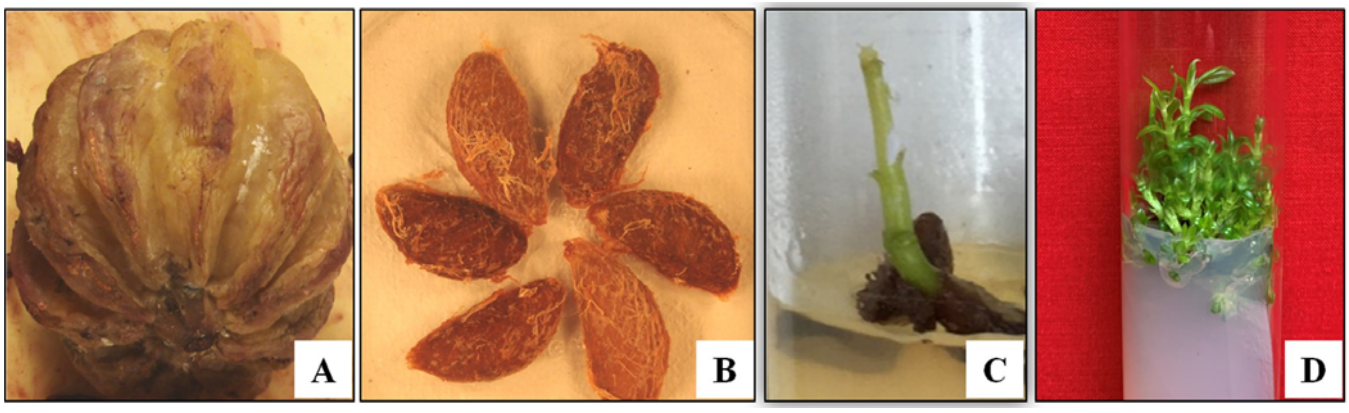


Fig. 7.3. *Garcinia gummi-gutta* (A) Fruits; (B) Seeds; (C) *In vitro* induced shoots; (D) Shoot proliferation in multiplication medium after seven subcultures

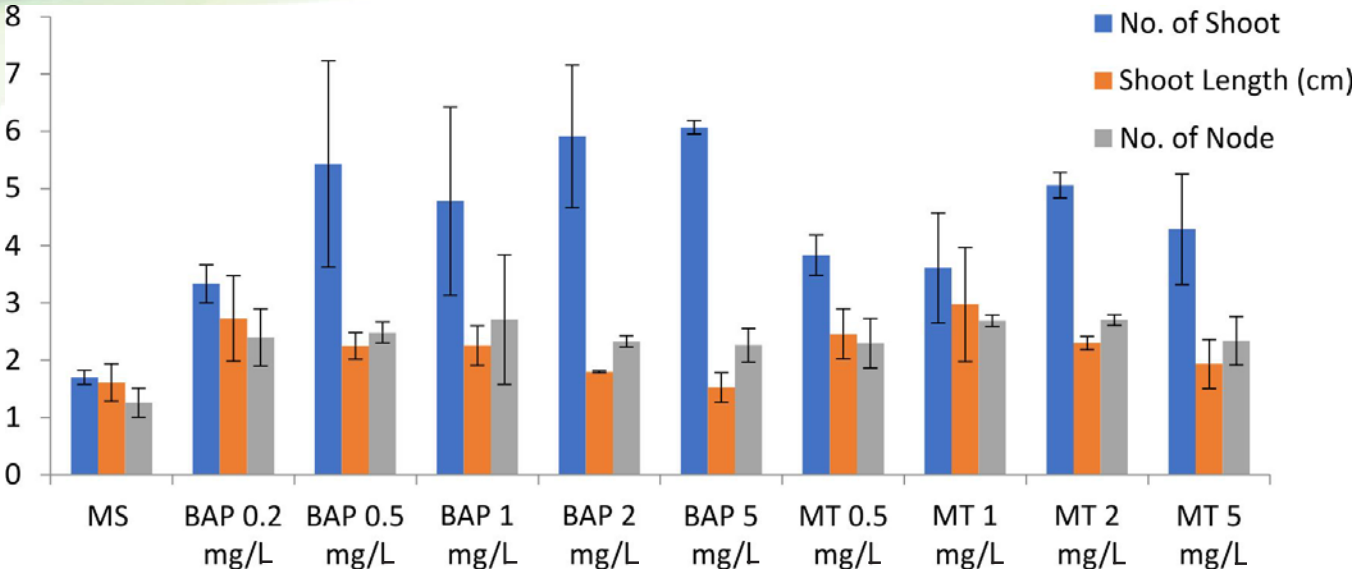


Fig. 7.4: Effect of BAP and MT on shoot parameters of *A. lakoocha*

7.2.2 *In vitro* conservation protocols

Alliums : Shoot cultures of *A. albidum* (EC328484) and *A. ramosum* (EC328498), maintained on respective shoot multiplication media with 10% sucrose for 18 months at 8°C in dark, exhibited 63% and 56% regrowth, respectively, upon subculture to fresh medium.

Garcinia indica : Medium-term conservation of *in vitro* raised cultures of *G. indica* was standardized. The subculture duration of the cultures could be increased to 16 months without loss in regeneration in MS+6.66 µM BAP+0.53 µM NAA medium supplemented with (Fig. 7.5). The cultures exhibited 90% regrowth upon subculture on fresh medium.

Artocarpus lakoocha : Effect of temperature and inclusion of mannitol in media, were studied for slow growth *in vitro* conservation. Data of conserved cultures up to 6 months showed that incubation at 25°C had more robust shoots than those incubated at 5°C, 10°C and 22/5°C. Addition of 1, 2, 5 and 10 mg/l mannitol to MS did not show any significant difference in survival of cultures up to six months.

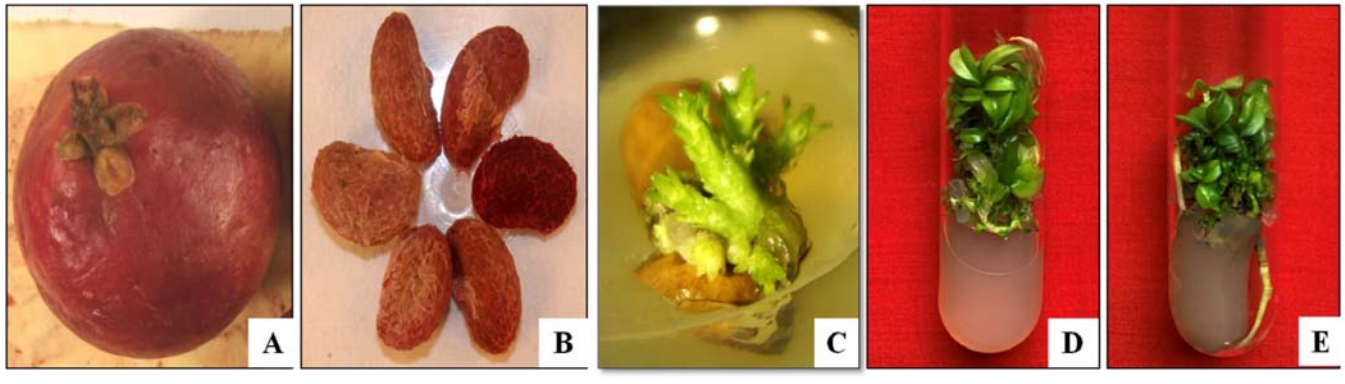


Fig. 7.5. *In vitro* slow growth in *Garcinia indica* (A) Fruits; (B) Seeds; (C) *In vitro* induced shoots; (D) Growth of shoots after 8 months of inoculation in slow growth media; (E) Shoot and root growth 16 months after inoculation in slow growth media

7.2.3 *In vitro* cryopreservation protocols

***Allium* spp.:** Droplet vitrification (DV) protocol, which had previously been developed in *A. chinense*, was applied to another accession (IC634132) using PVS3 (150 min), and there was 72% post-thaw regeneration. Cryopreservation experiments continued in *A. fasciculatum* (IC623460) using DV technique. Following pregrowth of shoot-tips (excised from mother cultures maintained on MS basal medium under culture room conditions) at 5°C on shoot multiplication medium containing 10% sucrose, there was improvement in post-thaw regrowth (38%) with PVS3 (150 min). Cryopreservation experiments were done with 51 accessions of *A. sativum* (from ICAR-DOGR, Pune) using DV technique. Post-thaw survival of shoot-tips (isolated from cloves), ranged from 0-100% and shoot regrowth varied from 0-80%.

Testing for regrowth following cryostorage, shoot-tips of *A. chinense, A. fistulosum, A. sativum*, and *A. tuberosum* exhibited nearly the same regrowth after 8-10 years of cryostorage (Table 7.3).

***Cicer microphyllum*:** Using DV technique, cryopreservation experiments continued in *C. microphyllum* (IC554567), a cold-tolerant CWR of chickpea. Shoot-tips, isolated from mother cultures maintained on shoot multiplication medium (B5 + 0.2mg/l BAP + 20 mg/l AgNO3 + 3% sucrose + 0.8% agar), were pre grown on B5 + 1% agar + 6% sucrose at 10°C. Following liquid nitrogen (LN) freezing, shoot-tips exhibited an average regrowth of 32%.

***Fragaria chiloensis* :** Three cryopreservation techniques, viz, encapsulation-dehydration, vitrification, and V-cryoplate were applied on *in vitro* grown shoot-tips of *F. chiloensis*. The post-thaw regrowth of cryopreserved shoot tips ranged from 2-15%. Regenerated plants were morphologically similar to the control plants (Fig. 7.6).

Table 7.3: Response of cryopreserved accessions of *Allium* spp. after 8-10 years of cryostorage

Accession	Response after 8-10 years of cryostorage		Response at the time of experiment	
	% Survival	% Regrowth	% Survival	% Regrowth
Allium sativum				
IC585712	70	60	20	20
IC585714	50	50	20	20
IC585715	50	40	25	25
IC633948	60	50	20	20
IC375070	96	50	90	30
IC374999	81	50	80	66
IC372944	97	56	80	50
IC48681	87	37	60	20
IC49360	48	28	100	25
IC49322	55	26	55	33
IC375014	96	46	90	40
IC372950	72	14	80	10
IC151090	88	28	70	30
A. tuberosum (IC554562)	40	40	40	40
A. chinense (IC353523)	44	33	40	40
A. fistulosum (IC353541)	33	33	25	25

Fig. 7.6. Cryopreservation of *F. chiloensis* using vitrification technique [L to R – cultures derived from meristem (control), 0.3 M sucrose, LS, PVS2, LN]

***Medicinal plants*:** Standardization /application of protocols for *in vitro* cryopreservation was continued in *Bacopa monnieri, Dioscorea deltoidea*, and *Rauvolfia serpentina* using DV and/or vitrification techniques. In *R. serpentina* (IC375975), shoot-tips, isolated from 6-month-old cultures, pre-grown on 0.5 M sucrose medium, exhibited 10% recovery of cryopreserved shoot-tips using DV and vitrification techniques. In *B. monnieri*, cryopreservation protocol was further refined and improved post-thaw regrowth (~80%) was obtained in two accessions (IC353204 and IC375976) using DV compared with 40% in earlier experiments using vitrification. This was validated on four other accessions.

***Musa balbisiana*:** Seed storage behaviour of *M. balbisiana* accessions EC653579, IC630992 and IC633382 was investigated for devising suitable conservation strategies. Mature seeds were desiccated to various MC (5,10,15, 20 and 25%) and stored at three temperatures (25, -20 and -196°C) to assess freezing sensitivity. Whole seeds as well as excised zygotic embryos were cryopreserved at the optimized MC using simple air dehydration technique. For recovery, data on *in vitro* regeneration of zygotic embryos was analyzed to determine optimal explant and conservation regime. Whole seeds in general were difficult to germinate whereas *in vitro* regeneration of zygotic embryos yielded high results (95 ± 5%). Seeds were found to be desiccation tolerant (viable up to 5% MC) and desiccated seeds (5-10%) were insensitive to ultra-low temperature (-20 and -196 °C), without significant loss of viability and germination potential. High moisture content (15, 20 and 25%) in seeds led to low regeneration potential (~50%) due to cold injury of cells at ultra-low temperatures (-20 and -196°C). No significant differences were observed in regeneration of fresh and cryopreserved desiccated (5-10% MC) excised embryos (90 ± 10%). Studies confirmed that *M. balbisiana* seeds are 'orthodox' in storage behavior, and can be easily conserved for short-term at 25°C, medium-term at -20°C and long-term at -196°C with 5-10% MC. However, unlike other typical orthodox seeds, regeneration of conserved seeds is only feasible through zygotic embryo culture under *in vitro* conditions, as desiccated whole seeds fail to germinate using standard protocols.

***Vaccinium ovatum*:** In an attempt to obtain higher post-thaw recovery of *in vitro* shoot-tips, glutathione treatment (0 and 24 µL) was tested on *in vitro* shoot tip cryopreserved using vitrification technique. Some 40% regrowth was observed both in control and after glutathione treatment.

***Vanilla planifolia*:** Cryopreservation of vanilla shoot-tips (IC573991) using the DV technique

was attempted. Shoot-tips were precultured for 3 days on high sucrose medium and dehydrated for five different time durations (0, 20, 30, 45 and 60 min) in PVS3 at room temperature, to study its effect on survival. Vanilla shoot tips were found to be very sensitive to desiccation. Control shoot tips with PVS3 added only prior to LN exposure also showed reduced survival (60%), and thereafter, the survival decreased with increasing PVS3 incubation time. Low post-thaw survival (20%) was observed after LN exposure, in shoot tips exposed to PVS3 for 20 min.

***Zingiber* spp.:** Seeds and embryos of *Zingiber neesanum* and *Z. wightianum* were studied for their tolerance to desiccation and freezing to explore the possibility for cryopreservation. Fresh seeds of both the species had high moisture content (46.16% and 59.62 % in *Z. neesanum* and *Z. wightianum*, respectively). Seeds of *Z. wightianum* desiccated to 24.28% MC retained their viability post LN exposure, while seeds of *Z. neesanum*, desiccated to 17.12% MC retained viability and germination post cryostorage. Excised embryos of both the species could be germinated *in vitro* successfully (Fig. 7.7).

7.2.4 Embryo rescue technique

Embryo rescue and in vitro regeneration to aid wide hybridization in linseed : Under the wide hybridization work for DBT funded mission programme on "Minor Oilseeds of Indian Origin (Linseed)", encouraging results were obtained through embryo rescue technique. The crosses of cultivated type *Linum usitatissimum* were made with wild types viz., *L. bienne* and *L. grandiflorum*. In crosses made between *L. usitatissimum* and *L. grandiflorum,* preliminary experiments indicated that the embryo degeneration starts on 12th day after pollination (DAP), and successful plantlet regeneration could be obtained from the embryos rescued on the 11th day after pollination. Embryo rescue from the cross made with *L. bienne* was successful in all crosses from 11th to 21st DAP. The media was standardized for maximum embryo regeneration and complete plantlets formation *in vitro* (Fig. 7.8).

7.2.5 Health testing of cultures

Health testing of in vitro germplasm of temperate fruits and tuber crops: Screening of 200 accessions of *in vitro* germplasm of temperate and minor fruits, *viz*., *Actinidia* spp. (6), *Morus* (27), *Pyrus* (17), *Fragaria* x *ananasa* (81), *Malus domestica* (33), *Prunus* spp. (15), *Vaccinium* (21) was done to check their health status for presence or absence of bacteria on Nutrient Agar medium through streaking method. All accessions were clean and free from bacterial as well as fungal contamination. Similarly, *in vitro* conserved accessions of sweet potato, *Dioscorea* spp. and aroids were tested for endogenous bacterial contamination. Efforts are underway to clean the contaminated cultures by rescue and/or meristem culture.

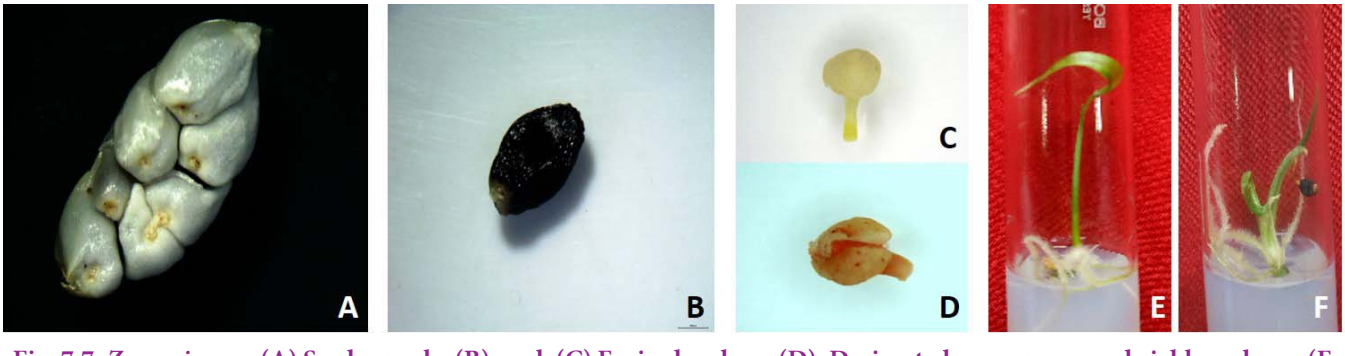


Fig. 7.7: *Z. neesianum* (A) Seed capsule; (B) seed; (C) Excised embryo (D); Desiccated – cryopreserved viable embryo; (E, F) *In vitro* raised plantlets

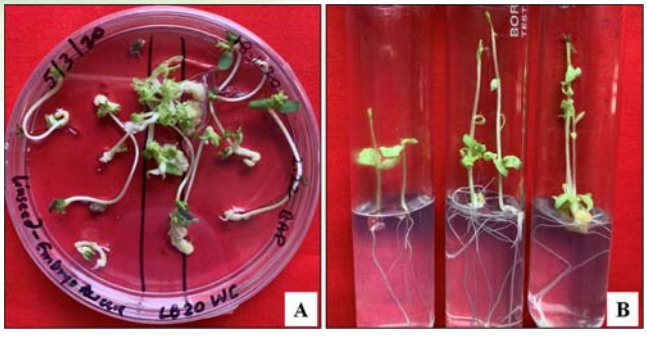


Fig. 7.8. *In vitro* regeneration of embryos rescued wide crosses A. *L. usitatissimum* (T 397) × *L. bienne* (EC 993389), B. *L. usitatissimum* (T 397) × *L. grandiflorum* (IC633096)

7.2.6 Hardening of *in vitro* conserved plants

In vitro collections of *Rubus* spp., *Vaccinium* spp. and *Morus* spp., conserved *in vitro* for more than 10 years were rooted and transferred to pots for hardening. The primary hardening was carried out in the newly constructed mist chamber at ICAR-NBPGR, New Delhi. Protocol was standardized to obtain successfully hardened plants of *Rubus* (Fig. 7.9a) and *Morus* spp. (Fig. 7.9b) with 95-100% survival, after 2-3 attempts.

Fig. 7.9: (A) *In vitro* conserved for more than 10 years, hadrened plants of *Morus* (mulberry); (B) *Rubus* spp. exotic collection: *In vitro* conserved for more than 10 years, hadrened plants

7.2.7 Genetic stability analysis of *in vitro* raised and cryopreserved germplasm

***Bacopa monnieri*:** A total of 39 ISSR primers were used for genetic stability analysis of plants of two accessions of *Bacopa monnieri* (IC353204 and IC375976), cryopreserved using two different techniques, vitrification and DV. No significant variation was observed between the banding profiles of *in vitro* multiplied material (tissue culture controls); plants used as cryopreservation controls and cryopreserved plants. High levels of genetic similarity (94.00 - 99.80%) were observed between the plants of the same accession, indicating no loss of genetic stability of the tested plants at the tested loci (Fig. 7.10).

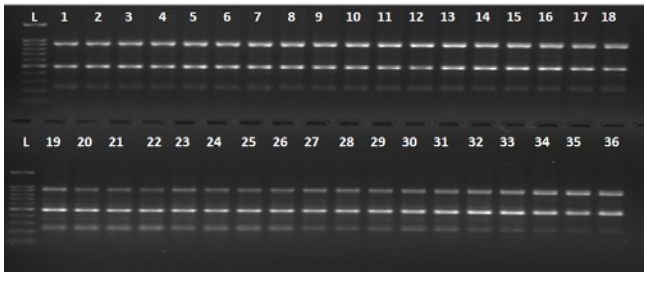


Fig. 7.10. Representative gel image of amplification of two accessions with ISSR primer UBC-826; Lane L: 100bp DNA marker; 1-18 IC353204 (1-3 - cryopreservation control at 0°C; 4-6 - cryopreservation control at 25°C; 7-9 –LN - vitrification at 0°C; 10 -12 LN-vitrification at 25°C; 13-15 LN- droplet-vitrification at 0°C; 16-18 LN-droplet-vitrification at 25°C); 19-36 – and IC375976 (19-21 - cryopreservation control at 0°C; 22-24 - cryopreservation control at 25°C; 25-27 – LN - vitrification at 0°C; 28-30 - LN vitrification at 25°C; 31-33 - LN-droplet-vitrification at 0°C; 34-36- LN droplet-vitrification at 25°C)

***Dioscorea deltoidea* :** Plants of three accessions of *D. deltoidea* (IC527303, IC527304, IC 527313), subjected to cryopreservation by vitrification and DV protocols were analysed for their genetic stability using 39 ISSR and 30 SSR markers. Analysis revealed no significant

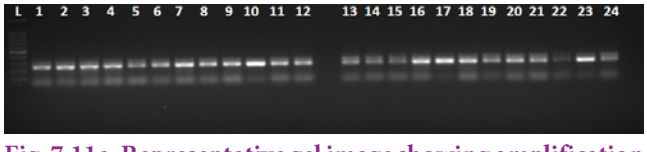


Fig. 7.11a. Representative gel image showing amplification of *D. deltoidea* (IC527304, IC527313) with SSR Primer 14081; L – Molecular weight marker, 1-12 IC527304 plants; 1-3 – *in vitro* mother plant; 4-6 - PVS2 controls, 7-9– LN - vitrification, 10-12-LN-DV; 13-24 IC527313- 13-15- *in vitro* mother plant; 16-18 - PVS2 controls, 19-21– LN - vitrification, 22-24-LN-DV

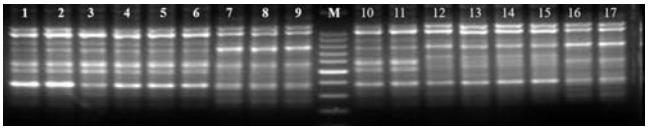


Fig. 7.11b. Representative gel image showing amplification of *D. deltoidea* (IC527303 and IC527313) with ISSR Primer UCB-835; M – Molecular weight marker, 1-9 IC527303 plants; 1-2 – *in vitro* mother plant; 3 - PVS2 controls, 4-6– LN - vitrification, 7-9-LN-DV; 10-17 IC527313 plants - 10-11- *in vitro* mother plant; 12— PVS2 control, 13-15– LN - vitrification, 16-17-LN-DV

differences between the plants of the same accession at the tested loci, and the plants were found to show 87-98% genetic similarity amongst themselves (Fig. 7.11).

***Stevia rebaudiana* :** A total of 40 EST-SSR primer pairs were used for analysis of genetic stability of plants of one accession of *S. rebaudiana* (IC624506), cryopreserved using three cryopreservation techniques, DV, D-plate method and V-plate method. The SSR banding patterns revealed an overall similarity level of 94% between the mother plants, controls and plants regenerated from cryopreserved shoot tips and on the basis of the SSR analysis, no significant variation was detected among the tested plants (Fig. 7.12).

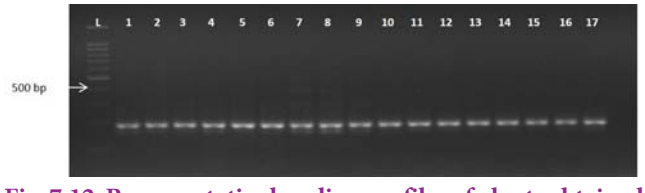


Fig. 7.12. Representative banding profiles of plants obtained by EST-SSR primer E65. L-100bp DNA marker; 1- *in vitro* mother plant; 2,3 - PVS2 controls; 4-6 – plants conserved by vitrification; 7-9 - plants conserved by droplet vitrification; 10-12- plants conserved by V-Plate method; 13,14 - D-Plate controls; 15-17 - plants conserved by D-Plate method

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

7.3.1 Germplasm augmentation and cryostorage

A total of 11,906 accessions comprising non-orthodox (intermediate and recalcitrant) and orthodox seed species and 2,194 genomic resources are being conserved in the Cryogenebank (Table 7.4). During the period, a total of 123 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 at temperatures between -160°C to -180°C.

Table 7.4: Status of cryopreserved germplasm (as on 31st December, 2020)

Categories	No. of accessions added in 2020	Total Accessions (no.)
Recalcitrant & Intermediate		
Fruits & Nuts	89	3,672
Spices & Condiments	0	164
Plantation Crops	0	121
Agroforestry & Forestry	0	1,645
Industrial Crops	2	1,343
Medicinal & Aromatic Plants	10	47
Total	**101**	**6,992**
Orthodox		
Cereals	0	289
Millets and Forages	0	293
Pseudo-cereals	0	76
Grain Legumes	0	813
Oilseeds	14	682
Fibers	0	68
Vegetables	0	587
Medicinal & Aromatic Plants	09	1,013
Narcotics & Dyes	0	35
Miscellaneous	0	78
Total	**23**	**3,934**
Dormant buds	0	**389**
Pollen grains	0	**591**
	123	**11,906**
Genomic resources	80	2194

7.3.2 Studies on desiccation and freezing sensitivity of germplasm

A total of 23 new species (47 accessions) were received from the explorations and collections made throughout India,. Desiccation

and freezing tolerance studies were done in seeds of *Ardisia macrocarpa* (9% MC), *Berberis umbellata* (11% MC), *Corylus ferox* (11% MC), *Corylus jacquemontii* (11% MC), *Cotoneaster microphyllus* (11% MC), *Elaeagnus parvifolia* (11% MC), *Holboellia latifolia* (9% MC), *Pyracantha crenulata* (9% MC), *Sambucus adnata* (9% MC), *Vaccinium glaucoalbum* (10% MC), *Viburnum cotinifolium* (6% MC), *and Zanthoxylum armatum* (11% MC). As the viability of the seeds reduced drastically below the critical MC (shown in paranthesis), these are categorized as intermediate seeds. Seeds of these species showing good post-thaw viability were further cryobanked for long-term storage.

Protocol for long term conservation of Docynia indica **:** Seeds of a wild edible fruit *Docynia indica*, commonly known as *Sohphoh khasi* collected from East Khasi Hills, Shillong. The MC of fresh seeds was as high as 23.3% with 90% viability. The viability of seeds remained unchanged upon desiccation till 8.9% MC although after cryopreservation, the viability dropped by 50%. Further reduction of seed moisture till 6% MC resulted in maximum viability after cryoexposure (80%). Complete loss in the viability of seeds post LN treatment was recorded when desiccated till 3% MC (Fig.7.13). The desiccation and freezing tolerance studies revealed *Sohphoh* seeds as intermediate type.

Protocol for breaking seed dormancy : Seed dormancy breaking protocol was standardized in *Pyracantha crenulata* (Indian hawthorn), *Etlingeria fenzlii, Viburnum cotinifolium* and *Zanthoxylum armatum*. The seeds of *Pyracantha crenulata* when soaked in leuke warm water for 24 h followed by GA_3 (250 ppm) spray showed 65% germination after 30 days. Soaking seeds of *V. cotinifolium* in 25% HCl for 15 min. enhanced germination to 70-90%. Seeds of *Z. armatum* only germinated when exposed to low temperature (5°C) for at least 1 month, while seeds of *E. fenzlii* could be germinated by soaking in normal water for 4 days.

7.3.3 Pollen germination studies and cryobanking

Pollen germination medium for Zea mays and Z. mexicana : The flowering time of the cultivated maize and the wild types are asynchronous, hence long-term storage studies to cryopreserve the pollen grains of the cultivated and wild maize (*Z. mexicana)* was done (Fig. 7.14). *In vitro* pollen germination was tested in 10 media combinations and the medium containing 10% sucrose, 0.05% H_3BO_3, 10mM $CaCl_2$, 0.05mM KH_2PO_4 and 3% PEG-4000 was found to be the best showing maximum pollen germination in fresh and LN stored pollen of both the species.

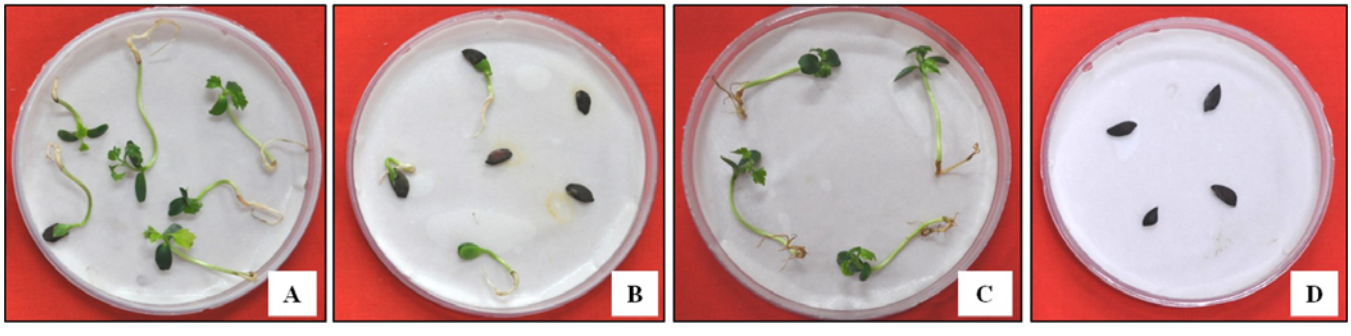


Fig. 7.13. Long-term storage in *Docynia indica* (Sohphoh khasi): (A) Fresh Seeds (23.3% MC; 100% Viability); (B) 6 h Desiccated seeds (8.9% MC; 50% Viability post LN); (C) 12 h Desiccated seeds (6% MC; 80% viability post LN); (D) 24 h Desiccated seeds (3%MC; no viability post LN)

Fig. 7.14. Pollen conservation of *Zea mexicana* (A) Tassel (B) *In vitro* germination of the pollen

7.3.4 Testing health status and regeneration of cryostored germplasm

Health status of 134 accessions of diverse crops, both fresh and cryostored, were checked and six were found infected. Post-cryo viability testing done for 44 accessions of fresh orthodox and non-orthodox seeds and 7 cryostored accessions revealed retention of viability after 5-10 years of their cryostorage (Fig. 7.15).

Fig. 7.15. Retesting of cryo-retreived germplasm of (A) *Azadirachta indica*; (B) *Capparis decidua*

7.3.5 Cryodatabase

More than 1,000 new entries comprising more than 10 attributes of cryobanked germplasm have been updated in the existing Cryodatabase. Curation of data for more than 100 accessions has been done.

Research Programme (Code: Title, **Leader)**
Programme I
PGR/TCCU-BUR-DEL-01.00: *Ex situ* conservation of plant genetic resources of vegetatively propagated crops using *in vitro* and cryopreservation techniques (**Anuradha Agrawal)**
Research project (Code, Title, **PI,** CoPIs & *Associates*)
PGR/TCCU-BUR-DEL-01.01: *In vitro* conservation of tuber crops with special reference to sweet potato, yams and taro (**Sangita Bansal**, Vartika Srivastava, *DK Nerwal*)
PGR/ TCCU–BUR-DEL-01.02: *In vitro* conservation of spices, plantation and new industrial crops [**Era V. Malhotra**, Anuradha Agrawal (up to Aug 6, 2020), Sangita Bansal (w.e.f. Aug 7, 2020,) *DPS Meena*]
PGR/ TCCU–BUR-DEL-01.03: *In vitro* conservation of bulbous and ornamental crops [**Ruchira Pandey** (up to Aug 31, 2020), **Gowthami R.** (w.e.f. Sept. 1, 2020), Neelam Sharma, Gowthami R. (up to Aug 31, 2020) and Vartika Srivastava (w.e.f. Aug. 7, 2020)]
PGR/TCCU–BUR-DEL-01.04: *In vitro* conservation of medicinal and aromatic plants with special reference to rare and endangered species [**Neelam Sharma** (up to Aug 7, 2020**),** Co-PI w.e.f Aug 8, 2020, **Gowthami R.** (w.e.f. Aug 8, 2020), Ruchira Pandey (up to Aug 31, 2020), Gowthami R (up to Aug 7, 2020), and Anuradha Agrawal (w.e.f. Aug 8, 2020)]
PGR/TCCU–BUR-DEL-01.05: *In vitro* conservation of tropical fruit crops species (**Anuradha Agarwal**, Era V. Malhotra, *DPS Meena*)
PGR/TCCU–BUR-DEL-01.06: *In vitro* conservation of temperate and minor tropical fruit crops (**Sandhya Gupta**, Narender Negi, *DK Nerwal*)
PGR/TCCU–BUR-DEL-01.07: Studies on genetic integrity of conserved germplasm [**Era V. Malhotra**, Sangita Bansal, Gowthami R. (up to Aug 6, 2020)]
Programme II
PGR/TCCU-BUR-DEL-02.00: *Ex situ* conservation of plant genetic resources of agricultural and horticultural crops using cryopreservation of seeds, dormant buds and pollen (**Anuradha Agrawal)**
PGR/TCCU-BUR-DEL-02.01: Cryopreservation of non-orthodox and orthodox seed species in various forms using standard protocols [**Sangita Bansal**, Era V. Malhotra (w.e.f. Aug 7, 2020), *AP Singh*]
PGR/TCCU-BUR-DEL-02.02: Investigating desiccation and freezing tolerance in non-orthodox seed species, dormant buds and pollen for cryopreservation [**Vartika Srivastava,** Gowthami R. (w.e.f. Aug 7, 2020)]

8 AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT

Summary: Agricultural Knowledge Management Unit (AKMU) at NBPGR is the center of PGR Informatics activities in ICAR. Aim of the unit is to facilitate easy access to PGR information to enhance PGR utilization through development and maintenance of PGR databases and web-based applications. The PGR Portal, NBPGR's principal web-based information resource, was accessed from many countries with an average number of >4900 views per month in 2020. AKMU's endeavor to disseminate information on PGR activities via Twitter has attracted as many as 2.5 lakh impressions (67% increase compared to last year) popularizing the role played by NBPGR.

8.1 PGR Portal: Access to information uninterrupted

PGR Portal has been providing the single window to access information on the plant genetic resources conserved in the Indian genebank. A few backend functional improvements were incorporated in the past year for stability improvement. The application is running 24X7 for past eight years. During the Covid19 pandemic period, PGR Portal ensured that researchers and students had uninterrupted access to PGR information except for a 40-day gap. During 2020, PGR Portal had 51,767 page views, at par with previous year. Google Analytics data show that 2859 users clocked >159 page views per day across 5072 sessions. Increasing popularity of PGR Portal among researchers was evident as 62% 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 30% users.

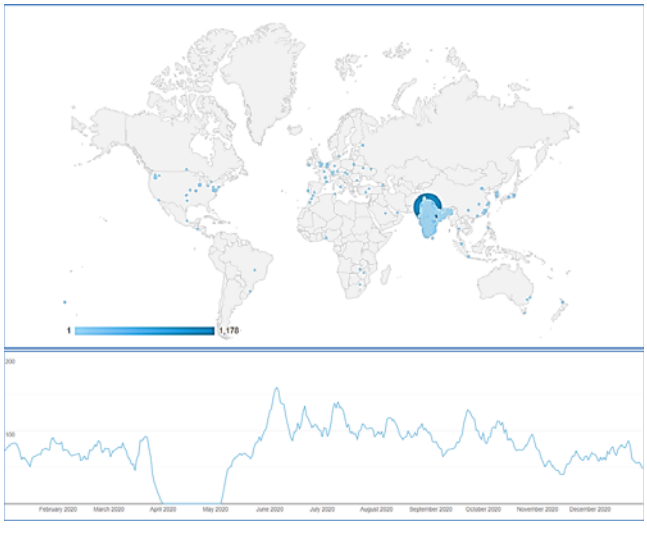


Fig. 8.1. Access to PGR Portal was from across the world (top) and throughout 2020 (except Covid19 pandemic forced server shut-down period (bottom). ***Source: Google Analytics***

8.2 Field genebank database and web-based application

Field genebank database was built and populated with data of 1247 accessions (815

Fig. 8.2. User interface of the Field Genebank Database

indigenous and 432 exotic) belonging to 74 crops (104 species). They include among others, mango (325), pomegranate (212), walnut (134), apple (100), pear (48), pecan (46), peach (37), grapes (26), cucumber (24), medicinal yam (21), apricot (20), etc. conserved across 11 locations. The home page shows *Infographics* of current status of data. User has options to use a *Quick Search* based on genebank ID or *Advanced Search* based on crop, location, etc.

8.3 AKMU dashboard and utility applications

AKMU dashboard provides a quick overview of databases and applications designed, built and hosted by NBPGR. Utility applications include: (i) finding out details of genebank accessions using IC/EC number; (ii) listing details of genetic populations (NILs/RILs) conserved in the genebank; (iii) verifying the passport data of accessions being used by researchers; (iv) displaying indigenous accessions on map; etc.

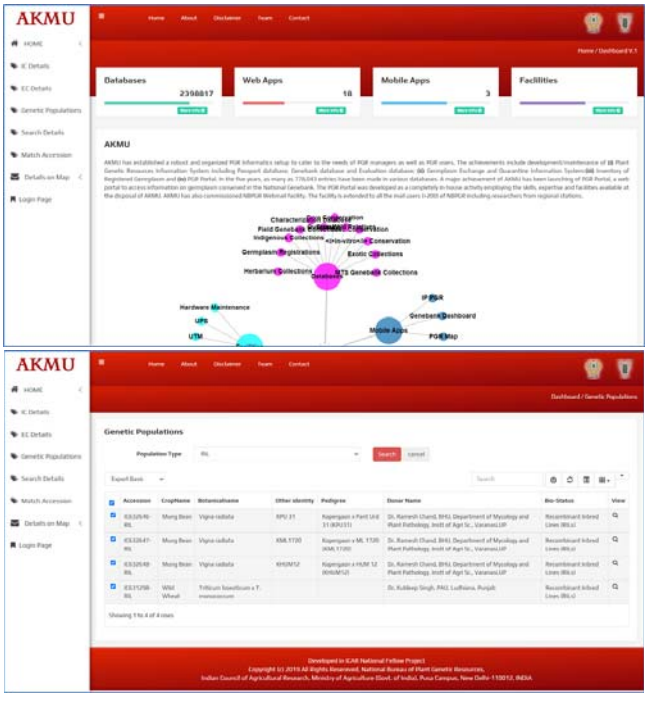
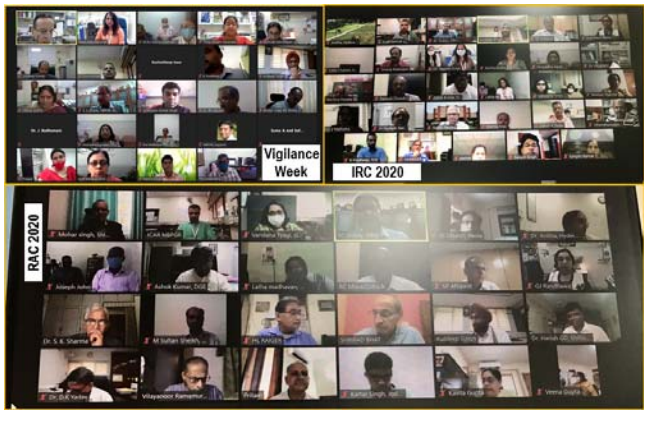


Fig. 8.3. User interface of the AKMU dashboard

8.4 Virtual meeting room facility

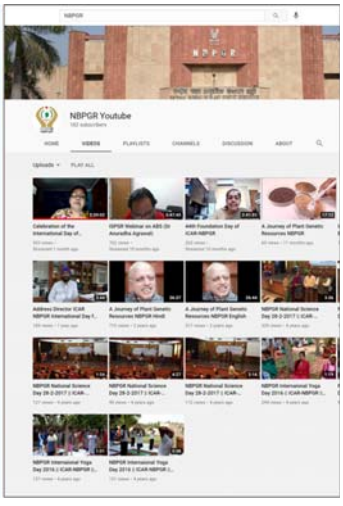
Due to extra-ordinary situation arising out of the Covid19 pandemic and the consequent lockdown/social distancing requirements—virtual meeting option was created by obtaining Zoom license for NBPGR (128466950) at a cost of INR 12000. With this facility of hosting meetings for up to 100 participants for any length of time, almost all kinds of activities of NBPGR were supported in a virtual mode. From June to Dec 2020, a total of 202 meetings were facilitated accounting for a total of 11,030 participants attending for a duration of 34,299 minutes (>570hours of online activity). The activities organized via zoom included 22nd RAC, 31st IRC (including many divisional pre-IRCs), 44th Foundation Day, 41st and 42nd PGRC, Genebank Safety Backup committee meetings, QRT report submission, all interviews at Delhi as well as regional stations, PGR course teaching, pre-qualifying viva, thesis seminars, teacher's day, training program (e.g. GIS by GEF team), project review meetings (CRP, DBT, GEF), brainstorming meetings (BDA, pre-project), webinars (ABS, PGR Course), IBSC, vigilance week activities, हिन्दी सप्ताह activities, SC-SP meeting as well as women cell meeting. By procuring, hosting and facilitating the above mentioned activities in a virtual mode, AKMU has ensured that (i) the diverse activities of the Bureau were carried out without interruptions; (ii) substantial cost incurred in organizing the physical meetings is saved; and (iii) colleagues from regional stations participated in all the institutional activities.



8.5 NBPGR on social media

NBPGR maintains a strong presence on the social media via the official twitter account

@INbpgr. During 2020, NBPGR tweeted 327 information bits, which attracted as many as 2.5 lakh (67% increase compared to last year) impressions. Twitter handle was a major medium of communication during the Covid19 lockdown and work-from-home conditions.



Two events were webcast live on NBPGR YouTube channel: 44th Foundation Day of ICAR-NBPGR (03.08.2020) and Webinar on Access and Benefit Sharing (27.08.2020). Three video clips of NBPGR activities were hosted.

8.6 PGR Informatics activities

Table 8.1: PGR data status (number of accessions)

Information	Activity	Additions during 2020	Status as on Dec. 31, 2020
Indigenous collections	IC number allotment	3160	636692
Exotic collections	EC number allotment	39359	1067305
Genebank information	Data addition	9052	448581
Characterization data	Data porting	33571	202935
CryoBase	Data addition	137	9967
Plant Germplasm Registration	Data addition	117	1643

Table 8.2: PGR Informatics portfolio of NBPGR (Open access)

Application	URL
NBPGR Homepage	www.nbpgr.ernet.in
PGR Portal	pgrportal.nbpgr.ernet.in
Import Permit and EC Data Search	exchange.nbpgr.ernet.in
Genebank Dashboard	genebank.nbpgr.ernet.in
National Herbarium of Crop Plants	pgrinformatics.nbpgr.ernet.in/nhcp
Biosystematics Portal	pgrinformatics.nbpgr.ernet.in/cwr
PGR Climate	pgrinformatics.nbpgr.ernet.in/pgrclim
Registered Crop Germplasm	www.nbpgr.ernet.in/registration/
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

8.7 Upgradation of Local Area Network of NBPGR

Local Area Network (LAN) infrastructure in the Bureau was upgraded during Oct-Dec 2020. The work involved—

a) Installation of 14 fiber cable backbones from AKMU to various division hubs, replacing the existing UTP.

b) The old campus is now connected with fiber cable for a secured, stable and fast data communication.

c) Replacement of obsolete LAN switches with latest high speed switches for fiber connectivity.

d) Provision of WiFi internet at Director's Chamber and HB Singh Committee Room.

e) Enhancing the NKN-NIC internet speed from 100Mbps to 1Gbps.

All the switches, routers and firewall are now set for transition from IPv4 to IPv6.

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

c) Hosted a web application for *Medicinal Plants Genomic Resource Database* http://www.nbpgr.ernet.in/med_plant/index.html and for *Amaranth Genomic Resource Database* http://www.nbpgr.ernet.in:8080/AmaranthGRD/ on the web server.

d) Facility to generate QR codes on the Germplasm Registration Certificates was implemented and an inventory search was added http://www.nbpgr.ernet.in:8080/registration/InventoryofGermplasm.aspx

e) NBPGR website was regularly updated by addition of advertisement (**32**), annual reports (**1**); books/manuals/bulletins (**7**); circulars (**18**); corrigendum (**15**); events (**2**); e-publications (**1**); newsletter (**7**); purchase / rate contract (**1**); tender (**67**); training (**1**); news (**50**).

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

IXX10707: PGR Informatics (**S Archak**, Radhamani J, Anuradha Agrawal, MC Singh, DP Semwal, Pragya, Kuldeep Tripathi, Rajeev Gambhir, Nirmala Dabral, Anang Pal)

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: One exploration and collection programme was undertaken during the year 2020 and a total of 57 accessions of pigeon pea (cultivated and wild) were collected from the Buldana and Aurangabad districts of Maharashtra. A total of 4161 accessions comprising 592 accessions during *rabi* 2019-20 and 3,569 accessions during *Kharif* 2020 were characterized and evaluated. Crop-wise accessions characterized were linseed (283), chickpea (100), safflower (59) and grain amaranth (150) during *rabi* 2019-20 and moth bean (1,545), mung bean (200), little millet (31), foxtail millet (100), sesame (1,538) and winged bean (155) in *kharif* 2020. Supplied 1,229 accessions of various crops for research purpose to 27 user agencies within India. Multiplied and regenerated 419 germplasm accessions of different crops during the reporting period. A total of 20,838 accessions of various crops/species germplasm comprising oilseeds (10,452), pulses (4,687), vegetables (2,034), potential crops (1,399), millets (1,536) and 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, a collection of pigeon pea (cultivated and wild) from tribal areas of Buldana and Aurangabad districts of Maharashtra was undertaken during 2020 21-31, January. A total of 57 accessions were collected from 39 collection sites (Villages) from Buldana, Aurangabad and adjoining districts. In total, 57 accessions belonging to two genera were collected. These includes, the targeted species of *Cajanus cajan* (42), *Cajanus scarabaeoides* (12), *Rhynchosia minima* (02) and *Rhynchosia rothii* (01).

High variability was observed in cultivated pigeon pea genotypes for pod colour, pod shape, seed colour and seed size. *Rhynchosia minima* was found to be present in cultivated pigeon pea fields whereas *Rhynchosia rothii* was confined to wild habitat. *Cajanus scarabaeoides* exhibited entirely isolated habitat in undisturbed wild areas mostly in hilly regions, wild life sanctuaries etc. The variation observed in pigeon pea was mostly in tribal areas whereas in plains there was no significant variation in cultivars. (Fig. 9.1 – 9.2)

Fig. 9.1. Collection site- Lonar Crater and typical habitat of *Cajanus scarabaeoides*

Fig. 9.2. Variability collected in cultivated pigeon pea

During this exploration, our team visited the village Kombhalne, Tal. Akole, Dist. Ahmednagar a native village of Padma Shri Rahibai Soma Popere. Team ICAR-NBPGR felicitated her for the prestigious award Padma Shri. She is a tribal woman farmer who is highly devoted to conserving native landraces of important crops of the region. From last 20 years, she has conserved and multiplied more than 122 landraces of different crops (paddy, hyacinth bean, millets, cucurbits, pulses, oil seeds, vegetables etc.) in her traditional seed bank and also distributed them to farmers from nearby villages (Fig. 9.3).

Fig. 9.3. Visit to village Kombhalne to felicitate Padma Shri Rahibai Soma Popere

9.2 Characterization and evaluation of germplasm

9.2.1 *Rabi* 2019-20

A total of 592 accessions were characterized and evaluated during *Rabi* 2019-20 and crop-wise accessions characterized were chickpea (100), grain amaranth (150), linseed (283) and safflower (59). 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).

Chickpea: One hundred chickpea accessions and four checks (PG-12, Vijay, SAKI 9516 and Warangal) were evaluated in Augmented Block Design (ABD). Promising accessions identified were for days to 50% flowering: SAKI 9516 (56 days), IC94934 and IC95127 (58 days); for pods per plant: IC94985 (171), IC94877 (162) and IC95068 (160); for yield per plant: IC94877 (26.20g), IC94946 (25.10g) and IC95126 (24.14g) and for test weight IC95126 (18.2g) and IC95127 (17.9g) (Fig. 9.4).

Fig. 9.4. Chick pea evaluation- Field view

Linseed evaluation trial: A total of 221 accessions of linseed were evaluated along with three checks (T-397, Kartika and Shekhar) in ABD. High variability was observed for days to flowering, plant types, plant height and other morpho-agronomical traits. The promising

genotypes identified for days to 50% flowering were EC0000526 (50 days) and IC0096489 (53 days); for plant height: IC002349 (80.33cm), IC0554605 (78.33 cm) and EC0041644 (77.00 cm); for number of capsules per plant: IC0526010 (587), IC0526041 (422) and IC0283435 (384); for seed yield per plant : IC0096647 (15.5g), IC0613907 (15.5g) and for 1000 seed weight: IC0096489 (9.8g), IC0096488 (9.7g) and EC0041700 (9.02g) (Fig. 9.5).

Fig. 9.5. Linseed evaluation- Field view

Linseed trait specific germplasm evaluation: A total of 62 linseed accessions along with eight checks were evaluated in ABD. The superior genotypes identified for days to 50% flowering were: IC0096499 and IC0096496 (54 days). For plant height, IC0096511 (71.33 cm), EC0115174 (70.67cm) and IC0096627 (64.33cm) were superior. Accessions IC0499045 (346), IC0007690 (290) and IC0498876 (283) recorded higher number of capsules per plant. For seed yield per plant IC00499045 (11.34g), IC0585286 (9.73g) and IC0498876 (9.03 g) were promising. Higher test weight was observed in IC499051 (8.64g) followed by IC0096499 (8.5g) and IC0585286 (8.48g) (Fig. 9.6).

Fig. 9.6. Variability observed in linseed for flower colour and shape

Safflower: A total of 59 accessions of safflower along with four checks (A-1, AKS-207, Bheema and JLA-152) were evaluated in Randomized Block Design (RBD) with two replications. Promising accessions identified for days to 50% flowering were IC0631950 and IC631963 (81days). For plant height IC0631935 (85.85cm) and IC0631936 (82.70cm); for capitula per plant: IC0631973 (18.82), IC0631969 (17.50); for seeds per capitula IC0631939 (31.40), IC631951 (29.20) and IC0631934 (28); for seed yield per plant IC0631978 (15.64g) and IC0631974 (11.30g) and for test weight A-1 (6.18g) followed by IC0631970 (5.95g) and IC0631932 (5.64g) (Fig. 9.7) were found superior.

Fig. 9.7. Safflower evaluation-Field view

AICRN on Potential crops trial

Grain amaranth: One hundred accessions along with four checks (BGA-2, GA-2, RMA-7 and Suvarna) were evaluated in ABD. Best accessions identified for days to 50% flowering were IC317517 (40 days), IC444193 and IC383578

(41days). For plant height IC444105 (125.2 cm) and IC317427 (107.8 cm) were best. Highest inflorescence length was recorded in GA-2 (60.2 cm) and Suvarna (52.4 cm). Check Suvarna also recorded superior performance for yield per plant (13.28g) (Fig. 9.8).

Fig. 9.8. Variability observed in grain amaranth for inflorescence shape, size and colour

Another set of 50 grain amaranth accessions was evaluated in ABD. Promising accessions identified were for days to 50% flowering IC279652 and IC279832 (41 days); for plant height BGA-2 (95.46 cm); for inflorescence length RMA-7 (57.6 cm) and GA-2 (55.8cm).

9.2.2 *Kharif* 2020

A total of 3,569 accessions were characterized and evaluated during *Kharif* 2020. Crop-wise accessions characterized were mung bean (200), moth bean (1,545), little millet (31), foxtail millet (100), winged bean (155) and sesame (1,538) in *Kharif* 2020. 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: Two hundred accessions of mungbean and four checks (AK 8802, PKV AKM-4, BM 2003-2 and PKV Green Gold) were evaluated in ABD. Promising accessions were identified for days to 50% flowering [PLM-403 (30 days), PLM-487 (30 days) and PLM-74 (31 days)], for primary branches per plant [IC15567 (6.8), IC11334-1 and IC11363 (6.2)], for pods per plant [PLM-314 (38), IC15567 (34.6) and PLM-387 (23.4)], for seeds per pod [PLM-487 (14.6) and PLM-1039 (14.4)] and for 100 seed weight [PLM-267 (5.28g) and BM-2003-2 (4.40g)].

Mothbean: A total 1,545 moth bean accessions along with four checks (RMO 40, RMO 225, RMO 435 and CZM-2) were raised in ABD in twenty blocks. Good variation was recorded for days to 50% flowering, plant growth habit, plant vigour and plant morphology. All the checks and accession IC396881 recorded lowest days to 50% flowering (33 days).

Little millet: A set of 31 promising accessions and three checks (JK-8, BL6 and DHLM-36-6) of little millet were evaluated for yield and yield attributing traits in RBD with two replications. Promising genotypes identified for days to 50% flowering were IC0493076 (72 days) and IC483143 (73 days); for plant height IC0482770 (133.30 cm) and IC483429 (130.6 cm); for panicle length GMPR-223 (36.10 cm), IC483142 and IC0483197 (34.90 cm); for seed yield per plant LIT-174 (12.65g), IC0482770 (12.11g) and IC0405011 (9.13g); for 1000 seed weight, accessions LIT-174 (2.65g), GPMR-153-2 (2.60g) and BL6 (2.45g).

Foxtail millet: One hundred 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 days to 50% flowering, plant height, number of productive tillers per plant, panicle length and test weight. Promising accessions identified were: for traits days to 50% flowering IC97103, IC97111 (42 days) and IC 97296 (48 days); for number of

productive tillers per plant SIA-3156 (5.85) and IC97113 (5.0); for plant height IC97099 (135.6 cm), IC120160 (135 cm) and IC97295 (134 cm); for panicle length IC97091, Narasimharaya (22 cm) and for 1000 seed weight Prasad (3.84 g). Highest seed yield per plant was recorded in IC28471 (8.92g) followed by IC97113 (8.12g) and IC28439 (7.76g).

AICRN on Potential Crops

A total of 155 accessions of winged bean were characterized and evaluated in three different trials under potential crops programme.

Trial-1: Thirty genotypes of winged bean and three checks (AKWB-1, IWB-1 and RMDWB-1) were evaluated in RBD with two replications. Accessions EC17826 and EC14266 (91 days) followed by EC27886 (92 days) were earliest in days to 50% flowering. Superior pod length was recorded in IC95227 (15.50cm), EC13018 (14.35 cm) and EC38825 (13.63cm). Maximum numbers of pods were recorded in EC38955-B (23.33), EC38821P4-3 (20.96) and EC116887 (20.70). Accessions EC27886-A3 (11), EC142662 (10.60) and EC142661 (9.70) had higher number of seeds per pod. High seed yield per plant was recorded in EC116887 (23.62g), IC95229 (22.80g) and EC38825 (19.24g). Accessions IC95227 (26.84g) and IBW-1 (23.47g) were promising for 100 seed weight.

Trial 2: Seventy five accessions of winged bean (1st year evaluation) 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 RWBGP-36, RWBGP-40, RWBGP-48 and RWBGP-49 (73 days): for pod length EC178274 (15.40 cm), IC 26946 (14.60 cm) and EC142661 (14.20cm): number of pods per plant IC26940 (33.30), RWBGP-34 (26.50) and EC142667 (25.00cm): number of seeds per pod EC178275 (13), EC38959 (12) and EC178300 (12); for seed yield per plant EC21904 (23.66g), EC38154 (22.69g) and RWBGP-34 (22.05g); for 100 seed weight EC142600 (26.31g), RWBGP-47 (24.76g) and EC11885 (23.72g).

Trial-3: Fifty winged bean genotypes and three checks (AKWB-1, IWB-1 and RMDWB-1) were evaluated in ABD (2nd year evaluation). Accessions RWBGP-18 (74 days), RWBGP-22 and RWBGP-23 (76 days) were earliest in days to 50% flowering). Superior pod length was recorded in RWBGP-3 (14.6cm), IC95239 (14.4cm) and EC178597 (13.9cm). Highest number of pods per plant was recorded in RWBGP-10 (31.25), EC178597 (26.0) and RWBGP-19 (24.5). For number of seeds per pod accessions RWBGP-19 (13) and RWBGP-2 (12) were promising. Seed yield per plant was superior in RWBGP-11 (35.25g), IC95239 (27.93g) and EC178597 (25.29g). Accessions RWBGP-22 (26.12g), RWBGP-20 (25.53g) and RWBGP-11 (25.50g) recorded higher 100 seed weight.

9.3 Regeneration and multiplication of germplasm

A total of 25 chickpea accessions were regenerated during the *Rabi* 2019-20 and 394 accessions consisting of mungbean (200), sesame wild (150), chilli (27), *Hibiscus sabdariffa* (14) and *Hibiscus cannabinus* (03) were regenerated during *Kharif* 2020.

9.4 Germplasm supply

Supplied 1229 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 (317), small millets (369), winged bean (106), horse gram (17), grain amaranth (100), pigeonpea (30), chickpea (91), niger (98), linseed (100) and drum stick (01).

9.5 Receipt

Received 10,476 accessions/varieties of germplasm comprising safflower (6,984), linseed (2,612), niger (747), *Brassica* (84), grain amaranth (23), wild okra (14), chickpea (09) and winged bean (03) from different agencies.

9.6 Medium term storage of germplasm

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

9.7 Field Gene Bank

A total 21 accessions consisting of *Aloe vera* (05), wild foxtail millet (08), soybean wild (03), West Indian cherry (01), *Simarouba glauca* (01), *Madhunashini* (03) 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: Conservation of agro-biodiversity and its utilization not only ensures the sustainability but also addresses the SDGs of zero hunger and good health & wellbeing (through ensuring nutrition and food security by on-farm conservation), climate action through resource conservation, responsible consumption and production leading to sustaining life on land. 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, 38 different collections were made in one exploration. Total 1209 accessions of various field, horticultural, WEUP crops were characterized, and 452 accessions were multiplied and rejuvenated for MTS seed replenishment. Total 597 accessions of various crop germplasms were shared with researchers across the country against MTA and seeds of 288 accessions of different crops was supplied to farmers for on-farm conservation. In addition 4241 live planting material was also supplied to the farming community. A total of 11,786 accessions in MTS and 1,282 accessions in FGBs are also being maintained. Several other activities were also undertaken like organizing farmers fair and trainings. An amount of Rs 186801/- was generated through sale of farm produce.

10.1 Germplasm exploration and germplasm collection

One exploration was undertaken under NEP at high altitude regions of Tungnath, Mondal and Bhyuandar valley of Chamoli, Uttarakhand and 36 accessions of various fruits crops including 32 accessions of wild temperate fruit crops *viz.*, *Prunus cornuta* (Jamun), *Ribes himalense* (Darbag) *Sorbus aucuparia* (Galao) and *Corylus jaquemontii* (Kapasi); 03 accessions of M&AP and 1 WEUP*viz.*, *Allium humile* and *Podophylum hexandrum* (Ban Kakri) were collected (Table 1).

10.2 Germplasm exchange and domestic supply

- Total 597 germplasm accessions of various crops *viz.*, amaranth (300), *Brassica rapa*(20), *B.juncea*(50), *Oryza sativa* (100), yellow sarson (16), strawberry (60), temperate fruit (35), chilli (115) and *Luffa acutangula* (37) were supplied to different indenters under MTA.
- Accessions of barley (56), finger millet (61), rice (42), buckwheat (11), soybean (20), barnyard millet (13), french bean (21), horse

Table 10.1: Detail of exploration undertaken

S. No.	Crop/Crop group	Period	Team	Collaborative institute	Areas Explored	Germplasm collected			
						M&AP	WEUP	Fruits	Total
	Under National exploration Plan								
1	Crop specific (Wild temperate fruits, MAP and other economically useful species)	19-29 Sept., 2020	K.M. Rai	—	Chamoli, Uttarakhand	03	01	32	36
	Total					**03**	**01**	**32**	**36**

gram (23), amaranth (20), wheat (15) and mustard (06) were supplied to farmers for on-farm conservation under UNEP-GEF projects and other activities. Total of 4241 live plants/rooted plant/grafted plant were supplied viz., kiwi (2546), kiwi seedling (800), strawberry (538), stone fruits (564) malta (666), kagazi nimboo (446) and other fruit crops (683) to different indenters or local farmers.

10.3 Germplasm characterization

- Characterization of about 137 accessions (unique landraces) of various *Rabi* season (2019-20) crops *viz.*, wheat *(Triticum* and *Aegilops)* (74); and barley (63) was done.
- A total of 847 accessions of various *Kharif* season (2020) crops *viz.*, paddy (200), minor millets (42), finger millet (51), soybean (63), horse gram (213), black gram (99), french bean (200), perilla (34), groundnut (10) and pigeon pea (08) were grown for characterization/evaluation/initial seed increase.
- Horticultural crops *viz.*, peach (22), plum (06), apricot (14), kiwi (05) and malta (12) were characterized for different qualitative and quantitative characters.
- 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

- Total 100 accessions of pea received from HQ were evaluated for powdery mildew resistance/tolerance but none of the accessions was found resistant/tolerant.
- Eight accessions of pigeon pea received from HQ are being evaluated for frost tolerance.

10.5 Germplasm multiplication

- Multiplication and rejuvenation of field crops *viz.*, lentil (05), mustard (25), fenugreek (18), pea (08), faba bean (19), coriander

Fig. 10.1. Organisation of awareness programs

Fig. 10.2. Distribution of seeds and planting material

(25), french bean (200), perilla (34) and groundnut (10) was done.

- 33 accessions of *Oregano* species, 48 accessions of medicinal and aromatic crops such as *Achillea, Artimisia, Costus, Rosa etc* were multiplied. Regeneration of 27 accession of medicinal and aromatic crops was done for replacement of old MTS seeds.

10.6 Germplasm conservation and maintenance

- A total of 11,786 accessions in MTS and 1,282 accessions in field gene banks (including newly introduced accessions) are being maintained.

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 (**Mamta Arya,** *P.S. Mehta*).

PGR/PGC-BHO-01.02: Management of genetic resources of temperate horticultural crops (**K.M. Rai,** *Anuj Kumar Sharma*).

PGR/PGC-BHO-01.03: Management of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species (**K.M. Rai, A. Raina,** Mamta Arya, *Anuj Kumar Sharma*).

Externally funded projects

Chemotyping and molecular profiling of bioactive metabolites in *Hemidesmus indicus* and *Costus speciosus*, adopted to different phytogeographical zones" under NASF. CCPI: Dr. K.M. Rai.

"Mainstreaming Agricultural Biodiversity Conservation and Utilisation in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability" under UNEP-GEF and Bioversity International. CCPI: Dr. Mamta Arya, Dr K.M. Rai.

11 BASE CENTRE, CUTTACK

Summary: Three exploration missions were undertaken and 259 acc. comprising pigeonpea, chickpea, gardenpea, lentil, mustard, linseed, wild rice, wild relatives of cucurbits, *Solanum*, *Abelmoschus* and M&AP were collected from Madhya Pradesh and Odisha. Major germplasm collections include landraces of *Brassica rapa* var. *Yellow sarson*, *Pisum arvense* and *Eruca sativa,* wild relatives of *Oryza, Corchorus, Solanum* and *Abelmoschus* spp. *Hibiscus panduriformis* Burm.f. (Malvaceae), a crop wild relative, was explored and its wild occurrence is a new distributional record for Odisha. Diversity, distribution and genetic diversity of 41 acc (5 taxa) of *Mucuna* collected from Odisha was assessed, which exhibited a wide range of inter- and intra-specific variability for flowers, pods and seeds. A set of 2627 acc. of various crops and wild relatives were multiplied/ regenerated and 573 acc. comprising cultivated rice (201), wild rice (235), *Ocimum* spp (49), *Hibiscus sabdariffa* (21), *Mucuna pruriens* var. *pruriens* (34), *Abelmoschus* spp (33) was characterized for different morpho-agronomic traits. The seed oil and fatty acid composition of five *Ocimum* spp (20 acc.) showed the presence of four major fatty acids *viz*., linolenic acid, linoleic acid, stearic acid and palmitic acid, an alternative source of industrial/ pharmaceutical applications. *Dioscorea* spp. (15) were analysed and insignificant diosgenin content (<0.0008%) reported in 3 wild species might be recommended for acceptance as food items. Cultivated rice (16) identified for flood tolerance and rhizome samples (9) of *Costus, Hedychium* and *Zingiber* were supplied to DGR and DGE, for molecular characterization and biochemical evaluation, respectively. Seed germplasm of *Mucuna pruriens* var *pruriens* IC-599290 (coll. no RCM/GD/75) having high L-DOPA content (7.1%) collected from Odisha was registered (INGR 19092). A set of 98 acc. comprising field legumes (74), cultivated rice (15), tubers (9) were supplied to ICAR-institutes/ university and 2084 accessions were received from GCD, NBPGR, New Delhi. A total of 1191 acc., comprising cultivated rice, field legumes, oil seeds, vegetable & fodder crops and CWR were deposited in NGB for LTS; tuber crops (2)for *in-vitro* and FGB (6) were conserved. A total of 621 acc. comprising M&AP, horticultural crops, tuber crops and CWR are being maintained in the FGB and a total of 1450 herbarium specimens are being preserved. Organised exhibition stall in National workshop, facilities to watch PM –Kisan Samman Nidhi web telecast, PGR visit programme to Sambhav-Sabarmati N.G.O. and "SwachhataPakhwada" events. Imparted training-cum-demonstration to 25 farmers of Maharashtra and participated in National Workshop. Advisory services were provided to the farmers of MGMG cluster villages.

11.1 Exploration and germplasm collection

Three exploration missions were undertaken and 259 acc., comprising pigeon pea, chickpea, gardenpea, lentil, mustard and linseed wild rice, wild relatives of cucurbits, *Solanum* and *Abelmoschus* and M&AP were collected from Madhya Pradesh and Odisha. Wide range of inter- and intra-specific variability was recorded among collected 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 pigeonpea, chickpea, gardenpea, lentil, mustard and linseed from Madhya Pradesh

First exploration mission was undertaken for germplasm collection of pigeonpea, chickpea, garden pea, lentil, mustard and linseed from Singrauli, Sidhi and Rewa districts of Madhya Pradesh during 11th to 24th March, 2020 in collaboration with ICAR-Indian Institute of Pulses Research, R.S., Bhopal (M.P.). A total of

Table 11.1: Details of exploration and germplasm collection mission during 2020

Crops/ Species	Areas	Collaboration	Period of collection	Collection sites	No. of spp.	No. of acc.
Pigeon pea, chickpea, garden pea, lentil, mustard and linseed	Singrauli, Sidhi and Rewa districts of Madhya Pradesh	ICAR-IIPR-R.S., Bhopal	11th – 24th March, 2020	83	9	152
Oryza rufipogon, *O. nivara* and *O. spontanea*	Dhenkanal and Jagatsinghpur (Odisha)	ICAR-NRRI, Cuttack	1st -6th Dec.. 2020	43	3	44
Wild relatives of cucurbits, *Solanum*, *Abelmoschus* and M&AP germplasm	Nayagarh and Ganjam districts of Odisha	ICAR-CHES (IIHR), Bhubaneswar	14th to 19th Dec., 2020	47	28	63
			TOTAL	**173**	**40**	**259**

Fig. 11.1. (L) Mixed cultivation of *Brassica rapa* var yellow sarson and *Pisum sativum* at Khular, Waidhan; (R)Rare cultivation of *Eruca sativa*, a neglected oilseed crop, collected from Dudmania, Singrauli

152 acc comprising *Cajanus cajan* (24), *Brassica rapa* var. *toria* (36), *Brassica rapa* var. *yellow sarson* (8), *Pisum sativum* (11), *Pisum arvense*(5), *Linumu sitatissimum* (33), *Lens culinaris* (18), *Cicer arietinum* (16), *Eruca sativa* (1) was collected. Significant germplasm collections include landraces of *Brassica rapa var. Yellow sarson*, *Pisum arvense* and *Eruca sativa*. A wide range of variability in morphological traits such as colour and size of flowers, pods and seeds of *Cajanus cajan, Brassica rapa* and *Cicer arietinum* found in different landscapes was recorded.

11.1.2 Exploration and germplasm collection of wild rice from Odisha

An exploration mission was undertaken and 44 acc of wild rice germplasm comprising *Oryza rufipogon* (22), *O. nivara* (18) and *O. spontanea* (4) were collected from Dhenkanal and Jagatsinghpur districts of Odisha (Fig. 11.2). Wide range of inter and intra specific variability was recorded among collected germplasm accessions for various morpho-agronomic traits.

Fig. 11.2. Wild rice: *Oryza rufipogon* and *O. nivara*, collected from Raghunathpur, Odisha

11.1.3 Exploration and germplasm collection of wild relatives of cucurbits, *Solanum*, *Abelmoschus* and M&AP from Odisha

Another exploration mission was conducted for germplasm collection of wild relatives of cucurbits, *Solanum*, *Abelmoschus* and M&AP from Nayagarh and Ganjam districts of Odisha in collaboration with ICAR-Central Horticultural Experiment Station (IIHR), Bhubaneswar during 14th to 19th Dec., 2020. A total of 63 accessions comprising *Coccinea grandis* (6), *Cucumis melo* var. *agrestis* (2), *Trichosanthes tricuspidata* (5), *Luffa aegyptiaca* (2), *Solanum torvum* (7), *Abelmoschus manihot* (3), *Amaranthus* spp. (5), *Corchorus* spp. (7), *Dioscorea* spp. (2), *Amorphophallus paeoniifolius* (1), *Celosia argentea* (1), *Hibiscus sabdariffa* (1), *Fioria vitifolia* (1) (Fig. 11.3), *Ocimum* spp. (8), *Abutilon indicum* (3), *Cassia* spp. (2), *Costus speciosus* (3), others (4), was collected from tribal dominated regions of Dasapalla and Mahanadi wildlife sanctuary and Taptapani hilly region covering the parts of Eastern Ghats and coastal plains of Odisha. Variability in fruit shape and size in cucurbits like *Coccinea grandis*, *Trichosanthes tricuspidata*, *Luffa aegyptica* were observed. Information on traditional uses of wild *Abelmoschus,* cucurbits, *Solanum* spp., *Dioscorea* spp. *Amorphophallus paeonifolius*, *Amaranthus* spp., *Corchorus* spp., *Hibiscus sabdariffa* etc. used as vegetables and medicinal plants were collected. About 25 specimens were collected and preserved as herbarium materials for future research / reference.

Fig. 11.3. Top Left: *Fioria vitifolia* (= *Hibiscus vitifolius*), a wild relative, stem used as fibre collected from Sorada, Ganjam district, Odisha; Bottom Left: *Cipadess abaccifera,* a high-valued medicinal plant; Right:*Amorphophallus paeoniifolius,* corm boiled and consumed as food and used in piles treatment

11.1.4 New record of Yellow *Hibiscus*

Hibiscus panduriformis Burm.f. (Malvaceae), popularly called as 'Yellow Hibiscus', (Fig. 11.4) a crop wild relative, was collected from two sites

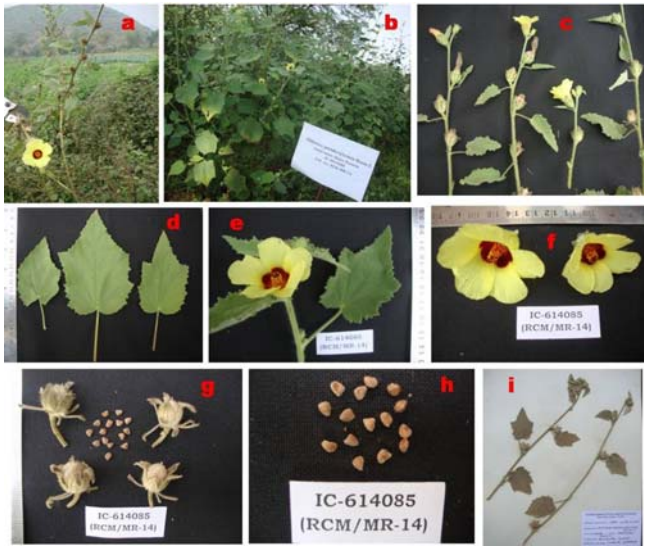


Fig. 11.4. *Hibiscus panduriformis*, a new plant record for Odisha. a. Occurrence in natural habitat, b. Maintained in FGB, c. Branch morphology, d. Structure of leaves, e. Apical twig, f. Flowers, g. Capsules, h. Seeds, i. Herbarium specimen

of natural habitats of Odisha and its wild occurrence was found to be new distributional record for the flora of Odisha. The seed germplasm bearing acc no. IC 614085 and IC 627240 were conserved in the National Gene Bank. The collected specimens were preserved as herbarium specimens (HS no. RCMisra 1085 to 1088) at ICAR-NBPGR Base Centre, Cuttack. The local people use the stem bark as coarse fibre for making twines and ropes.

11.2 Supportive research

11.2.1 Species diversity and morphological variability in *Mucuna* spp. in Odisha, Eastern India

The diversity, distribution and genetic variability of 41 accessions representing five taxa of *Mucuna* viz. *M. gigantea,M. monosperma, M. nigricans* and *M. pruriens var. pruriens* including one domesticated species *M. pruriens* var. *utilis* collected from Odisha were assessed (Fig. 11.5). The agro-morphological characters, distance correlation coefficient and principal coordinate analysis exhibited a wide range of inter- and intra-specific variability in its inflorescence, flowers, pods and seeds. The morphological data with respect to flower colour; shape, size, pubescence and lamellae ornamentation of pods, pods/ cluster, seeds/pod; seed colour, hilum length and 100 seed weight were recorded. The information on ITK collected from major tribal communities revealed its immense importance for food and healthcare needs.

11.3 Germplasm characterization

A set of 573 accessions comprising cultivated rice (201), wild rice (235), *Ocimum* spp (49), *Hibiscus sabdariffa* (21), *Mucuna pruriens* var. *pruriens* (34), *Abelmoschus* spp (33)was characterized for different morpho-agronomic traits.

11.3.1 Cultivated rice

A set of 201 acc of cultivated rice germplasm augmented from exploration missions and ICAR-NBPGR, New Delhi was characterized for 17 agro-morphological traits. These were grown in augmented design with 6 blocks and 5 checks (Swarna, IR-64, Ketakijoha, panidhan& Geetanjali) with a spacing of 20 X 20 cm. Wide range of variability with respect to maturity duration, plant height, EBT, panicle length, panicle weight, 100 grain weight, sterility percentage including colour of basal leaf, leaf blade, internode, apiculos, seed coat and husk and type of panicle and awn were recorded (Tables 11.2, 11.3 and Fig. 11.6).

Fig. 11.5. Left panel (a-e):Variability in flowers of *Mucuna:* a. *M. gigantea*, b. *M. monosperma*, c. *M. nigricans*, d. *M. pruriens var. pruriens*, e. *M. pruriens var. utilis*; Right panel (a-e):Variability in pods of *Mucuna:* a. *M. nigricans*, b. *M. monosperma*, c. *M. pruriens var. pruriens*, d. *M. pruriens var. utilis*, e. *M. gigantea*

Table 11.2: Variability and frequency distribution among qualitative traits in cultivated rice

Traits	Descriptor states (Frequency %)
Basal leaf color	Green (66.3), Light P.P (7.4), P.P. lines (11.9) purple (10.4)
Leaf Blade color	Green 116 (57.4) Pale green (3.0), Dark green 67 (33.2) Purple type 5 (2.5)
Internode color	Green (67.2) , Light gold (3.0), Purple lines (23.8), purple (6.0)
Ligule color	White (79.1), PP lines (18.4), Purple (2.5)
Collar color	Green (86.1), Pale green (1.0), Purple (12.9)
Auricle color	Pale green (87.6), Purple (12.4)
Panicle type	Intermediate (93.5), (3.0), Open (3.5)
Awning	Absent (96.0), Long & full (4.0)
Awn color	Absent (96.0), Straw (1.5), Brown(1.5), purple (1.0)
Apiculus color	Straw (78.1), Purple (15.9), Red (3.5), Others (2.5)
Stigma color	White (66.2), Lt. purple (12.9), Purple (17.4), Lt. green (3.5)
Lemma palea color	Straw (74.1), PP.furrow (8.0), Purple (6.5), Black (5.0), Brown(2.0) & Others (4.4)
Seed coat color	White (72.1), Lt. Brown (17.4), Black (9.5) & Others (1.0)

Table 11.3: Variability among quantitative traits in cultivated rice germplasm

Traits	Range		Best check	Promising lines
	Minimum	Maximum		
Plant height (cm)	40.8(IC0631826)	159.4 (EC956403)	IR-64 (132.6)	EC956403, IC0631801
EBT	3.0(IC0631812)	13.4(EC852131)	Geetanjali(9.5)	EC852131, EC934737
Panicle length (cm)	13.7(DP/BCM 2319)	39.0(EC934754)	Swarna(26.5)	EC934754, 934783
Panicle wt. (g)	0.94 (IC0631796)	8.25(EC956316)	Swarna(6.2)	EC934735,956316
Grains/panicle	22.6DP/BCM2287	346.33EC934735	Swarna(286)	EC934735, 956316
Chaffs/panicle	3.6(EC956384)	113.3(DP/BCM- 2281)	Geetanjali(3.5)	DP/BCM2281
Leaf length (cm)	33.9(DP/BCM 2281)	70.58(EC934728)	IR-64(46.5)	EC934728
Leaf width(cm)	0.4(IC0631801)	0.9(EC956338)	Ketakijoha(0.85)	EC956338
Ligule length (cm)	0.5(IC0631826)	2.7(EC956338)	Swarna(2.0)	EC956338
100 seed wt. (g)	0.84(EC0631810)	3.42(EC956428)	IR-64(3.01)	EC956428

11.3.2 Wild rice

A set of 23 acc comprising *Oryza nivara* (18) and *Oryza rufipogon* (5) was characterized for13 agro-morphological traits (Table 11.4). Each accession was maintained in three rows in a plot size of 3.84m^2/entry following a spacing of 40x40cm. Observation on 13 different agro-morphological traits was recorded and range of variation for various quantitative traits was calculated.

11.3.3 *Ocimum* germplasm

Forty-nine accessions of *Ocimum* spp. comprising *O. americanum* (8), *O. tenuiflorum*

Fig. 11.6. Variability in panicle type among cultivated rice germplasm

(10), *O. basilicum* (8), *O. citriodorum* (9), *O. gratissimum* (11) and O. *kilimandscharicum* (3) 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 in Table 11.5.

11.3.4 *Hibiscus sabdariffa*

Twenty-one acc of*Hibiscus sabdariffa* (roselle), used as vegetable,were characterized for 33agro-morphological and economic traitsin RBD with two replications and promising genotypes such as IC-610799, 610800, 619334

Table 11.4: Range of variability among quantitative traits in wild rice germplasm (23 acc)

Traits	Range		Mean	SEM (±)
	Minimum	Maximum		
Days to 50% flowering	94.0	121.5	114.4	0.79
Days to maturity	119.3	149.0	144.20	0.81
Plant height (cm)	109.6	151.5	129.30	2.81
Leaf length (cm)	51.7	79.8	68.53	2.06
Leaf width (cm)	1.0	1.65	1.28	0.05
EBT/plant	3.8	11.2	7.60	1.16
Panicle length (cm)	16.8	24.5	20.04	0.98
Grains/panicle	49.6	195.3	103.5	5.8
Spikelet fertility (%)	24.6	88.5	64.05	1.36
100 grain weight (g)	1.4	2.9	2.05	0.28

Table 11.5: Range of variability among quantitative traits in *Ocimum* germplasm (49 acc)

Sl. No.	Species	Highest estimation of herbage yield/plant (g)	Highest estimation of essential oil yield/ plant(ml)
1.	*O. americanum*	431.1 (IC599362)	1.3 (IC599329, 599362)
2.	*O. basilicum*	513.9 (IC599326)	1.3 (IC599326, 599337)
3.	*Ocimum tenuiflorum*	477.0 (IC589192)	2.1 (IC589192, 599368)
4.	*O. gratissimum*	584.1 (IC599334)	2.7 (IC589184, 599334)
5.	*O. citriodorum*	442.8 (IC599357)	2.4 (IC624514, 599357)
6.	*O. kilimandscharicum*	435.6 (IC627244)	2.3 (IC627244)

Table 11.6: Range variabilityin pod and seed characters of *M. pruriens* var. *pruriens*

Traits	Minimum	Maximum	Average	SE	CV (%)
Pod length	6.84 (IC599321)	9.38 (IC589197)	8.337	0.116	8.17
Pod width	1.60 (IC599321)	1.98 (IC589194)	1.799	0.018	5.90
No. of pods/ cluster	7.7 (IC599342)	22.0 (IC599320)	12.447	0.611	28.65
No. of seeds/ pod	5.0 (IC589208)	7.0 (IC589194)	5.858	0.077	7.73
Seed length	0.88 (IC599301)	1.24 (IC599296)	1.019	0.013	7.63
Seed width	0.62 (IC599301)	0.88 (IC599342)	0.755	0.009	7.67
100 seed weight	22.90(IC599320)	47.54 (IC599342)	31.489	0.961	17.81

and RCM/PK/19/22 were identified for multiple traits viz. plant height, fresh leaf yield/ plant, calyx yield/ plant and number of fruits/plant and 100 seed weight.

11.3.5 *Mucuna pruriens*

The range of variability for important traits pertaining to pod and seed characters of *M. pruriens* var. *pruriens* (34) was compiled and minimum and maximum, average, standard error and coefficient of variation (CV) were recorded. Significantly, high CV was observed in number of pods/ cluster and seed weight indicating that a wide variation exists for these traits (Table 11.6). The pod pubescence varied from dense to moderately hairy and hair colour was much variable such as light brown, reddish brown, dark brown, grey, dull red, brick red and straw coloured. The shape of pods was sigmoid, curved at both ends with or without a prominent line. The colour of seeds showed a wide variability ranging from off white, light green, light brown, dark brown, grey, mottled dark grey, mottled yellowish brown, deep black to mosaic black.

11. 4 Germplasm evaluation

11.4.1 Biochemical evaluation of *Ocimum* spp.

The seed essential oil content and fatty acid composition of five *Ocimum* spp (20 acc.) comprising six essential oil chemotypes were evaluated. Significant variations ranging from 10.95% to 21.37% w/w were observed. The results of fatty acid profiling of methylated oil by GC and GC-MS revealed predominance of poly-unsaturated fatty acids of á-linolenic acid and linoleic acid similar to linseed oil. Oil composition showed presence of four major fatty acids i.e. linolenic (55.79-72.95%), linoleic (17.44-26.91%), stearic acid (2.27-7.07%), and palmitic acid (6.43-15.73%). High linolenic acid content was observed in *O. citriodorum*(66.69-72.95%) followed by *O. americanum*(57.96-71.98%). Eugenol rich chemotypes showed slightly lower content of linolenic acid in *O. gratissimum* (58.05-60.10%) and *O. tenuifolium* (55.79-62.79%). Therefore, basil seed oil may be an alternative source for several industrial and pharmaceutical applications that require linolenic and linoleic acid.

11.4.2 Biochemical evaluation of *Dioscorea spp.*

Diosgenin content (%) of wild tubers of 15 acc of *Dioscorea* (7 species) were quantitatively analysed and insignificant diosgenin (< 0.0008%) reported in *Dioscorea pentaphylla* (RCM/AP/60), *D. oppositifolia* (RCM/AP/23) and *D. hamiltonii* (RCM/AP/20) might be recommended for acceptance as food items.

Fig. 11.7. Left: Long size lint of *Desi* cotton (*G. arboreum*); Right: *G. barbadense* having high fibre strength and staple length

11.4.3 Evaluation of *Desi* and perennial cotton (*Gossypium* spp.)

Fourteen cotton germplasm acc comprising 10 *Gossypium arboreum* and 4*G. barbadense* collected from Tripura were evaluated in collaboration with ICAR-CICR, Nagpur. The collected acc of *desi* cotton (*G. arboreum*) were represented derivatives of race '*cernuum*' and '*burmanicum*' (Fig. 11.7). The morphological variants of *desi* cotton were compact types, having short sympodia, long boll with short staple fibre. The range for fibre quality traits such as fibre staple length (17.2 - 19.1 mm), fibre strength (15.0 - 16.7 g/tex), micronaire (>7), Elongation Index (4.1 -4.6) and Short Fibre Index (45.1 - 61.4) was recorded for *desi* cotton. Among *G. arboreum* accessions, two were natural coloured brown linted cotton. The range of fibre quality traits for fibre staple length (32.6 - 34.9 mm), micronaire (5.8 - 6.4) and fibre strength (21.6 - 24.7 g/tex) was recorded for *G. barbadense*. The collected accessions were conserved in FGB and MTS of ICAR-CICR, Nagpur for future utilization in cotton improvement. *Desi* coloured cotton cultivation is highly suitable for sustainable organic farming and preparation of export oriented eco-friendly coloured garments and cotton improvement programme.

11.4.4 Cultivated rice

A set of 16 accessions of cultivated rice germplasm identified for flood tolerance, out of 54 accessions evaluated during *Kharif* 2019, were supplied to DGR for molecular characterization.

11.4.5 Tuber crops

Nine accessions of rhizome shred samples comprising *Costus speciosus* (5), *Hedychium* spp. (3) and *Zingiber zerumbet* (1) were supplied to the Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi for evaluation of biochemical compounds.

11.5 Registration of genetic stock

Seeds of *Mucuna pruriens* var *pruriens* (velvet bean), a wild medicinal legume, IC599290 (collector no. RCM/GD/75) for high L-dopa content (7.1%) collected from coastal delta zone of Odisha (Jajpur district) was registered (INGR 19092).

11.6 Germplasm multiplication

A total of 2,627accessions comprising cultivated rice (2,211), wild rice (235), *Ocimum* spp. (34), *Abelmoschus* spp. (33), *Hibiscus sabdariffa* (21), *Luffa* spp.(10), *Cajanus cajan* (3), chilli(12), blackgram (13), green gram(4),

Mucuna spp (4),*Trichosanthes* spp. (3), *Canavalia gladiata* (2) and *Scleichera oleosa* (1) along with *Dioscorea* spp. (19), *Costus speciosus*(8), *Hedychium* spp. (3), *Zingiber zerumbet* (1) were multiplied/regenerated for characterization, herbage and oil yield and further biochemical evaluation.

11.7 Germplasm exchange

A set of 89 accessions comprising *Cajanus cajan* (24), *Pisum sativum* (11), *Pisum arvense* (5), *Lens culinaris* (18), *Cicer arietinum* (16), collected during exploration mission in Madhya Pradesh and cultivated rice (15) under MTA were supplied to ICAR-IIPR, R.S., Bhopal and Jamia Hamdard, New Delhi respectively for multiplication, characterization and conservation and research purpose. Nine rhizome samples comprising *Costus speciosus* (5), *Hedychium* spp. (3) and *Zingiber zerumbet* (1) were supplied to Division of Germplasm Evaluation for biochemical analysis. Besides, a set of 2,084 acc comprising cultivated rice (2,058), wild rice (16) and black gram (10) was received from Division of Germplasm Conservation, ICAR-NBPGR, New Delhi for seed multiplication and Conservation in NGB.

11.8 Germplasm conservation

A set of 1,191 accessions comprising cultivated rice germplasm (895) multiplied during *Kharif* 2019, wild relatives of cucurbits (41), *Abelmoschus* spp. (6), *Solanum* spp. (16), *Cucumis sativus* var. *hardwickii* (16) and *Cajanus cajan* (27), *Pisum sativum* (11), *Pisum arvense* (5), *Lens culinaris* (18), *Cicer arietinum* (16), *Brassica rapa* var. *toria* (36), *Brassica rapa var. Yellow sarson* (8), *Linum usitatissimum* (33) and *Eruca sativa* (1), fodder species (37), *Vigna unguiculata* (6), *Vigna radiata* (3), *Vigna mungo* (5), *S. melongena* (2), other vegetable crops (5), economic crops (4) collected from Odisha, West Bengal and Madhya Pradesh were deposited for LTS in National Gene Bank, ICAR-NBPGR, New Delhi. Two rhizome/ tuber germplasm propagules viz. *Zingiber zerumbet* and *Dioscorea alata* were deposited for *in-vitro* conservation. In addition, *Amorphophallus paeoniifolius* (1), *Costus speciosus* (3), *Dioscorea alata* (1) and *D. oppositifolia* (1) were added to the FGB of the centre. Wild rice (9) was deposited at ICAR-NRRI, Cuttack for conservation in MTS.

11.9 Germplasm maintenance

A total of 621 acc comprising M&AP (241), *Ocimum* spp. (34), *H. sabdariffa* (21), *Cajanus cajan* (3), tuber/aroids (27), horticultural crops (6), wild *Oryza* spp (235), wild *Abelmoschus* (33), *Costus speciosus* (8), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Luffa aegyptiaca* (3), *Trichosanthes* spp. (3), *Canavalia gladiata* (2) and *Scleichera oleosa* (1), are being maintained in the FGB/ experimental plots of the centre.

Some important species of medicinal and aromatic plants viz. *Abutilon indicum, Aristolochia indica, Abelmoschus moschatus, Argyreia nervosa, 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, Stevea rebaudiana, Strychnos potatorum, Solanum sisymbrifolium, Tinospora cordifolia, Watakaka volubilis* etc are being maintained in the field genebank of the centre for academic research purpose.

11.10 New initiatives of Herbarium preservation

The herbarium of the centre is housed with about 1,450 voucher specimens belonging to crop wild relatives, high valued M&AP and other economically useful plants collected from parts of Odisha, Bihar, Madhya Pradesh, West Bengal, Mizoram, Tripura and Manipur. The important specimens such as *Abelmoschus angulosus* var. *grandiflorus*, *Abelmoschus angulosus* var. *mahendragiriensis*, *Abelmoschus moschatus*, *Abelmoschus tuberculatus* var. *deltoidefolius, A. tuberculatus* var. *tuberculatus*, *Abelmoschus crinitus*, *Abelmoschus manihot* var. *tetraphyllus, Mucuna pruriens* var. *utilis, Hedychium coronarium, Zingiber zerumbet, Hibiscus cannabinus*, *Solanum lycopersicum* var. *cerasiforme, Cajanus cajan* etc were augmented to the herbarium. Scanning of some voucher specimens of significant species/ crop wild relatives and high valued medicinal plants was initiated and computerization is in progress.

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

PGR/EXP- BUR-CUT- 01.00- Augmentation, characterization, evaluation, maintenance, regeneration, conservation documentation and distribution of plant genetic resources of Odisha and adjoining regions- (**Dr. R.C. Misra**)

PGR/EXP-BUR-CUT- 01.02- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of medicinal & aromatic plants, wild economically useful and rare and endangered plants of Odisha and adjoining regions. (**R.C. Misra,** D.R.Pani)

12 REGIONAL STATION, HYDERABAD

Summary: During the period under report a total of 44,979 samples (14,918 imports; 30,061 exports) were processed for quarantine clearance. 54 phytosanitary certificates were issued. Import samples (12,209) infested/infected with pests/pathogens were salvaged and released. Post-entry quarantine inspection was conducted on 5,715 accessions of different crops grown at PEQIA of ICRISAT (1,568) and AVRDC (100), ICRISAT glasshouse (265), private industry (3,437), public organizations (23) and NBPGR (322). Quarantine services were extended to 43 organizations in South India. One collaborative exploration was undertaken for collection of pigeon pea, cowpea and wild pigeon pea germplasm from the Jayashankar Bhupalpally, Warangal, Jangaon, Mahabubabad and Mulug districts of Telangana State. A total of 75 accessions was collected including accessions of cultivated pigeon pea and wild species. In addition, two special missions, one for the collection of wild pigeon pea germplasm (*Rhyncosia beddomei*) in Seshachalam hill ranges of Eastern Ghats and the second for identifying sites for collection of *Momordica cymbalaria* (kasara kaya in Telugu) from Kurnool district of Andhra Pradesh were also undertaken. A total of 1,371 accs. of different agri-horticultural crops was raised for characterisation, evaluation, rejuvenation and multiplication. Under the DBT Project, in association with Agri Biotech Foundation, 1,000 accessions of blackgram were sown for screening against *Yellow mosaic virus*. In addition, 15 varieties of Amaranths were also characterised and evaluated under the AICRN PC Project. In all, 327 accessions consisting of indigenous crop germplasm (113) and exotic germplasm (214) were multiplied and sent to NGB for long-term storage. 433 accessions of evaluated and multiplied indigenous germplasm were added to the MTM at the station. Also facilitated the conservation of 32 accessions of taro and four accessions of sweet potato from College of horticulture & Research Station, IGKV, Chhattisgarh at the TCCU, ICAR-NBPGR, New Delhi and ICAR-NBPGR Regional Station, Thrissur. A total of 959 germplasm accessions were provided to 30 SAUs/ICAR institutes against 33 indents.

12.1 Germplasm quarantine

A total of **44,979** samples comprising **14,918 import** samples and **30,061 export** samples was received for quarantine processing as detailed below. In all, two international organizations, 11 public organizations (ICAR institutes, universities/state govt. organizations) and 30 private organizations received the quarantine service from this station. Resources worth **Rs.33,57,211/-** were generated through quarantine processing of imported consignments.

12.2 Import Quarantine

A total of **14,918** samples including paddy (6,439), maize (3,626), wheat (174), barley (128), sorghum (1255), pearl millet (341), finger millet (413), *Guizotia abyssinica* (15), groundnut (2), bambara groundnut (50), soybean (130), pigeonpea (19), chickpea (16), chilli (169), tomato (187), brinjal (16), bitter gourd (300), lima bean (30), common bean (591), carrot (5), onion (72), ridge gourd (66), sponge gourd (68), cauliflower (65), watermelon (3), papaya (1), okra (716), *Brassica napus* (39) and cotton (3) were imported from different countries.

12.1.1 Interceptions

During quarantine processing, the following major pathogens were intercepted.

Paddy: White tip nematode, *Aphelenchoides besseyi* from Philippines; **Maize:** *Drechslera*

maydis from France; *Rhizoctonia bataticola* from Thailand, *Stenocarpella maydis* from USA (Fig. 12.1A), *D. maydis, D. australiensis, Fusarium verticillioides, F. semitectum. Lasiodiploidia* sp., and *Pestalotiopsis* sp. from Philippines and Indonesia, *Stemphylium* sp. from France; **Brinjal:** *Rhizoctonia solani* from Japan; **Bitter gourd**: *Phoma* sp., *Drechslera* spp., *Choanephora* sp from Thailand; **Papaya**: *Phoma* sp. from USA; **Sorghum:** *Colletotrichum acutatum, C. graminicola, Drechslera setariae, Fusarium* sp. and *Phoma* sp from Argentina, *Pestalotiopsis* sp. and *Phoma sorghina* from Niger (Fig. 12.1B); **Ridge gourd:** *Phoma* sp. from Vietnam; **Carrot**: *Phoma* sp. from Japan; **Chilli**: *Phoma* sp from Taiwan; **Onion:** *Curvularia lunata, Stemphylium* and *Fusarium semitectum* from Indonesia; **Tomato:** *C. lindemuthianum* and *D. australiensis* from Japan; **Cotton:** *Fusarium equiseti* from Uganda

Imports released: Seed samples (12,209) consisting of paddy (6,141), maize (3,302), wheat (174), barley (128), sorghum (1,248), finger millet (20), pigeonpea (19), lima bean (30), common bean (6), tomato (160), chilli (145), brinjal (16), okra (120), onion (72), carrot (5), bitter gourd (252), ridge gourd (89), pumpkin (3), sponge gourd (187), papaya (11), watermelon (3), *Guizotia abyssinica* (15), groundnut (2), canola (39), cotton (3), *Cosmos bipinnatus* (16) and *Celosia plumose* (3) were processed and released after necessary mandatory treatments.

12.1.2 TSOP treatment

The mandatory trisodium orthophosphate treatment (10% sol) was given to the imported germplasm of tomato (137) from Taiwan (87), UK (24) and Dubai (26), and chilli (145) from Taiwan (130), UK (12) and Thailand (3) before release to the consignees.

12.1.3 Import germplasm salvaging details

Total number of samples infected/infested: 5028

Fungi: 5023; (Pathogenic-2522; saprophytes-2501); Bacteria: 87; Viruses: Nil; Nematodes: 39; Insects: Nil; Weeds: Nil

Number of samples salvaged: 5028

Number of samples detained: 0

Number of samples rejected in lab: 0

12.3 Export Quarantine

Crop germplasm samples (30,061) consisting of maize (23,135) received from CIMMYT and sorghum (653), pearl millet (2478), finger millet (353), barnyard millet (68) proso millet (9), pigeonpea (105), chickpea (1065) and groundnut (2195) received from ICRISAT were processed for export purpose. In all, 462 samples were detained or withdrawn, which includes 131

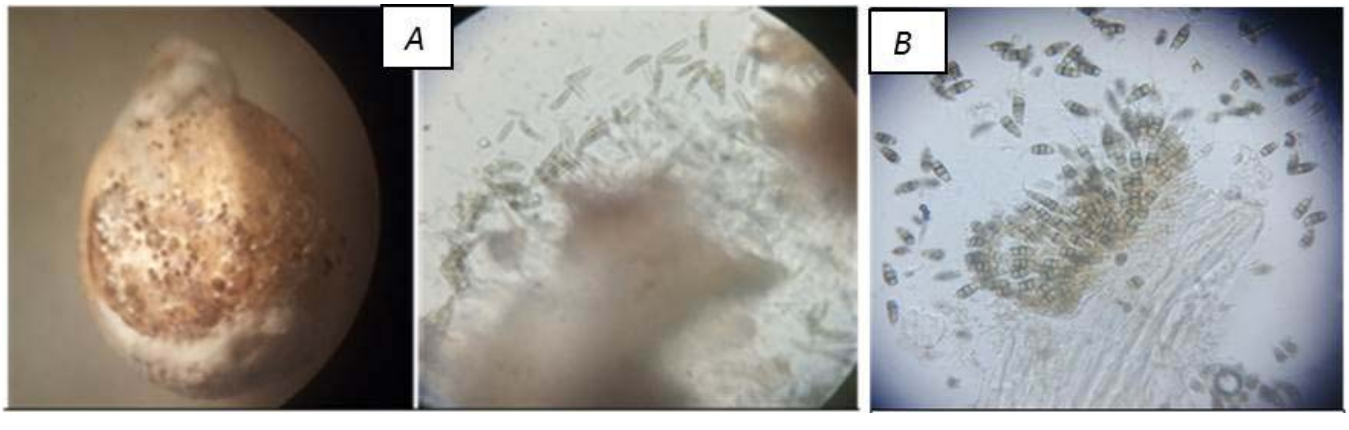


Fig. 12.1. A. *Stenocarpella maydis* intercepted on maize from USA. B. *Pestalotiopsis* sp. observed on sorghum from Niger

samples of sorghum due to Gram –ve bacteria (85), *Fusarium* sp. (24), *Curvularia* sp. (2), *Phoma* sp. (1), *Curvularia* sp. & *Phoma* sp. (1), insect infestation (13) and nil germination (4); 89 samples of pearl millet due to Gram-ve bacteria (82), *Fusarium* sp. (6) and insect infestation (1); 17 samples of groundnut due to Gram –ve bacteria (7), *Rhizoctonia* sp. (7) and nil germination (3); 19 samples of pigeonpea due to Gram –ve bacteria (6), *Fusarium* sp. (8), insect infestation (2) and nil germination (3); 191 samples of chickpea due to Gram –ve bacteria (118) and insect infestation (1), and 1 sample of barnyard millet due to *Fusarium* sp. were detained. In addition, 1 sorghum, 55 pearl millet, 2 pigeonpea and 28 chickpea samples that were submitted for processing were withdrawn. In all, 54 Phytosanitary certificates were issued.

12.3.1 Post-entry quarantine observations

Post-entry quarantine inspection was conducted on 5,715 accessions of different crops grown at PEQIA of ICRISAT (1,568) and AVRDC (100), ICRISAT glasshouse (265), private industry (3,437), public organizations (23) and NBPGR greenhouse (322).

12.3.1.1 PEQ at ICRISAT glass house

Post-entry quarantine inspection of sorghum (176) from Kenya, common bean (72) from Colombia and wheat accessions (17) from UK grown at ICRISAT glass house was conducted for quarantine pests. All the accessions were found healthy.

12.3.1.2 PEQ at ICRISAT field

Post-entry quarantine inspection of pearl millet (553 accessions) from Zimbabwe (442) and Kenya (111), and sorghum (1015 accessions) from Niger, grown in the fields of ICRISAT was conducted at regular intervals. Leaf samples of pearl millet exhibiting leaf spots and leaf blight symptoms revealed the presence of seed borne fungi such as *Curvularia, Drechslera setariae, Periconia byssoides, Phoma* sp and *Puccinia penniseti* (rust) from Zimbabwe. One pearl millet plant from Kenya consignment showing damping off symptoms was uprooted. While in sorghum, three *Maize streak virus* (MStV) suspected plants and one accession (ISS 428) with downy mildew infected plants were uprooted and incinerated. The sorghum accession (ISS-184) exhibiting blight symptoms, revealed the presence of *Drechslera setariae.* Stem borer incidence was more prominent in sorghum consignment.

12.3.1.3 PEQ at AVRDC

Post-entry quarantine inspection pepper accessions (100) meant for AVRDC and grown in the field of ICRISAT was conducted. All the accessions were found healthy. Incidence of powdery mildew, mites and thrips infestation was noticed.

12.3.1.4 PEQ NBPGR

Post-entry quarantine growing of soybean accessions (123 of 143) from USA, received from NBPGR New Delhi was done in the quarantine green house. Twenty samples were detained due to the presence of downy mildew oospores (*Peronospora manshurica*) during visual examination and washing test. All accessions were found healthy, except few plants, which showed suspected symptoms of *Bean common mosaic virus* (BCMV). However, suspected samples were not positive on ELISA testing. Soybean pods in some accessions, which showed blighted appearance, revealed the presence of *Phoma* sp. All accessions were submitted for long term conservation in the National Gene Bank. In addition, 130 accessions from USA were received from NBPGR, New Delhi were grown in quarantine greenhouse for post entry growing. No germination observed in 39 accessions.

Remaining 91 accessions were inspected at regular interval and found healthy, except one accession (PI416868), which was found infected with *Soybean mosaic virus*. Infected plants were uprooted and incinerated. The harvested seeds were sent to NBPGR, New Delhi.

Bambara groundnut accessions (50) belonging to six consignments from Mali (10), Niger (7 & 9), Ghana (10), Tanzania (6), and Uganda (8) received from NBPGR, New Delhi were grown for post-entry quarantine inspection and multiplication. No germination observed in one accession from Niger and another accession (EC1036877) from Niger did not bear pods. Pods of remaining accessions (10 from Mali and 5 from Niger) were harvested, dried and sent to NBPGR, New Delhi. Two accessions from Ghana showed the incidence of *Bean common mosaic virus* (Fig. 12.2). Regular inspections were carried out to check for the presence of exotic pest occurrence.

Fig. 12.2. Post-entry quarantine growing of Bambara nut accessions from Tanzania and Niger in the glasshouse of NBPGR Regional Station

12.3.1.5 PEQ at Public organizations

Post-entry quarantine inspection of maize consignment (23 accessions) from USA grown at Winter Nursery Centre of ICAR-IIMR, Hyderabad was conducted. *Drechslera maydis*, pathogen of Southern corn leaf blight was detected in EC1005606, EC1005620 and EC1005621 accessions and harvested produce of these accessions was examined for *D. maydis* and found free from the same. Other pathogens detected include *Alternaria alternata, Curvularia lunata, Fusarium semitectum, Myrothecium roridum, Nigrospora* sp., *Phoma* sp. *Periconia byssoides* and *Puccinia polysora*. Seeds of accessions EC1005611 and EC1005612 did not germinate.

12.3.1.6 PEQ at Private industries

Post-entry quarantine inspection of 31 consignments of different crop germplasm (3,437 accessions) consisting of maize (3053) imported from South Africa (578), Mexico (1199), Italy (8), Egypt (1), Thailand (421), Philippines (234), Indonesia (138) and USA (464); okra (67) from USA; bitter gourd (178) from Thailand; Barley (139) from Australia (19) and Netherlands (120) were conducted during 2020. The details of observations and action taken were given in Table 12.1 and Fig. 12.3 (1-4).

12.3.1.7 Inspection of harvested produce at ICRISAT

Harvested produce (1556 accessions) consisting of sorghum from Niger (841), Zimbabwe (59) and Kenya (146); and pearl millet from Zimbabwe (405) and Kenya (105) was inspected at ICRISAT. The pearl millet accessions SDPM 3042 and SDPM 5111 from Zimbabwe and A87C2C581BHT and LC ICMA 1 from Kenya showing severe ergot symptoms were detained and incinerated Fig. 12.4.

12.4 Other activities

12.4.1 Multiplication of wild *Arachis* spp

Wild *Arachis* spp., (59 accns) supplied by NBPGR, New Delhi were sown in the polyhouse for multiplication at the station. Of these, 46 accessions were germinated and got established. However, two different plants of one accession (IC0338555) showed bacterial wilt (*Ralstonia solanacearum*) infection and *Peanut stripe virus* infection, which was confirmed by ELISA. Another accession (IC0420097) also showed

Table 12.1: Details of post entry quarantine inspections (PEQI) undertaken at private industries during 2020.

Crop	No. of accessions	Source country	Name of the site	Observation and action taken
Maize	690234138	South Africa Philippines Indonesia	M/s Pioneer Hi-Bred (P), Bengaluru	Incidence of Northern corn leaf blight (*Exserohilum turcicum*), Southern corn rust (*Puccinia polyspora*) and Fall armyworm (*Spodoptera furgiperda*) infestation was recorded.
	119618	Mexico Italy	M/s Pioneer Hi-Bred (P), Hyderabad	Plants infected with *Drechslera maydis* in EC965550 accession in Mexico consignment and EC972498 and EC976314 accessions in Italy consignment was uprooted and incinerated. In addition, *Curvularia* sp., *Fusarium semitectum*, *Periconia byssoides* and *Phoma* sp. were recorded in Mexico consignment.
	464	USA	M/s Pioneer Hi-Bred (P), Hyderabad	Southern corn leaf blight infected plants in EC1038276 (11 no., all plants), EC1038493 (1 no.) and EC1038609 (1 no.) accessions were uprooted and incinerated. Plant (1 no.) suspected with viral disease in EC1038422 was uprooted and incinerated. In addition, *Alternaria alternata*, *Cercospora* sp., *Choaenophora* sp., *Curvularia lunata*, *Drechslera halodes*, *Fusarium semitectum*, *F. verticillioides*, *Nigrospora* sp., *Myrothecium* sp., *Periconia byssoides* and *Phoma* sp. were recorded on diseased leaves.
	1	Egypt	Hytech Seed India Ltd. Hyderabad	All samples were found healthy
	158	Thailand	Limagrain India Pvt Ltd. Hyderabad	Plants suspected with *Maize streak virus* disease in EC1002548 (2no.), EC1002549 (1 no.) and EC1002555 (2 no.) accessions were uprooted and incinerated. Local accessions, meant for DNA isolation and other purposes, were grown all around the plot where exotic accessions were grown. All the exotic maize accessions were uprooted and incinerated.
	3	Mexico	Rallis India Ltd, Hyderabad	Virus suspected plant (1 no) in EC1036526 accession was uprooted and incinerated. Northern corn leaf blight (*Exserohilum turcicum*), rust (*Puccinia polysora*) symptoms, fall armyworm (*Spodoptera frugiperda*) infestation was noticed.
	218	Thailand	Limagrain India Pvt Ltd. Hyderabad	Plant (1 no.) suspected with viral disease in EC1002551 accession and Southern corn leaf blight (SCLB) infected plants in EC1002548 (all plants, 6 no), EC1002558 (1 no), EC1002560 (all plants, 14 no.), EC1002592 (1 no.) EC1002594 (2 no.), EC1002602 (2 no.), EC1002604 (7 no.), EC1002605 (2 no.), EC1002614 (1 no.), EC1002616 (1 no.), EC1002617 (all plants, 16 no.), EC1002620 (1 no.), EC1002621 (1 no.), EC1038236 (2 no.) accessions were uprooted and incinerated. Northern corn leaf blight (*Exserohilum turcicum*) was observed on EC1002602 (2 no.) accession. In addition to *D. maydis*, other pathogens such as *Choanephora* spp., *Fusarium semitectum*, *Nigrospora* spp. and *Phoma* spp were detected on diseased leaves.

Crop	No. of accessions	Source country	Name of the site	Observation and action taken
	45	Thailand	Tierra Agrotech Pvt Ltd. Hyderabad	Southern corn leaf blight (*Drechslera maydis*) was detected in EC1007185, EC1007171, EC1007185 and EC1007174 accessions and were advised to uproot and incinerate *D. maydis* infected plants. Northern corn leaf blight (*E. turcicum*) was recorded on EC1007173, EC1007174 and EC1007179 accessions. In addition, *Alternaria alternata*, *Cercospora* sp., *Curvularia lunata*, *Puccinia polysora, Fusarium semitectum*, *Periconia byssoides* and *Phoma* sp. were recorded on diseased leaves. Fall Armyworm (*Spodoptera frugiperda*) infestation was noticed.
Barley	19120	Australia Netherlands	Limagrain India Pvt Ltd. Hyderabad	Virus disease suspected plant in EC1015296 accession was uprooted and incinerated. In addition, *Alternaria alternata*, *Cladosporium* sp. and *Phoma* sp. were detected in Netherlands consignment
Okra	67	USA	HM Clause, Bengaluru	Leaf hopper infestation and powdery mildew incidence was noticed on several accessions. 15 accessions (EC1009998, EC1009999, EC1010004, EC1010005, EC1010012, EC1010013, EC1010019, EC1010020, EC1010022, EC1010032, EC1010036, EC1010037, EC1010038, EC1010047 and EC1010049) were found susceptible to YVMV.
Bitter gourd	100	Thailand	Rallis India Ltd, Bengaluru	17 virus-infected plants in EC1028053 (1), EC1028058 (1), EC1028081 (1), EC1028086 (1), EC1028088 (1), EC1028089 (2), EC1028090 (1), EC1028091 (2), EC1028096 (1), EC1028097 (2), EC1028098 (1), EC1028125 (1), EC1028135 (1) and EC1028142 (1) were uprooted and incinerated
	78	Thailand	Bioseed Research India, Hyderabad	*Polerovirus* incidence was recorded on 104 plants in 44 accessions and all the virus-infected plants were uprooted and incinerated. Downy mildew incidence was also noticed on several accessions.

Fig. 12.3 (1). Maize consignment from Thailand, being uprooted and incinerated due to non-compliance of maintaining isolation

Fig. 12.3 (2). Bitter gourd plants from USA, suspected with virus infection, grown at Rallis India Limited (A TATA Enterprise) Bengaluru; Uprooting of affected plants (Right)

Fig. 12.3 (3). *Polerovirus* infected plant (left); uprooting and incineration of *Polerovirus* infected plants (right) from Thiland grown at Bioseed Research India, Hyderabad

Fig. 12.3 (4). Symptoms of Southern corn leaf blight in maize (left); uprooting and incineration of SCLB infected maize plants from Thailand plants (right) at Limagrain India Pvt Ltd. Hyderabad

Fig. 12.4. Harvested produce of pearl millet accessions from Zimbabwe and Kenya, showing ergot infection

bacterial wilt infection. Accessions were inspected at regular intervals and 38 accessions were harvested. Among these, 15 multiplied accessions having more than 100 seed were sent to the National Gene Bank for long term conservation. Remaining 23 accessions with <100 seed were conserved in the MTM.

12.4.2 Amaranthus adaptation trial

Amaranthus varieties (15 accns) are being grown in the field for assessment of yield production and adaptability in the Telangana region. Virus suspected samples were noticed in 11 varieties and 22 samples were drawn covering all replications and conducted ELISA against *Cucumber mosaic virus* (CMV), based on the previous season's experience. Of the 22 tested, 16 samples (9 varieties) were found to be CMV positive. RMA-4 variety was found to be susceptible to CMV in all the three replications. Molecular confirmation of the pathogen was done using primers specific for amplification of coat protein and Movement protein of CMV.

12.5 Germplasm Exploration and Collection

An exploration was conducted for the collection of pigeon pea germplasm and its wild relatives in collaboration with AICRP pigeon pea centre (RARS, Warangal, PJTSAU) (Fig. 12.5). The survey resulted in collection of pigeon pea, cowpea and wild pigeon pea germplasm from the Jayashankar Bhupalpally, Warangal, Jangaon, Mahabubabad, Mulug districts of Telangana State. The survey was very intensive and a total of **75** accessions was collected including accessions of cultivated pigeon pea (56), cowpea (9), maize (1), blackgram (1), greengram (2), horsegram (1) and chillies (1). Wild species included wild pigeon pea (*adavi kandi - Cajanus scarabaeoides* -2), wild blackgram (*Pteramnus labialis* -1) and wild bhendi (*adavi bhenda - Abelmoschus ficulneus*-1).Good diversity was observed in pigeon pea and cowpea germplasm. Landraces collected were as follows: pigeon pea: *chinna kandi, batana kandi, pinakandi and pedda kandi*; cowpea: *bobbarlu*; maize: *makka jonna*; blackgram: *bochhu minumulu*; greengram: *pesarlu, pachcha pesalu*; horsegram: *nalla ulavalu* and chillies: *labbakaya*.

In addition, two special missions were also undertaken. The first was for the collection wild pigeon pea germplasm (*Rhyncosia beddomei*) in Seshachalam hill ranges of Eastern Ghats (Fig. 12.6). This was a revisit to the site 20 years after its first sighting. *Adavi kandi* is endemic to Seshachalam hill range of Andhra Pradesh. It is known to possess abortifacient, antibacterial, antifungal, antidiabetic and hepatoprotective properties; leaves used for wounds, cuts, boils and rheumatic pains by adivasi tribes (*Sugali, Yanadi, Chenchu, Nakkala, Erukala*) inhabiting the forests. Genetic erosion (loss of habitat) was observed during the current visit. A few live plants were collected and are being established in polyhouse.

The second was a preliminary visit for identifying sites for collection of *Momordica cymbalaria* (*kasara kaya* in Telugu) from Kurnool district of Andhra Pradesh (Fig. 12.7). This species is found occurring in the semi-wild state along field bunds in black cotton soils; it is a very tasty seasonal vegetable (fruits sold in market for Rs.180-200 per kg.). There is no organised commercial cultivation and market produce is usually collected from wild. A monoecious species, it is propagated through tubers. It is reported to possess medicinal properties such as hepatoprotective, anti-

Fig. 12.5. Collection of pigeon pea germplasm from farmer's backyard

diarrhoel, nephro- protective, antidiabetic, antimicrobial and anti-allergic activity. It shows high potential as an underutilised vegetable for domestication and commercialisation.

Fig. 12.6. Collection of wild pigeonpea

Fig. 12.7. Collection of *Kasara kaya* from Kurnool

12.6 Germplasm Characterisation and Evaluation

A total of 1,371 accs. of different agri-horticultural crops were raised for characterisation, evaluation, rejuvenation and multiplication along with appropriate check varieties during *Rabi*/summer 2019-2020 [283 accessions including amaranths (15), chillies (118), dolichos bean (60) and sesame (90)]; kharif 2020 [923 accessions comprising sorghum (15), browntop millet (47), Italian millet (48), maize (103), blackgram (293), greengram (42), cowpea (45), pigeon pea (4), horsegram (1), sesame (85), brinjal (38), chilli (124), field bean (70), kenaf (1), okra (1), roselle (6); and rabi/summer crop 2020-2021 [165 accessions including cowpea (50), sorghum (19), dolichos bean (42), tomato (54)]. Under the DBT Project, in association with Agri Biotech Foundation,

1,000 accessions of blackgram were sown for screening against *Yellow mosaic virus*. In addition, 15 varieties of Amaranths were also characterised and evaluated under the AICRN PC Project. Promising accessions were identified for important traits in different agri-horticultural crops as follows:

Brown top millet: Plant height (IC613551 - 101.7cm): IC613546 (114.7), IC613554 (106.0), IC613562 (104.4), IC613553 (103.7); Basal tillers (IC613547 - 21.1): IC613561 (28.7), IC613546 (27.3); Seed yield/ plant (IC613547 - 14.9g): IC613546 (19.4), IC617953 (17.3); Days to flowering (IC613547 (6.8): IC613557 (51.0), IC613547 (52.0), IC617953 (53.0).

Italian Millet (Fig. 12.8): Plant height (PS-4 - 168.7cm): IC438725 (190.5), IC308936 (180.1), IC308939 (179.6), IC308975 (176.3); Panicle length (Lepakshi- 24.0 cm): IC308936 (40.3), IC308939 (32.8), IC308975 (32.2); Seed yield/ plant (PS-4 - 32.8g): Ise-1511 (48.7), IC610532 (46.4), Ise-1629 (40.2), IC426581 (37.8); Days to flowering (Srilakshmi - 49.7): IC308861 (46.0), IC382958 (47.0)

Fig. 12.8. Promising accessions of Italian Millet

Maize: Kernel rows (DHM-121M- 15.7: BB-14294 (16.0), NSJ-426 (16.0); 100 Seed weight (Vivek Hyb-51-E 36.7g): PSR-13255 (42.0); Days to tasselling (Early Composite -48.3): IC332069 (36.0), IC332070 (37.0); Days to silking (Vivek Hyb-51-E- 50.7): IC332069 (37.0), IC332070 (37.0).

Sesame (Fig. 12.9): Plant Height (JLT-26 - 140cm): RJR-084 (165), RJR-053 (153), IC013878 (140.8); Days to 50% flowering (GT-10 - 47): NSKMS-13 (37), NSKMS-20 (37), NSKMS-71 (37), NSKMS-73 (37), IC004981 (37), IC014082 (37); No. of capsules per leaf axil: IC014082 (2), IC014136 (1.3); Capsules/ plant (JLT-26 - 38): IC132167 (94), IC131936 (82), IC073518 (70), IC004981 (58), NSKMS-13 (57), NSKMS-20 (56), IC026309 (56), IC081563 (56); No. of locules per capsule (GT-10 - 2):IC004981 (4), IC014082 (4), IC014136 (4), IC026309 (4), IC042952 (4), IC052587 (4), IC073518 (4), IC096229 (4); 1000 Seed wt.(Savithri 2.5g): NSKMS 40 (3.4), NSKMS-

Fig. 12.9: Sesame accession (IC132167) with large number of capsules per plant and high 1000 seed weight

59 (3.2), IC132167 (3.1) (Fig. 8), IC043110 (3.1), NSKMS-153 (3), IC131607 (3), IC016244 (3).

Greengram: Germplasm accessions that survived heavy rains and waterlogging included IC0628779, IC0623694 and IC0625786 (Fig. 12.10); Among the new collections characterised and multiplied, KEP 45, KEP 46, KEP 102 and KEP 145 were the earliest to flower at 31 days.

Fig. 12.10. Greengram accessions tolerant to waterlogging

Brinjal: Primary branches (Arka Neelkanth - 10.0): IC136309 (10.2), IC111074 (10.0); Fruit length (Pusa purple long -16.3cm): IC136177 (18.0); Fruit breadth (Bhagyamathi - 5.5cm): IC137751 (9.9), NS/ DBT/ 042 (9.5), IC136309 (8.0), IC112341 (7.6); 100 Seed weight (Bhagyamathi - 0.4gm): IC136061 (0.5), IC136249 (0.5), IC136258 (0.5), IC136297 (0.5); Number of fruits(Pusa purple long - 7.0): IC144525 (15.0), PSR-13292 (11.5); Yield/ plant (Shyamala - 0.9kg): PSR-13292 (1.4) (Fig. 12.11).

Chillies: Plant height: IC329995 (127.6), EC391087 (122.0), IC390029 (115.0), IC278055 (114.0); Fruit length: IC347044 (13.9), IC561715 (12.3), EC391083 (12.2), IC399051 (11.6); 25 dry fruit weight (CA-960 - 21.7g): IC076291 (115.0), EC399552 (53.0), IC570484 (42.5), EC399569 (41.0); Days to flowering (Pusa Jwala

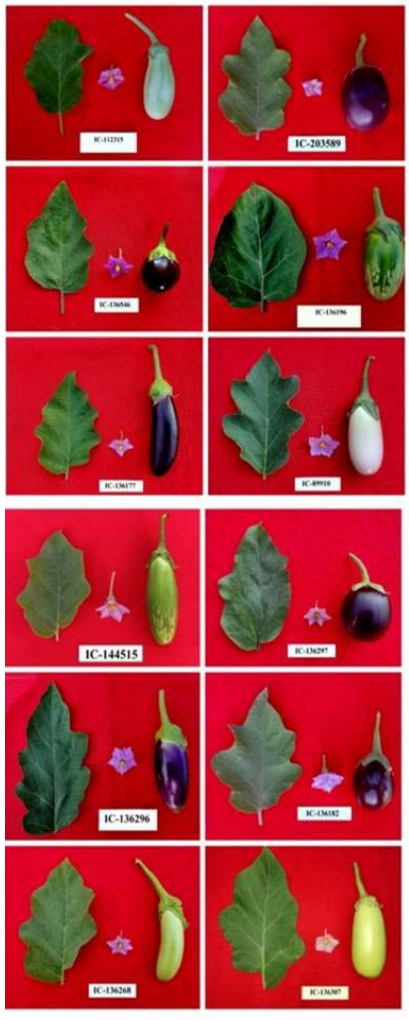


Fig. 12.11. Phenotypic diversity in Brinjal

- 95.3): IC561671 (63.0), IC561614 (68.0), IC561673 (68.0), IC561691 (68.0) (Fig. 12.12).

Dolichos Bean: Pod length (RND-1 (16.2cm): IC427423 (16.7), ADP-10 (16.2); Pod width (Arka Sambhram - 1.7cm: IC383197 (5.1), IC427424 (2.7), IC427436 (2.6); Single pod weight (RND-1 8.4g): IC383197 (23.6), IC427424 (17.1), IC427428 (11.5) (Fig. 12.13).

Field Bean: Pod length (TFB-10 - 6.1cm): IC446556 (12.3), IC261257 (7.6), IC426988 (6.6); Single pod weight (TFB-10 - 3.9)g), IC446556 (6.9), IC261257 (5.3), IC598469 (5.2); Seeds/ pod (TFB-1 - 4.2): IC446556 (4.8),

Fig. 12.12. Variation in Chillies germplasm

Fig. 12.13. Variation in *Dolichos* germplasm

IC261257 (4.4), IC526944 (4.3), IC526916 (4.3); 100 Seed weight (TFB-10 -32.5g): IC446556 (46.5), IC426988 (35.0), IC598469 (35.0), PSRJ-13095 (35.0).

Amaranthus: 15 varieties were evaluated for yield production and adaptability in the Telangana region (Fig. 12.14).

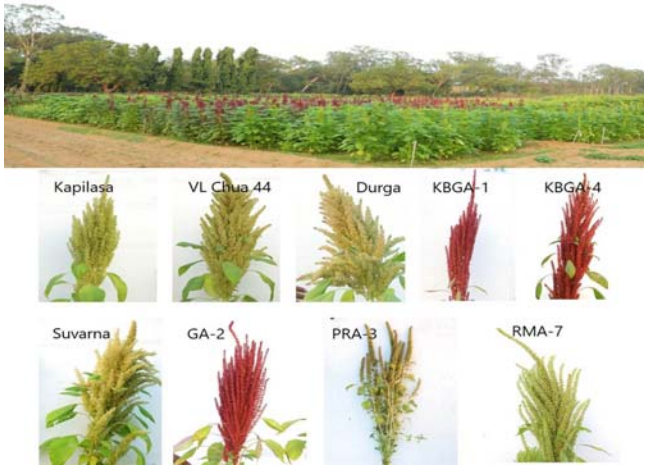


Fig.12.14. Amaranthus Varietal Adaptability Trial (AICRN PC)

12.6.1 Screening germplasm for resistance against biotic stresses

Advance screening of six chilli accessions, confirmed the resistance in EC402105, EC399535, EC391083 accessions against *Meloidogyne incognita* which recorded the galls less than 10 per root system. Metabolic profiling of roots of susceptible and resistant chilli plants exposed to the *M. incognita* revealed the increase in phenolic compound [(Phenol, 4,4'-(1-methylethylidene) bis-)] in the roots of resistant accessions, EC402105 (320.32%), EC399535 (562.79%), EC391083 (964.92%) compared to susceptible cultivar, Arka Lohit. The terpene (Squalene) and monoterpenoid phenol derivative of p-Cymene (Thymol, TBDMS derivative) were also increased significantly in resistant genotypes. Other compounds detected were alkanes, esters, ketones, amine and amide in the roots of resistant accessions of chilli. In addition, germplasm of 10 accs. of brinjal wild species consisting of *S. incanum* were also screened for their resistance reaction to root-knot nematode, (*Meloidogyne incognita*) and all were found susceptible based on number of root galls/ plant.

12.7 Germplasm Registration

Filing for registration with PPVFRA: Application of a Blackgram Farmer's Variety (*Erraminumulu*) (Fig. 12.15) along with seed samples and Photographs have been filed with PPVFRA on behalf of the BMC Members/ Farmers of Doultabad-504 102, Tanoor Mandal, Nirmal District, Telangana who are the custodians of this Farmer's Variety.

Fig. 12.15. Blackgram Farmer's variety *Erraminumulu* from Doulatabad, Nirmal, Telangana

Proposal for Registration of Maize accession: A proposal for registration of maize germplasm (IC332069) was sent to Institute Germplasm Identification Committee (IGIC). This accession, is an early flowering maize (*Zea mays* L.) and is a potential germplasm source for developing early maize cultivars.

12.8 Germplasm Conservation

Germplasm sent to NGB: Ninety-eight samples of germplasm consisting of pigeonpea (23) sorghum (14), pearl millet (12), italian millet (13), little millet (16), finger millet (20) were characterized and multiplied under RKVY project and sent to NGB for Long-Term Conservation. In addition, 213 samples of exotic soybean from USA, after PEQ inspection were multiplied and sent to NGB for long-term storage. Besides these, 15 multiplied accessions of wild *Arachis* spp were also sent to the National Gene Bank for long term conservation.

Germplasm sent to GHU: A total of 35 accessions of pulses including blackgram and greengram along with 57 accessions of sorghum and millets collected during exploration on *Vignas*, sorghum and millets was sent to GHU for National accessioning and long-term storage. In addition, 75 accessions of collected germplasm consisting of pigeon pea (56), cowpea (9), greengram (2), blackgram (1), maize(1), horsegram (1), chilli (1), *Cajanus scarabeoides* (2), *Pteramnus labialis* (1), *Abelmoschus ficulneus* (1) were also sent to Germplasm Handling Unit, ICAR-NBPGR, New Delhi for National accessioning and long-term storage.

Germplasm shared with NAGS: One set of the pulses collected during the exploration comprising 48 accessions were shared with Dr DK Patil, ARS, Badnapur, Jalna, Maharashtra for evaluation and multiplication and further use in breeding programmes. A total of 72 accessions of collected germplasm consisting of pigeon pea (56), cowpea (9), greengram (2), blackgram (1), horsegram (1), *Cajanus scarabaeoides* (2), were shared with collaborator for characterization, evaluation and multiplication [(Dr N Sandhya Kishore, Senior Scientist, AICRP (Pigeon pea) ,RARS, PJTSAU, Warangal]. In addition, one set of the sorghum and millets germplasm collected (71 accessions) during exploration was shared with the collaborator Dr M Elangovan, IIMR, Hyderabad for further evaluation and use in breeding programmes.

Medium Term Module: 433 accessions of germplasm comprising evaluated and multiplied material of blackgram (23), brown top millet (47), sesame (85), brinjal (38), tomato (54), sorghum (34), greengram (42), and amaranths (15) were added to the MTM at the station. Facilitated the conservation of 32 accessions of

Taro (*Colocasia esculenta* var. *antiquorum* L. Schott and 4 accessions of Sweet potato (*Ipomoea batatas*) obtained from College of Horticulture & Research Station, Indira Gandhi Krishi Vishwavidyalaya. A set of each germplasm was dispatched to Tissue Culture &Cryo-preservation Unit, ICAR-NBPGR, New Delhi and ICAR-NBPGR Regional Station, Thrissur. One set has been planted in big cement pots for maintenance.

12.9 Germplasm Distribution

A total of 959 germplasm accessions were provided to 30 SAUs/ICAR institutes against 33 indents including brown top millet (9), chillies (339), blackgram(150), brinjal(20), maize (17), finger millet (1), jack/swordbean (15), tomato (361), and yardlong bean (38), Besides these, 9 accessions of wild species of different crops including *Lycopersicon hirsutum, Lycopersicon peruvianum, Solanum insanum, Sesamum alatum and Solanum incanum* were also distributed against various indents. 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 farmer's varieties registered with PPVFRA, including *Erramachcha kandi* (pigeonpea) and *Pelala jonna (sorghum)* and *Vayunowka jonna* (sorghum) were also distributed to tribal farmers for popularization, multiplication, sharing and to form a cooperative for production, marketing and creation of a value chain.

12.10 Green gram Farmer's variety (*Balintha pesalu*) registration with PPVFRA - A Success Story

A Green gram Farmer's variety (*Balintha pesalu*), promising with erect, medium height, synchronous, medium maturing (Flowering: 43 days), pod medium length (up to 9.0 cm) and yellow seeds, having high soluble sugars (19.2%), carbohydrates (50.7%), iron (11.8 mg/ 100g), phenols (109 mg/ 100g) and antioxidants (273mg/ 100 g) was registered with PPVFRA (Application No. F3 VR4 14 877) through Biodiversity Management Committee, Dampur-504 251, Bheemini Mandal, Mancherial District, Telangana. This farmer's variety is traditionally consumed by mothers to improve lactation after delivery and well known to the farming community in Telangana (Fig. 12.16).

12.11 Germplasm Released as varieties

Yardlong Bean –*Arka Mangala:* Released by ICAR-IIHR, Bangalore through pure line selection from a germplasm accession IC582850, collected from Jeypore, Koraput Odisha in 2011 was earlier released for cultivation throughout India through the CVRC. The variety is suitable for Punjab, UP, Bihar, Jharkand, Karnataka, Tamil Nadu and Kerala. Plants are tall (3-4 m), pole type require staking; pods are very long (70-

Fig. 12.16. Green gram Farmer's variety (*Balintha pesalu*) registered with PPVFRA

80 cm), with 20-22 seeds, light green, stringless, round, tender with crisp texture and mature in 60 days with a pod yield of 25 t/ha in 100 days. Pods are string less, can be snapped very easily and are without parchment. This variety is mainly proposed for the fresh market (Fig. 12.17).

Fig. 12.17. Yardlong bean variety *Arka Mangala* released for cultivation throughout India

Yardlong bean variety *Sahasra* was released by Sri Konda Laxman Telangana State Horticultural University as a pure line selection from IC582860 (KV/ TSA-35) from Vizianagaram, Andhra Pradesh. The variety is pole type, with a crop duration of 76 days; pods are long light green fleshy, tender with good cooking quality; The variety is tolerant to aphids and has a yield potential of 19.95 mt/ ha (Fig. 12.18).

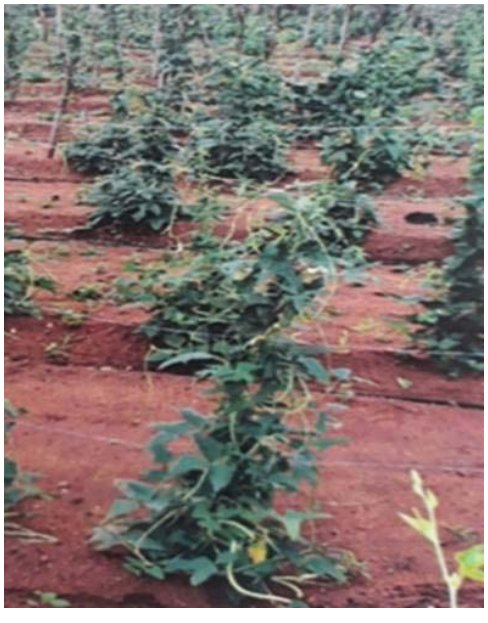


Fig. 12.18. Yardlong bean variety *Sahasra* released for Telangana and Andhra Pradesh

Cluster Bean Variety ***Telangana Gokarakaya*** was released by Sri Konda Laxman Telangana State Horticultural University [(SVRC/ Notified (2019)] through a pure line selection from IC103295 from Gujarat. The variety has a yield potential of19.2 q/ ha and 13.5 q/ ha (seed yield).This variety is recommended for cultivation in Telangana region (Fig. 12.19).

Fig. 12.19. Cluster Bean Variety Telangana *Gokarakaya* recommended for cultivation in Telangana region

The Coriander variety **Rajendranagar Kottimeera** was developed by SKLTSHU from NBPGR germplasm accession IC512365 by pure line selection was released for cultivation in Telangana (Fig. 12.20). It was found to be promising with a potential of 19.1 q/ ha (Green leaf).

Fig. 12.20. Coriander variety Rajendranagar Kottimeera released for cultivation in Telangana

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

Programme I: PGR/PQR-BUR-HYD-01.00: Quarantine processing of plant germplasm under exchange and supportive research (**B Sarath Babu** (up to 31.05.20)**, K Anitha** (w.e.f. 01.06.20))

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**, B Sarath Babu (upto 31.05.20), SK Chakrabarty (upto 31.12.19), N Sivaraj (upto 31.03.20), Prasanna Holajjer, Bhaskar Bajaru (w.e.f. 01.06.20) and *Babu Abraham*)

PGR/PQR-BUR-HYD-01.02: Post-entry quarantine processing of imported germplasm (**SK Chakrabarty** (up to 31.12.19); **B Sarath Babu** (up to 31.05.20); **Prasanna Holajjer** (w.e.f. 01.06.20); K Anitha, Bhaskar Bajaru (w.e.f. 01.06.20) and *Babu Abraham*)

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 (**B Sarath Babu** (up to 31.05.20)**, K Anitha** (w.e.f. 01.06.20))

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**, SR Pandravada, N Sivaraj, P Pranusha, Bhaskar Bajaru (w.e.f. 01.06.20) and *Babu Abraham*)

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, N Sivaraj, P Pranusha, Prasanna Holajjer and *Babu Abraham*)

13 REGIONAL STATION, JODHPUR

Summary: Total 1350 germplasm accessions of various crop groups comprising 302 accessions during *Rabi* 2019-20 and 1048 accessions during *Kharif* 2020 were characterized and evaluated at Jodhpur station. During *Rabi* 2019-2020,three sets of 224 accessions of wheat mini core were evaluated against drought and terminal heat stress tolerance. A total of 34 accessions of Indian mustard and 20 accessions of fenugreek have been characterized and evaluated for morphological charactersand screened against biotic and abiotic stresses. Twenty four accessions of pomegranate were characterized for various morphological and quality parameters. Crop wise accessions characterized and evaluated during *Kharif* 2020 including clusterbean (300), mung bean (228), moth bean (200) and cowpea (320)for morphological traits and various biotic stresses. The experiments were conducted in Augmented Block Design/ Randomized complete Block Design and the agro-morphological characters were recorded as per the Minimal Descriptors Published by ICAR-NBPGR. The trait specific promising germplasm accessions were identified in these crops. Supplied 1467 accessions of various crops, viz., cluster bean (350), pearl millet (288), mung bean(317), moth bean (190), muskmelon (20) and cowpea (302) were supplied from MTS for research purpose to 19 user agencies with in India. Multiplied and regenerated 303 germplasm accessions of different crops during the period under reporting. Total453germplasm accessions of perennial crops are being maintained as live plants in the field gene bank. A total of 43,085 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 Characterization and Evaluation of Germplasm

13.1.1 *Rabi* 2019-20

A total of 302 accessions were characterized and evaluated during *Rabi* 2019-20. Crop wise accessions characterized and evaluated were three sets of wheat mini core accessions (224 acc.), Indian mustard (34 acc.), fenugreek (20 acc.) and pomegranate (24 acc.). The experiments were conducted in ABD/RBD design.

13.1.1.1 Evaluation of wheat germplasm against drought and terminal heat stress

Wheat minicore set (224 accessions) along with 4 checks *viz.*, HD2967, WR-544, HD3086 and C-306 was evaluated against drought and terminal heat stress for 14 agro-morphological traits. Data were recorded and promising accessions identified (Table 13.1).

13.1.1.2 Preliminary evaluation of Indian mustard for abiotic stresses

A set of 34 accessions of *Brassica juncea* along with three checks was evaluated against moisture stress to study the effects of drought on yield and yield related characters. These accessions were grown under irrigated (normal) and rainfed (moisture stress) conditions. In case of rainfed condition, pre-sowing irrigation and one life saving irrigation was applied when more than 80 % plants showed leaf rolling. Data were recorded for morphological traits and promising accessions identified.

13.1.1.3 Characterization of methi germplasm for agro-morphological traits

A total of twenty accessions of fenugreek kept in MTS facility were multiplied and characterized for agro-morphological traits in *Rabi* 2019-20.

Data were recorded on morphological traits as per descriptors.

13.1.1.4 Preliminary evaluation of methi germplasm for biotic stresses

A total of twenty accessions of fenugreek were screened under natural condition for identifying resistance level against powdery mildew disease caused by *Erysiphe polygoni*. Out of 20 germplasm accessions one accession EC 510588 gave immune reaction to powdery mildew disease. There was not a single spot appeared to these accessions. Thus, these accession shown absolute resistance and can be used in resistance breeding against powdery mildew disease. All the other accessions showed some degree of susceptibility to powdey mildew disease. There was heavy disease severity during late vegetative stage of crop growth.

13.1.1.5 Preliminary evaluation of Indian mustard germplasm for biotic stresses

A total of thirty four accessions of mustard were screened under natural condition for identifying resistance level against white rust caused by *Albugo candida* and powdery mildew disease caused by *Erysiphe cruciferarum*. Out of 34 germplasm accessions, 33 accessions gave susceptible reaction to white rust and powdery mildew diseases. One of the accession (IC 422166) was identified which gave complete resistance reaction against the white rust disease andmoderately resistant reaction against powdery mildew disease (Fig. 13.1 & 13.2).

Fig. 13.1. Mustard germplasm accessions IC 422166 showing resistance reaction against white rust disease

Fig. 13.2. Mustard germplasm accessions IC 422166 showing moderately resistance reaction against powdery mildew disease

13.1.1.6 Characterization of pomegranate germplasm for morpho-chemical traits

Twenty four accessions of pomegranate being conserved in field gene bank were characterized for morphological characters during*Rabi* 2019-20. Promising accessions identified for various traits as mentioned (Table 13.1).

13.1.2 *Kharif* 2020

A total of 1048 accessions were characterized and evaluated during *Kharif* 2020. Crop wise accessions sown for characterization and evaluation include cluster bean (300), mung bean (228), moth bean (200) and cowpea (320)for agor-morphological traits and various biotic stresses. 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 Descriptors Published by ICAR-NBPGR.

13.1.2.1 Characterization and Evaluation of Mothbean (*Vigna aconitifolia)* germplasm

A totalof 200 accessions of moth bean were sown during *Kharif* 2020 for characterization and evaluation of traits of agronomical importance.Due to erratic rainfall seed setting could not be takes place in moth bean germplasm. There was heavy incidence of yellow mosaic virus disease and most of the accessions got affected with YMV. One of the moth bean accessions, IC 103016 has shown resistant reaction against the YMV in field condition. It showed heavy lush green foliage and maybe useful as a fodder crop (Fig. 13.3).

Fig. 13.3. Moth bean accession (IC 103016) showing field resistance against yellow mosaic disease

13.1.2.2 Characterization and Evaluation of Mung bean (*Vigna radiata)* germplasm

A totalof 228 accessions of mung bean were sown during *Kharif* 2020 for characterization and evaluation of traits of agronomical importance. Due to erratic rainfall seed setting was not observed in mung bean germplasm.

13.1.2.3 Characterization and Evaluation of Cow pea (*Vigna unguiculata)* germplasm

A total of 320 accessions of cowpea along with four checks (FTC-27, NS-24/8-2, GC-3 and V-585) were evaluated in ABD. High variability was observed for various characters and promising accessions identified (Table 13.1).

An accession of cowpea EC 72409 showed absolute field resistance against viral diseases. It may be a dual purpose accession where leaves remain green after pods maturity. It shows upright growth pattern and absence of tendrils. It is suitable for mechanical harvesting as it has shown resistance to lodging and remains upright till maturity (Fig. 13.4).

Table 13.1. Characterization and evaluation of agri-horticultural crops germplasm during 2020

S. No.	Crops	No. of accessions	Characters	Promising accessions
1	Wheat	672	High Grain Weight Long Spike Size	IC 539313 IC 539316
2	Mustard	34	Drought tolerant accession with DSI (<0.5) for days to 50 5 flowering Drought tolerant accession with DSI (<0.5) fornumber of siliqua per plant Drought tolerant accession with DSI (<0.5)for1000 seed weight Drought tolerant accessions with DSI (<0.5)forseed yield per plant Resistance accessions against white rust and powdery mildew diseases	IC 422176 IC422188 IC422171 IC422160, IC422168 IC 422166
3	Pomegranate	24	High TSS content (>20) Rind weight (> 75 g) Juice pH	EC81839 EC 104349 (<3.5) Jodhpur local
4	Ber	26	High TSS content (>20) High phenol content (>250) High antioxidant content (>400)	IC 625852 IC 625864 IC 625864
5	Karonda	18	Precocious (February), heavy bearer (>20 Kg)	EC35952
6.	Ker	15	Twice in flowering (Dec & June) Bigger size fruit ((13.5g)	IC 103395 IC 103393
7	Jojoba	95	Higher yielder ((>5 Kg)	EC 99691EC 33198
8	Methi	20	Resistance against powdery mildew disease	EC 510588
9	Moth bean	200	Yellow mosaic virus resistant	IC 103016
10	Cow pea	320	Resistance against YMV and dual purpose utility for seed and fodder Days to initial flowering (<36) Days to 50% flowering (<44) Days to 80% maturity (<62) 100 seed weight (>19.5)	EC 72409 EC 724363 and EC 101929 EC 724484 and EC 101929 EC 724529 and EC 101929 EC 724279 and EC 724328
11	Cluster bean	300	All node pod bearing habit Determinate type plant type All node pod bearing, determinate type, early maturity Single stem, all node bearing and determinate type Vegetable purpose guar Bacterial blight disease resistance Days to initial flowering (<37 days) Days to 50% flowering (<42 days) Days to 80% maturity (<80 days) 100 seed weight (>5 g)	PLG-396, PLG-381, PLG-318 PLG-311P1, IC-200751, PLG-327P1 IC-200746 IC-140784P1 PLG-324, IC-40850, PLG-330, IC-11749, IC-34317, IC-200735, IC-370468, IC-28276, IC-9191, IC-11704, IC-3773, IC-1179, PLG-370 PLG-420, IC-8456 and PLG-745 IC 9021P1 and PLG-296P1 IC 200746 and IC 9021P1 PLG 296P1 and IC 200746 PLG-420, IC-9021P1 and IC-200735

Fig. 13.4. Dual purpose, disease resistant cow pea accession EC 72409

13.1.2.4 Characterization and Evaluation of Cluster bean (*Cyamopsis tetragonaloba)* germplasm

A total of 300 accessions of cluster bean along with four checks (RGC-1066, RGC-986, PLG-85 and RGC-1038) were evaluated in ABD. High variability was observed for various characters and promising accessions identified (Table 13.1) (Fig. 13.5, 13.6 & 13.7).

Fig. 13.6. Single plant selection of cluster bean accession IC 140784P1 shown promising traits of determinate growth with all node pod bearing habit and single stem

Fig. 13.5. Cluster bean accession IC 200735 found early in 50% flowering (41 days) and 80% maturity (79 days) as compared to best check value

Fig. 13.7. Cluster beanaccession PLG-420 showed resistance reaction against bacterial blight disease under field conditions

13.2 Regeneration and multiplication of germplasm

During the period under report, a total of 303 accessions were grown for regeneration and multiplication. This includes Moth bean (17), Mung bean (20), Pearlmillet (200) and 66 accessions collected during exploration from three districts of western Rajasthan.

13.3 Germplasm Conservation

13.3.1 Germplasm Conservation in MTS unit

Total43085 accessions of agri-horticultural crops are being conserved at the station,as seeds being conserved in the MTS facilities. In MTS, seeds of a total of 43085 accessions of cereals & millets (14,524), legumes (16,321), oilseed (5183), plants of economic importance (943), medicinal plants (1519), Indian grasses (361), fiber and fodder plants (544), Indian fruits (1571), Indian spices (659) and Indian vegetables (1459) are being maintained.

13.3.2 Germplasm Conservation in Field Gene Bank

Total 453 germplasm accessions of horticultural crops are being maintained as live plants in the field gene bank of the station (Table 13.2).

Table 13.2: Horticultural crops germplasm being maintained in field gene bank

S. No.	Hindi Name	English name	Scientific name	No. of accessions
1	Nimboo	Lemon	*Citrus limon*	19
2	Jamun	Indian Blackberry	*Syzygiumcumini*	10
3	Anar	Pomegranate	*Punicagranatum*	26
4	Ber	Indian plum	*Ziziphusmauritiana*	26
5	Karonda	Cranberry	*Carissa carandas*	18
6	Carnauba	Carnauba Wax Palm	*Copernicia prunifera*	1
7	West Indian cherry	Semeruco	*Malpighiaemarginata*	2
8	Linaloe	Mexican linaloe	*Bursera glabrifolia*	1
9	Desert teak	Rohida	*Tecomellaundulata*	2
10	Khajoor	Datepalm	*Phoenix dactylifera*	5
11	Gunda	Lasura	*Cordia myxa*	17
12	Gundi	-	*Cordia rothii*	8
13	Sahjan	Drumstick	*Moringaoleifera*	12
14	Jaal tree	-	*Salvadoraoleoides*	2
15	Jangal jalebi	-	*Pithecellobiumdulce*	1
16	Sahtut	Mulberry	*Morus alba*	2
17	Kair	-	*Capparis decidua*	15
18	Hingotia	Desert date	*Balanitesaegyptiaca*	16
19	Kamal cactus	Agave	*Agave americana*	26
20	Jojoba	Goat nut	*Simmondsiachinensis*	95

S. No.	Hindi Name	English name	Scientific name	No. of accessions
21	Guggul	-	*Commiphorawightii*	30
22	Aonla	Indian gooseberry	*Phyllanthusemblica*	41
23	Baelpatra	Bael	*Aegle marmelos*	19
24	Amrood	Guava	*Psidiumguajava*	10
25	Sitaphal	Sugar Apple	*Annona squamosa*	3
26	Bidi leaf tree	Bauhinia	*Bauhinia racemosa*	3
27	Aam	Mango	*Mangiferaindica*	1
28	Imli	Tamarind	*Tamarindusindica*	1
29	Ghritkumari	Aloe	*Aloe vera*	2
30	Phalsa	-	*Grewiaasiatica*	19
31	Bouganvilla	*Bougainvillea*	*Bougainvillea spectabilis*	1
32	Sadabahar	Periwinkle	*Catharanthusroseus*	1
33	Murwa	Marjoram	*Origanummajorana*	1
34	Chameli	Jasmine	*Jasminumofficinale*	1
35	Nag Champa	-	*Mesuaferrea*	2
36	Vajradanti	-	*Barleriaprionitis*	1
37	Mehndi	Henna	*Lawsoniainermis*	1
38	Kaner	-	*Neriumindicum*	2
39	Amaltas	Golden shower	*Cassia fistula*	1
40	Kummat	-	*Acacia senegal*	1
41	Gudhal	Hibiscus	*Hibiscus rosa-sinensis*	1
42	Simarouba	-	*Simaroubaamara*	1
43	Harsinghar	Night jasmine	*Nyctanthes arbor-tristis*	1
44	Meetha neem	Curry leaf tree	*Murrayakoenigii*	1
45	Shatavari	Asparagus	*Asparagus racemosus*	1
46	Ashwagandha	-	*Withaniasomnifera*	1
47	Kela	Banana	*Musa acuminata*	1
48	Mogra	Arabian jasmine	*Jasminumsambac*	1
49	Khejri		*Prosopis cineraria*	1
	Total			**453**

13.4 Germplasm Supplied

During the period, a total of 1507 accessions of various crops, viz., cluster bean (350), pearl millet (288), mung bean(317), moth bean (230), muskmelon (20) and cowpea (302) were supplied from MTS to 15 indenters belonging to ICAR Institutes, SAUs and other research organizations engaged in crop improvement programmes (Table 13.3).

Table 13.3: Seed supplied to various indenters

S. No.	Crop	No. of accessions	To whom
1.	Clusterbean	300	Dr. Ravish Panchta, CCSHAU, Hisar
2.	Clusterbean	50	Dr.Veena Gupta, DGC, NBPGR
3.	Mung bean	17	Dr. RajwantKalia, CAZRI, Jodhpur
4.	Mung bean	300	Dr. Sevanarayanam, TNAU
5.	Pearl millet	50	Dr. Manoj Kumar, AICCRP Pearlmilet, Mandore, Jodhpur
6.	Pearl millet	80	Dr. Dama Ram, AP, AU Jodhpur
7.	Pearl millet	100	Dr. Rumana Khan, RLB CAU, Jhansi
8.	Pearl millet	50	Sukhpal Singh, Foragen Seeds, Hyderabad
9.	Pearl millet	08	Dr. PrveenSoni, University of RajasthanJaipur
10.	Moth bean	40	Dr.RajwantKalia, CAZRI, Jodhpur
11.	Moth bean	50	Sameer S Bhagyawant, Gwalior
12.	Moth bean	100	Dr. Surendra K Meena, IIPR, Bikaner
13.	Moth bean	40	Dr. Mukesh Jain, JNU, New Delhi
14.	Musk melon	20	Dr. P Umamaheswarappa, Karnataka
15.	Cowpea	302	Dr. Sevanarayanam, TNAU
	Total	**1507**	

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

PGR/DGC-BUR-JOD-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in arid and semiarid regions (**Kartar Singh**).

PGR/DGC-BUR-JOD-01.01: Management of genetic resources of agri-horticultural crops in arid and semi arid regions (**Kartar Singh**; Neelam Shekhawat).

PGR/DGC-BUR-JOD-01.02: Evaluation of Agri-horticultural crops germplasm against abiotic stress tolerance in arid and semi arid regions (**Neelam Shekhawat;** Kartar Singh).

PGR/DGC-BUR-JOD-01.03: Evaluation of Agri-horticultural crops germplasm against biotic stress tolerance in arid and semi arid regions (**Kartar Singh**; Neelam Shekhawat).

14 BASE CENTRE, RANCHI

Summary: Two exploration programme were undertaken in Jharkhand to collect accessions of cereals, pulse, vegetable, oilseed and crop wild relatives. A total of 179 accessions of lentil, 21 accessions of Fababean and 2,410 accessions of Horsegram were evaluated/characterised for grain yield attributes and morphological traits. Besides, accessions of Jackfruit and Tamarind characterized and/or evaluated for agro-morphological attributes to identify superior accessions. 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 on Sept 30, 2020 in Rania block of Khunti district of Jharkhand.

14.1 Exploration and germplasm collection

14.1.1 Germplasm exploration (2)

From Nov. 09-21, 2020 a total of 50 accessions of field crop and their wild relatives collected from Giridih, Deoghar, Pakur, Dumka and Jamtara districts of Jharkhand. Based on exploration findings potential areas as Biodiversity hotspots were proposed for Crop Wild Relatives namely, *Cajanus scarabaeoides* (Lanka block of Latehar, Jharkhand), *Oryza nivara* and *O. Rifipogon* (Bangabad block of Giridih, Jharkhand).

Besides, 17 blocks of the three districts were surveyed for the occurrence of off-season Jackfruit. Off season/ continuous bearing plants were identified in Namkum Block of Ranchi, Rania block of Khunti and Thetaitangar as well as Kolebeira block of Simdega district. Scion of these potential sources will be grafted in rainy season. In addition, 2 accessions of sitaphal collected during the exploration and being raised in nursery.

14.2 Gemplasm evaluation, characterization and multiplication

Lentil core was evaluated (a total of 179 accessions) along with four checks namely IPL 220, L 4727, L 4729, RVL 31 by following Augmented Block Design its performance summarised in Table 1.

Table 14.1: *Per se* performance of lentil accessions

S. No.	Characters	Range	CD (0.05)	CV (%) Error	CV (%) Phen.
1	Leaflet length (cm)	0.60-1.60	0.32	12.68	16.66
2	Leaflet width (cm)	0.20-0.40	0.10	15.21	20.61
3	Days to 50% flowering (DAS)	39.00-135.00	9.07	5.25	20.66
4	No. of secondary branches	2.00-9.00	3.35	24.61	39.17
5	Plant height (cm)	18.00-54.00	13.27	14.99	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

A total of 21 entries along with three checks of Faba Beans (*Vicia faba*) evaluated under rainfed condition. Out of which entry number 252831 (6.8 cm long pod with 122 days for 80% maturity) found superior over the best check namely Vikrant (5.3 cm and 129 Days). Further, 17 F_3 populations along with three checks of Faba Beans (*Vicia faba*) evaluated for yield attributing traits that led to identification of entry number 252855 (7.5 cm), 252873 (7.1 cm) and 252874 (7.1 cm) with higher pod length over the best check Basabeer (5.9 cm). In parallel, a total of 17 entries along with four checks of the crop evaluated under late sown condition and identified entries number 252805 (54 g), 252798 (52.5 g), 252799 (51.9 g) with higher 100 seed weight over best check Yahya (47 g).

A total of 2,410 accessions of Horsegram (*Macrotyloma uniflorum)* is being characterized since last two years. Both the years data sent to crop coordinator (DBT minor pulses) in order to develop core set of the crop. Further, based on two years performance trait specific accessions identified for registration purpose (Table 14.2).

Table 14.2: Selected accessions of Horsegram (*Macrotyloma uniflorum*)

Sl. No.	Trait	Accession
1	Number of pod/ plant	IC 120837 (350), IC 261287 (315), IC 262143 (312), IC 145292 (311), IC 261284 (310), IC 145286 (310), IC 47185 (300), IC 139357 (300)
2	Determinate habit	IC 33072
3	Bold seed	IC 121635, IC 145264
4	Fodder purpose plant type	IC 261286

Bael: A total of 106 accessions of bael (*Aegel marmalos*) characterized for morphological attributes. *Per se* performance of the population for qualitative and quantitative traits presented in Table 14.3 and Table 14.4, respectively.

Table 14.3: *Per se* performance of bael (*Aegel marmalos*) accessions for qualitative traits

Sl. No.	Qualitative Trait	Performance
1	Growth habit	Drooping (52), Semi-spreading (30), Spreading (14), Upright (30)
2	Phyllotaxy	Pentastichous (94), Tristichous (32)
3	Leaf shape	Lanceolate (16), Lanceolate to Ovate (24), Ovate (67), ovate to elliptic (2), Broadly ovate (17)
4	Leaf apex	Acuminate (8), Acute (35), Aristate (83)
5	Leaf base	Attenuate (7), Cuneate (26), Round (91), Tapering (2)
6	Leaf surface	Rough (60), smooth (66)
7	Leaf margin	Crenate (64), Crenulate(61)
8	Thorni-ness	Thorny (47), Thornless (78)
9	Fruit shape	Elliptical (18), Globose (30), ovate (8), Round (70)
10	Fruit surface	Rough (113), Smooth (12)
11	Styler end cavity	Depressed (35), Highly depressed (38), Shallow (53)
12	Stem end cavity	Depressed (44), Fattened (36), Shallow (46)
13	Locule arrangement	Centric (31), Highly centric (87), Scattered(8)
14	Seed shape	Oblong (22), Round (104)
15	Pulp colour	Yellow (75), Light Yellow (51)

A total of 110 Jackfruit accessions characterised during the reporting period for morphological attributes including yield attributing traits. The characterization is continued since 2017 and their mean performance over years (2017-2020) mentioned in Table 14.5.

Trait specific accessions identified in the population for enhanced utilisation in Jackfruit improvement programme (Table 14.6).

Table 14.4: *Per se* performance of bael (*Aegel marmalos*) accessions for quantitative traits

S. No.	Attribute	Range		Mean	CV (%) Phen.	Promising accessions
		Min.	Max.			
1	Inter nodal distance (cm)	1.60	5.00	3.00	20.86	IC348029 (5), IC348041 (4.9), IC348042 (4.3), IC436506 (4.24), IC209917 (4), IC348032 (4), IC209918 (3.8), IC209919 (3.8), IC594242 (3.8)
2	Leaf length (cm)	6.30	15.60	9.86	15.50	IC594268 (15.6), IC531738 (14.6), IC436490 (13.3), IC594260 (12.4), IC594253 (12.1), IC594259 (12.1), IC594255 (11.9), IC348025 (11.9), IC348038 (11.8)
3	Leaf width (cm)	2.80	8.50	5.23	17.61	IC594268 (8.5), IC531738 (7.4), IC594245 (7.14), IC436490 (7.1), IC594255 (7), IC594260 (6.9), IC594271 (6.8), IC594253 (6.7), IC594247 (6.64)
4	Fruit weight(kg)	0.16	1.55	0.55	48.04	IC285308 (1.55), IC594253 (1.31), IC594259 (1.28), IC594245 (1.24), IC594261 (1.22), IC594284 (1.08), IC209918 (0.99), IC436486 (0.97), IC585279 (0.96)
5	Total seed	15.50	125.00	61.23	36.20	IC594269 (125), IC594251 (116), IC594253 (108), IC594308 (103), IC339940 (102.5), IC594247 (100), IC594270 (99), IC594244 (98), IC594254 (98)
6	Total soluble solids (Brix) Pulp	20.30	47.00	32.51	14.77	IC339940 (47), IC339941 (46.95), IC594255 (43), IC594246 (41.9), IC209923 (41.3), IC285308 (40.62), IC209915 (38.7), IC209917 (38.6), IC209920 (38.45)

Table 14.5: Mean performance for quantitative traits in Jackfruit population

Attribute	Unit	Range	Mean±SE	Coefficient of Variation (%)
Leaf blade length	cm	8.3 - 17.1	13.35± 0.10	14.34
Leaf blade width	cm	3.1 – 10	7.07± 0.13	15.85
Petiole length	cm	0.8 - 2.7	1.56± 0.04	27.68
Fruit length	cm	18 – 53	36.20± 0.42	20.95
Fruit diameter	cm	10.5 – 29	17.20± 0.35	19.05
Pedicel length	cm	4.7-62.1	16.49± 0.85	53.44
Fruit base length	cm	1.0 - 11.2	5.44±0.17	32.34
Fruit base diameter	cm	1.4 - 4.2	2.07±0.05	23.16
Flake length	cm	3.6 - 8.44	5.86±0.12	21.60
Flake width	cm	2.0 - 4.54	3.36±0.06	18.08
Rachis length	cm	6.4 – 42	25.73±0.65	26.58
Rachis width	cm	2.0 -11.7	5.87±0.17	30.24
Seeds/fruit	no.	12.0 -663	169±10.00	62.52
Seed test weight	g	32.4 - 116.65	57.11±1.65	30.23
Fruits/tree	no.	7.0 -56	12±1.34	61.00
Fruit weight	kg	1.03 - 22.23	7.79±0.38	50.95
Rind weight	kg	0.74 - 12.34	3.52±0.17	52.13
Rachis weight	kg	0.1 - 16.8	4.53+ 0.82	66.62
Flake weight	kg	0.16 - 7.5	2.64±0.15	60.89
Seed weight	kg	0.04 - 3.09	0.93±0.05	60.22

Table 14.6:Trait specific superior accession(s) in Jackfruit

Sl. No.	Trait	Unique accession	Mean performance
1	Earliness for 50% fruit bearing	IC24369 starts bearing 50% fruit (at least 500g size) from December	In general accessions starts bearing 50% fruit (at least 500g size) from February
2	Number of fruit/plant	IC438858 (107 fruit/plant)	46 fruit/plant
3	Dwarf canopy	IC24345 (16 years old plant height: 2.4 m); IC24351 (16 years old plant height: 2.7 m)	16 years old plants height ranges between 5-7.8 m

In addition, a unique Jackfruit accessions (IC542353) identified with less interovular sterile fibrous tissue due to localised occurrence (Fig 14.1). The trait is of immense commercial utility for vegetable purpose Jackfruit where the fibrous tissue is an undesirable trait.

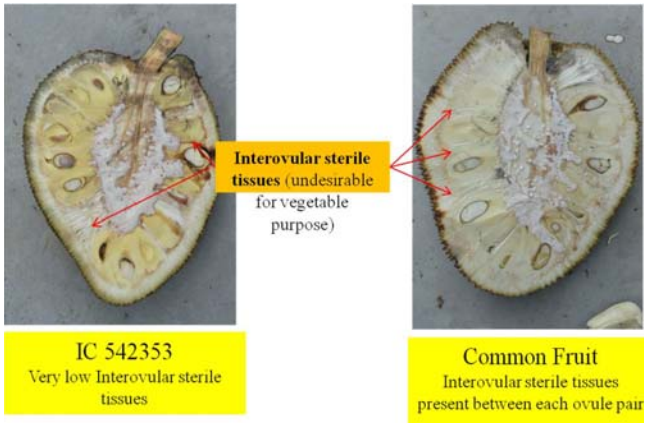


Fig. 14.1. Localized occurrence of inter-ovular sterile tissues in Jackfruit accession namely IC 542353

14.3 Germplasm multiplication and maintenance

A total of 617 accessions of fruit/ vegetable/ natural dye yielding plants are being conserved in field gene bank of the station (Table 14.7).

Table 14.7: Details of accessions conserved in field gene bank

S. No.	Crop		No. of accession
	Common name	Botanical name	
1	Jamun	*Syzygium cumini*	52
2	Bael	*Aegle marmelos*	162
3	Jackfruit	*Artocarpus heterophyllus*	246
4	Aonla	*Phyllanthus emblica*	19
5	Banana	*Musa* species	34
6	Lakoocha	*Artocarpus lacucha*	14
7	Mehandi	*Lawsonia inermis*	25
8	Drumstick	*Moringa oleifera*	14
9	Tamarind	*Tamarindus indica*	51
	Total		**617**

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, Programme Leader)

(PGR/PGC-BUR-RAN-01.00): Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in Bihar, Jharkhand and adjoining areas. (**SB Choudhary**)

Research Projects (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 [**SB Choudhary;** Reshmi Raj K. (Till 14.08.2020); Shephalika Amrapali (From 07.02.2020); AK Gupta (Till 30.09.2020)]

Project-2 (PGR/PGC-BUR-RAN-01.02): Management of PGR of horticultural crops and perennial medicine [**Shephalika Amrapali** (From 07.02.2020); Reshmi Raj K. (Till 14.08.2020), SB Choudhary (from 06.02.2020)]

15 REGIONAL CENTRE, SHILLONG

Summary: One multi-crop exploration was conducted in Goalpara (Assam) and adjoining districts of Meghalaya. A collection of 81 accessions covering in 37 species/taxa of targeted crops and CWRs was made during the period. A total of 2,099 accessions comprising maize (700), rice (414), *Coix* (74), buckwheat (800), mustard (25), cowpea (55), ash gourd (04) and cucumber (27) are conserved in MTS. The station has established 641accessioions comprising banana (45), guava (7), ginger & turmeric (352), *Colocasia spp.* (122), *Dioscorea spp.* (56) citrus & minor fruits (59) in the FGB. Field crop germplasm (1694 acc.) comprising maize (430), rice (400), *Coix* (74), buckwheat (700), mustard (26), cowpea (60) & ash gourd (04) was multiplied during 2020. A total of 959 accessions of various crops consisting maize (766), rice (100), mustard (70), chilli (21), turmeric (01) & buckwheat (01), were supplied to various indenters as per MTA. Station successfully conducted two Biodiversity Fair cum PGR awareness camps at Umpowin village of Ri-Bhoi district (Meghalaya) and Hayuliang village of Anjaw district (Arunachal Pradesh) in collaboration with their respective KVKs under Tribal Sub Plan (TSP).

15.1 Germplasm exploration

A multi-crop exploration was undertaken in Goalpara (Assam) and adjoining districts of Meghalaya. A total of 81 accessions covering in 37 species/taxa of targeted crops and crop wild were collected. Notable collections consisting small sized pumpkin (HP-8), *Luffa cylindrica* where fruit length is not exceeding 4-5 cm (HP-29), purple pigmented *Colocasia esculenta* (HP-28) and a farmer's variety of Balijan block called "Balijan Baingon". Good variability in ridge gourd, ash gourd, scented sponge gourd and taro was observed.

Fig. 15.1. Farmers variety of brinjal collected from Balijan block of Goalpara

Fig. 15.2. Farmers variety of brinjal collected from Balijan block of Goalpara

Fig. 15.3. Small sized sponge gourd collection

15.2 Characterization of germplasm

15.2.1 Characterization of ricebean germplasm

A total of 120 ricebean accessions were evaluated for 12 different agro-morphological traits. Accessions IC7587, IC137190, IC137199, IC137200, IC140795, IC140808, IC243512, IC369282, IC369355, IC374605, IC394201, IC394425, IC394438 germinated in minimum number of days (8). Accessions IC137200 and IC419603 were recorded for minimum number of days (60) to attain 50% flowering. Accessions IC009634, IC7587-A and RSR-SKS-59 recorded highest values for plant height (191cm), number of branches/plant (5.67) and seed weight/plot (375g), respectively. IC009634 recorded highest values for different traits *viz*., leaflet length

Table 15.1: Descriptive statistics of agro-morphological traits of *Vigna umbellata* (ricebean) accessions

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Accessions
1	Days to Germination	10.5	8	21	2.46	23.42	IC7587 A, IC137190, IC137199, IC137200, IC140795, IC140808, IC243512, IC369282, IC369355, IC374605, IC394201, IC394425, IC394438 (8)
2	Days to 50% flowering	66.34	60	78	3.15	4.75	IC137200, IC419603
3	Plant height (cm)	73.87	26.67	191	22.71	30.74	IC009634
4	No. of branches/plant	2.37	0.67	5.67	0.99	41.66	IC7587-A
5	Leaflet length (cm)	9.72	3.2	14.37	1.46	15.02	IC009634
6	Leaflet width (cm)	6.23	3.37	10.73	1.06	17.00	IC009634
7	Pod length (cm)	9.74	6.2	12.83	0.99	10.18	IC009634
8	Seed length (cm)	0.72	0.503	1.131	0.08	10.60	IC009634
9	Seed width (cm)	0.42	0.307	0.69	0.05	11.82	IC009634
10	Seed length/Width ratio	1.73	1.46	2.49	0.15	8.63	IC137199
11	100 seed weight (g)	7.53	4.29	38.05	2.95	39.15	IC009634
12	Seed weight/plot (g)	208.8	10	375	80.15	38.39	RSR-SKS-59

Fig. 15.4. Field evaluation of ricebean germplasm

Fig. 15.5. Variability in ricebean seed size and colour

(14.37 cm), leaflet width (10.73cm), pod length (12.83cm), seed length (1.131cm), seed width (0.69cm) and 100 seed weight (38.05g).

15.2.2 Characterization of *Flemingia procumbens* (sohphlang) germplasm

Twenty-seven accessions of *Flemingia procumbens* (sohphlang) were characterised for

Table 15.2: 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)	61.72	46.00	84.33	9.41	15.25	IC0627404
2	Plant height (cm)	50.91	38.00	61.22	5.30	10.40	IC0627401
3	No. of nodes/plant	13.25	10.89	15.78	1.16	8.78	IC0627423
4	Petiole length	3.72	3.18	4.37	0.31	8.33	IC0627411
5	Leaf length (cm)	2.73	2.24	3.22	0.24	8.80	IC0627401/ IC0627420
6	Leaf width (cm)	2.65	2.26	3.12	0.21	7.89	IC0627401
7	Days to 50% flowering	142.89	136.00	149.00	4.11	2.87	IC0627404/ IC0627405/ IC0627410
8	No of flowers/ Inflorescence	4.85	4.33	6.00	0.48	9.96	IC0627413
9	Pedicel length (cm)	0.36	0.20	0.43	0.07	20.04	IC0627405/ IC0627424
10	Single tuber weight (g)	11.50	8.00	19.44	2.97	25.83	IC0627425
11	Tuber weight/plant (g)	225.68	86.66	361.66	75.01	33.24	IC0627423/ IC0627423
12	Tuber+shoot weight/plant (g)	249.38	93.32	406.66	84.67	33.95	IC0627423/ IC0627423
13	Tuber weight/plot (g)	1029.19	260.00	1825.00	423.23	41.12	IC0627403
14	No. of tubers/plant	13.49	7.67	28.33	4.67	34.58	IC0627416
15	Tuber length (cm)	5.59	3.84	7.71	0.84	15.02	IC0627425
16	Tuber width (cm)	1.98	1.35	2.46	0.25	12.44	IC0627417
17	HI/plant	0.91	0.85	0.97	0.03	3.29	IC0627424

Fig. 15.6. Field evaluation of *Flemingia procumbens* germplasm

Fig. 15.7. Diversity in *Flemingia procumbens* tubers

17 agro-morphological traits. Superior accessions were identified for various traits plant-cover (IC0627404, 84.33 cm), plant height (IC0627401, 61.22cm), number of nodes/plant (IC0627423, 15.78), petiole length (IC0627411, 4.37cm), leaf length (IC0627401/ IC0627420, 3.22cm), leaf width (IC0627401, 3.22cm), 50%-flowering (IC0627404/ IC0627405/ IC0627410, 149 days), number of flowers/inflorescence (IC0627413 , 6), pedicel length (0.43cm), single-tuber-weight IC0627425, 19.44g), tuber weight/ plant and tuber+shoot weight/plant (IC0627423, 361.66g, 406.66g), tuber weight/ plot (IC0627403, 1825g), number of tubers/plant (IC0627416, 28.33), tuber-length (IC0627425, 7.71cm), tuber-width (IC0627417, IC0627419, 2.46cm) and HI/plant (IC0627424, 0.97).

15.2.3 Characterization of *Coix lacryma-jobi* germplasm

Twenty-one agro-morphological traits were studied in 74 accessions and 02 checks of *Coix lacryma-jobi*. Superior genotypes were identified for various traits such as IC629196 for number of tillers/plant (4.66), JTN-17/IC629196 for plant height (190/217.5cm), IC334134 for number of nodes/plant (15.5), IC604098/ IC601106 for culm diameter (2.02/2.03cm), JTN-16 for angle between leaf and stem (4.00cm), IC604098 for leaf blade length (89.00cm), IC604098 for leaf blade width (6.75cm), RSR-SKS-75/ IC629198 for days to 50% flowering (101,102), IC334134 for bract length (8.73cm), JTN-1/ IC-334317 for number of seeds/plant (1435/135), JTN-17/IC-89385 for 100 seed weight ((18.12/15.45g), JTN-1/RS-RS-13 for seed weight/plant (126/135g), IC629198/ JTN-1 for seed weight/plot (890/955g), IC374506 for seed length (1.84cm), IC89385 for seed width (0.90cm), IC374506 for seed length/ width ratio (2.47), IC89395/IC89394 for kernel length (0.62cm), IC89385/JTN-15for kernel width (0.62cm) and IC22156 for kernel length/ width ratio (1.65).

Variations in qualitative traits were also observed where plant growth habit ranged from upright to semi-upright to spreading. Strong to medium to weak culm glaucosity was observed across the accessions. Leaf pubescence was absent and leaf attitude droopy in all the accessions studied. Different seed colours were observed viz. cream, brown, off white, white, grey and light grey. Seed shape varied from oval to elliptic while seed surface stripes varied from striped to intermediate smooth and smooth. Seed hull hardiness ranged from hard to medium to soft.

Table 15.3: Descriptive statistics of agro-morphological traits of *Coix lacryma-jobi* accessions.

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
1	Days to germinate	6.00	6.00	6.00	0.00	0.00	-
2	First leaf unfolding	8.00	8.00	8.00	0.00	0.00	-
3	No. of tillers/plant	1.50	0.00	4.67	0.79	53.15	IC629196 (4.66)
4	Plant height (cm)	298.04	190.00	400.00	54.73	18.36	JTN-17 (190)/IC629196 (217.5)
5	No. of nodes/plant	11.93	8.00	15.50	1.63	13.63	IC334134 (15.5)
6	Culm diameter (cm)	1.38	0.56	2.03	0.27	19.50	IC604098(2.02)/ IC601106(2.03)
7	Angle between leaf and stem (cm)	2.46	1.75	4.00	0.52	21.17	JTN-16 (4.00)
8	Leaf blade length	72.00	48.50	89.00	9.11	12.66	IC629196 (89.00)
9	Leaf blade width	5.19	3.50	6.75	0.60	11.59	IC604098 (6.75)
10	Days to 50% flowering	108.93	101.00	117.00	3.14	2.88	RSR-SKS-75 (101)/ IC629198 (102)
11	Bract length (cm)	5.38	3.27	8.73	1.00	18.55	IC334134 (8.73)
12	No. seeds/ Plant	644.50	257.33	1435.00	251.23	38.98	JTN-1 (1435)/IC334317 (1135)
13	100 seed weight	9.69	4.53	18.12	2.31	23.84	JTN-17(18.12)/IC89385 (15.45)
14	Seed weight/plant	43.71	15.00	135.00	20.68	47.30	JTN-1(126)/RS-RS-13(135)
15	Seed weight/plot	454.08	160.00	955.00	169.12	37.24	IC629198(890)/ JTN-1(955)
16	Seed length (cm)	0.97	0.12	1.84	0.19	19.16	IC374506(1.84)
17	Seed width (cm)	0.69	0.25	0.90	0.09	13.60	IC89385 (0.90)
18	Seed length/width Ratio	1.43	0.16	2.47	0.28	19.22	IC374506 (2.47)
19	Kernel length (cm)	0.53	0.30	0.63	0.07	14.07	IC89395(0.62)/IC89394(0.62)
20	Kernel width (cm)	0.52	0.26	0.63	0.07	14.24	IC89385/JTN-15(0.62)
21	Kernel length/width ratio	1.03	0.67	1.65	0.13	12.71	IC22156 (1.65)

Fig. 15.8. Field evaluation of *Coix lacryma-jobi* germplasm

Fig. 15.9. Variability in *Coix lacryma-jobi* seed shape, size and colour

15.2.4 Germplasm evaluation

Correlation study on eight yield related parameters of forty eight ginger accessions revealed that yield per plant(YPP) is positively and significantly(p=0.01)correlated with number of primary rhizome(0.478), number of secondary rhizome(0.548), thickness of primary rhizome (0.595) and weight of the mother rhizome (0.944) and positively correlated with length of the primary rhizome(0.088, thickness of primary rhizome (0.201), length of secondary rhizome (0.155) and thickness of secondary rhizome (0.176). Weight of the mother rhizome is significantly (p=0.01) correlated with number of primary rhizome (0.0393), length of the primary rhizome (0.409) and thickness of the secondary rhizome (0.570) and also significant(p=0.05) with length of the secondary rhizome (0.319). Its weight is positively correlated with number of secondary rhizome (0.209) and thickness of the primary rhizome (0.0227).

15.2.5 Characterization of *turmeric* (*Curcuma longa* L.) germplasm

Correlation of eight yield related parameters of the 112 turmeric accession revealed that yield per plant is positively and significantly (p=0.01) correlated at with number of primary rhizome (0.430), number of secondary rhizome (0.261), thickness of primary rhizome (0.590), length of

Table 15.4: Characterization of ginger germplasm in FGB.

Characters	Mean	Acc.	Max.	Acc.	Mean	SD	CV(%)
Number of primary rhizome	1	IC-211432	4	IC-540381	2.26	.67	29.6
Number of secondary rhizome	1.7	IC-584358	3.7	IC-584363	2.55	.45	17.6
Length of primary rhizome(cm)	3.1	IC-584341	8.6	IC-540381	5.65	1.19	21.1
Thickness of primary rhizome(cm)	1.7	IC-526698	6.3	IC-584352	2.78	.97	34.9
Length of secondary rhizome(cm)	1.8	IC-584356	8.6	IC-540381	5.6	1.16	20.7
Thickness of secondary rhizome(cm)	1.5	IC-584356	3.7	IC-850381	2.50	.50	20.0
Weight of Mother rhizome(g)	28.3	IC-584327	385	IC-540381	136.50	71.67	52.5
Yield per plant(g)	83.3	IC-211645	1115	IC-540381	411.25	213.57	51.9

(CV- Coefficient of variation, SD- Standard deviation.)

Table 15.5: Characterization of turmeric germplasm in FGB

Characters	Mean	Acc.	Max.	Acc.	Mean	SD	CV(%)
Number of primary rhizome	3.0	IC-588788	7.7	IC-280945	5.16	0.99	19.3
Number of secondary rhizome	1.3	IC-420402	5.7	IC-330394	3.26	0.77	23.6
Length of primary rhizome(cm)	4.5	IC-420449	9.3	IC-521331	6.31	1.07	16.9
Thickness of primary rhizome(cm)	1.1	IC-586776	4.3	IC-211434	2.03	0.53	26.1
Length of secondary rhizome(cm)	2.6	IC-212606	7.6	IC-212590	4.64	0.99	21.2
Thickness of secondary rhizome(cm)	1	IC-586776	2.7	IC-521331	1.50	0.28	18.6
Weight of Mother rhizome(g)	20	IC-330435	103	IC-335367	49.17	17.22	35.0
Yield per plant(g)	83.3	IC-420557	831.7	IC-330394	255.40	149.03	58.4

(CV- Coefficient of variation, SD- Standard deviation).

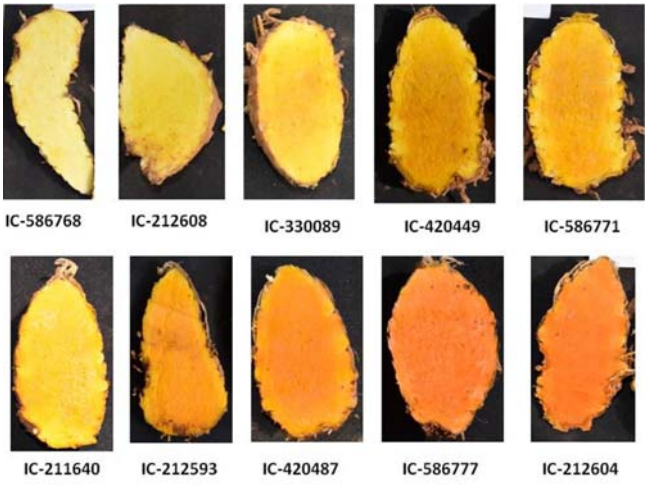


Fig. 15.10. Diversity of colour intensity in turmeric accessions (*Curcuma longa* L.)

the secondary rhizome (0.449), weight of the mother rhizome (0.606) and positively correlated with length of the primary rhizome (145). Weight of the mother rhizome is significantly (p=0.01) correlated with number of primary rhizome (0.395), thickness of the primary rhizome (0.595) and also significant (p=0.05) with length of the secondary rhizome (0.208). Its weight is positively correlated with number of secondary rhizome (0.014) and length of the primary rhizome (0.041).

15.2.6 Evaluation of *Prunus nepalensis* (Sohiong)

15.2.6.1 Standardization of Sohiong seed storage conditions for seed viability and germination

Effect of different seed storage days and conditions on seed moisture content, viability and germination of Sohiong *(Prunus nepalensis* Serr.) seeds were studied. Different storage conditions were used *viz*. a) room temperature dry sand, b) room temperature moist sand, c) 5°C dry sand and d) 5°C moist sand. The sohiong seeds were stored under various storage conditions for 15, 30, 45 and 60 days before taking out the seeds to check moisture content and viability. For viability testing, seeds from each storage condition were sown and subsequently, germination percentage was calculated. Seeds stored at room temperature in moist sand were observed to retain highest moisture content at 45 days of storage. Similarly, seeds stored at room temperature in moist sand showed highest germination percentage at all the storage days. However, the highest germination percentage was observed after 60 days of storage at room temperature in moist sand.

Fig. 15.10. Sohiong fruits

Fig. 15.11. Germinated Sohiong seedlings

Fig. 15.12. Fully developed Sohiong seedling

15.3 Germplasm regeneration/maintenance and conservation

A total of 2099 accessions comprising maize (700), rice (414), *Coix* (74), buckwheat (800), mustard (25), cowpea (55), ash gourd (04) and cucumber (27) are conserved in MTS. The station has established 641 accessioions comprising banana (45), guava (7), ginger & turmeric (352), *Colocasia* spp. (122), *Dioscorea* spp. (56) citrus & minor fruits (59) in the FGB. Field crop germplasm (1694 acc.) comprising maize (430), rice (400), *Coix* (74), buckwheat (700), mustard (26), cowpea (60) & ash gourd (04) was multiplied this year.

15.3.1 Establishment of minor fruit Field Gene Bank (FGB)

Thirty six accessions of different minor fruits including *Citrus* spp. were established in FGB during 2020.

15.4 Germplasm supply

A total of 959 accessions of various crops consisting maize (766), rice (100), mustard (70), chilli (21), turmeric (01) & buckwheat (01), were supplied to various indenters as per MTA

Table 15.6: List of different germplasm supplied

Institute name	Germplasm	Number
College of Agriculture, UAHS, VPKAS, Shimoga	Rice	100
ICAR, Hawalbagh, Almora	Mustard	70
ICAR, Lamphelpat, Imphal	Chilli	21
ICAR, Umiam	Maize	741
ICAR IIMR, PAU Campus, Ludhiana	Maize	10
ICAR, Lamphelpat, Imphal	Maize	15
IASST, Guwahati, Assam	Turmeric	1
Department of Agriculture, Meghalaya	Buckwheat	1
	Total	959

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

PGR/PGC-BUR-SHL-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of plant genetic resources in north-eastern India (**Harish GD**)

Research Projects (Code: Title, **PI,** CoPIs)

PGR/PGC-BUR-SHL-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural crops (paddy – low land/upland, maize and mustard) and their wild relatives. (**Harish GD** and S Hajong and Julius Uchoi)

PGR/PGC-BUR-SHL-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of horticultural crops (chilli, ginger, turmeric, yams, taros, citrus, banana and passion fruit) and their wild relatives. (**S Hajong**, Harish GD and Julius Uchoi)

PGR/PGC-BUR-SHL-01.03: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of underutilized (UU) crops and their wild relatives. (**Harish GD,** S Hajong and Julius Uchoi)

Externally Funded Projects

16113200013 (1011844): 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. **(Harish GD)**

16113200014 (1011967): Genetic diversity and biochemical profiling of Job's tears (*Coix lacryma-jobi* L.) accessions from North-east India – implications for evolution and breeding. **(S Hajong)**

16 REGIONAL STATION, SHIMLA

Summary: One exploration trip was undertaken during February 2020, and a total of 25 accessions of different fruit crop species were collected. A sweet kernel peach genotype has been identified and collected from Bari village, Kinnaur HP. Total 1,077 accessions of seed propagating crops were characterized and evaluated for agro-morphological traits, in which some accessions showed substantial variation. In grain amaranth, promising accessions were identified for six important agronomic traits *viz*., EC519515 (early maturity and dwarf type, 109 days and 99.7 cm), SKY74 (infl. length, 80.4 cm), IC568197 (plant height, 298.1 cm), AS/SKY/KCB/NAIP-52 (seed yield/plant, 140.0 g). In Buckwheat, IC37279, IC16552; IC341664 and IC109716 were found promising for days to maturity, no. of inflorescence/plant, and 1000-seed weight. In chenopod, IC7958 (early maturing, 100 days), IC7957 (plant height, 298.4 cm and higher seed yield/plant, 126.70 g) and IC258332 [(higher seed vol. (g/10ml), 7.52 g)], were identified. In french bean, EC500715 and IC405482 showed high no. of pods/ plant and high 100-seed weight, respectively. Likewise in field pea, JCR-JV-29 and EC838141 showed superiority for pod length and number of seeds/ pod and no. of clusters/ plant, respectively. As far as screening of french bean germplasm against BCMV is concerned, this resulted into the identification of some highly resistant sources against the virus. Total 4 genetic stocks, 2 each of wild lentil and french bean were approved for their registration. While in horticultural crops, total 131 germplasm accessions comprising of apple (30), pear (25), plum (18), peach (25), apricot (21), *Rubus* spp. (4) and hazelnut (8) were characterized for important pomological traits. An early maturing apricot accession (IC558065) identified three week early than all the quantifiable data must be preasented (eg. no. of daymaturity after potential) available accessions in FGB. In peach, one accession, EC280769 identified against high fruit weight ranged from 120 g to 140 g per fruit with juicy and excellent aroma with cream colour pulp. Accession IC209731 of *Rubus hypargyrus* reported with red colour fruit with highest fruit weight (20.0 g/10 fruits) and TSS 14.5 (°B). One accession of Hazelnut IC558093 recorded with highest nut (42.0 g/10 fruits) and kernel weight (16.66 g/10 kernels).

16.1 Germplasm exploration

One exploration was carried out in the month of February, 2020 for the collection of identified germplasm of fruit crops from Uttarkashi district of Uttrakhand. A total of 25 collections were made comprising of apple (8), pear (5) apricot (2) behmi (3) and walnut (7). One set of these collections was sent to ICAR-NBPGR Bhowali station and another set was grafted in the available rootstock at Shimla for further establishment in the Field Gene Bank. A unique germplasm (sweet kernel) of peach identified and collected from Village Bari, Kinnaur, Himachal Pradesh (Fig. 16.1). The germplasm was evaluated for some of pomological traits viz., fruit length (42.10 mm), fruit width (39.06 mm), fruit weight (37.6 g) and TSS (14.08 °B).

Fig. 16.1. Sweet kernel peach

16.2 Germplasm introduction

Three accessions (EC1033578, EC1033579 and EC1033580) of *Diospyros digyna* were

imported from the USA in the form of scion wood. Attempts were taken to establish these accessions on *Diospyros lotus* seedling rootstock and also through grafting, budding and direct rooting, however none of the accession survived.

16.3 Germplasm characterization and evaluation of field crops

A total of 1,077 accessions comprising of french bean (196), grain amaranth (173) buckwheat (252), and chenopod (61) were sown during *Kharif* season of 2020 and 395 accs. of field pea in *Rabi* season of 2019-20, along with standard checks in Augmented Block Design (ABD) (Table 16.1). Observations were recorded as per the minimal descriptor developed by NBPGR for various agro-morphological traits and remarkable variability was observed among the germplasm accessions. Promising germplasm for various traits were identified using range, mean and coefficient of variation for different traits as shown in Table 16.2.

In grain amaranth, the average plant height was 232.0 cm, while it ranged from (99.7-298.1 cm), mean inflorescence length 60.24 cm (36.3-80.40 cm), mean days to maturity 149 days (109-166 days), 1000 seed weight 0.71 g (0.5-0.90g) and average seed yield/plant 55.17 g (12.5-140.01g). The substantial data resulted into the identification of some promising accessions for elite traits such as, EC519515 (early maturity and dwarf type, 109 days and 99.7 cm) (Fig. 16.2), SKY74 (infl. length, 80.4 cm), IC568197 (plant height, 298.1 cm), AS/SKY/KCB/NAIP-52 (seed yield/plant, 140.0 g). Similarly in buckwheat wide range of variation recorded from 71-142 maturity days, mean no. of infl./plant 26.38, mean 1000-seed weight 19.38 g, while it ranged from 11.5-31.7 g and mean seed yield/plant 2.40 g ranged from 0.17-7.52g. Accessions of buckwheat namely IC37279 and IC16552 (early maturity, 71, 72 days) (Fig. 16.3); IC341664 (no. of infl./plant, 50.66) and IC109716 (higher 1000- seed wt., 31.70 g) found promising.

Fig. 16.2. EC519515 of grain amaranth identified for early maturity and dwarf type

In Chenopod, mean days to maturity were 126 days which ranged from 100 to 156 days, average infl. length was 39.07 cm and ranged

Table 16.1: Germplasm characterization and evaluation of field crops

Crop	Accessions	Checks
French bean	196	Triloki, Baspa, Jawala
Grain amaranth	173	Durga, PRA-2, Annapurna, PRA-3
Buckwheat	252	PRB-1, Himpriya, VL-7, Shimla B-1
Chenopod	61	EC507741, NIC-22503, PRC-9801, IC415477
Field Pea	395	Arkal, Azad Pea, DMR-11, DMR-7, HFP-4, IC279125, Super Linkon
Total accessions	**1077**	

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

Character	Range	Mean ±SE	CV%	Promising accessions
French bean				
Days to flowering	33-99	48.08 ± 0.68	19.81	EC500743, IC448927, IC405546, IC37156
Days to maturity	74-150	95.76 ± 0.97	14.32	IC341851, IC381273, EC500687, IC329610
Pod length (cm)	7.3-21.05	13.72 ± 0.19	19.44	EC894826, EC500676, IC545763, IC328871
No. of pods/plant	04-31	14.18 ± 0.44	43.53	EC500715, IC448962, IC313295, IC341810
No. of seeds/pod	3.5-09	5.55 ± 0.07	19.12	EC500765, EC500721,EC500386, IC405549
100 -seed weight (g)	12.54-61.4	30.94 ± 0.80	36.63	IC405482, IC405533, IC381156, IC311094
Grain Amaranth				
Days to flowering	42-108	81.47±0.87	14.070	EC519515, JCR-1969, JCR-1962, IC13383
Days to maturity	109-166	149.91±0.65	05.78	EC519515, IC38373, IC38361, IC38331
Plant height (cm)	99.7-298.1	232.34±2.70	15.30	IC568197, IC38397, IC7921
Infl. length (cm)	36.3-80.40	60.24±0.70	15.23	SKY-74, JCR-1977, EC169606
Seed yield/plant(g)	12.5-140.0	55.17±1.90	45.29	AS/SKY/KCB/NAIP-52, IC22544, EC322030
1000-seed wt. (g)	0.5-0.90	0.71±0.01	13.46	JCR-1965, IC22489, IC38373
Buckwheat				
Days to flowering	26-60	44.30±0.53	19.13	IC16552, IC313139, IC447576
Days to maturity	71-142	111.66±0.79	11.19	IC37279, IC16552, IC49667
Plant height (cm)	40.90-238.4	147.92±2.96	31.73	IC37279, IC109717, IC26593,
No. of infl./plant	5.5-50.66	26.38±0.80	48.33	IC341664, IC361131, IC361194, IC49666
Seed yield/plant(g)	0.17-7.52	02.40±0.08	54.50	IC37306, IC204080, IC202277
1000- seed wt. (g)	11.5-31.7	19.38±0.23	18.70	IC109716, IC37306, IC599211
Chenopod				
Days to flowering	52.00-112.0	75.34±1.66	17.16	IC341704, NIC22506, IC258253
Days to maturity	100.0 -156.0	126.69±1.47	9.09	IC7958, IC341704, NIC-22506
Plant height (cm)	122.40-298.40	200.35±5.07	19.75	IC7957, IC599554, IC599555
Infl. length (cm)	26.50-66.40	39.07±1.01	20.24	IC415421, IC599554, IC599555
Seed yield/plant (g)	11.28-126.70	52.28±3.46	51.63	IC7957, NIC-22517, IC341698
Seed vol.(g/10ml)	5.56-7.52	6.53±0.05	6.24	IC258332, IC341709, IC599552
Pea				
Days to flowering	97-169	131.66±0.70	10.63	5426/P-2098, IC427130, IC346094
Days to maturity	168-220	200.63±0.52	05.48	IC372568, IC374352, 5426/P-2098
Plant height (cm)	42.26 -199.2	120.77±1.60	26.38	EC838189, EC838233, EC838236
No. of pods/plant	4.0-35.5	20.53±0.28	27.59	EC838143, P-2967, EC838196
No. of seeds per pod	2.5-10	5.28±0.05	19.23	JCR/JV-29, JCR/JV-39, IC415499
Pod length (cm)	3.45-14.9	6.66±0.06	18.89	JCR/JV-29, JCR/JV-20, JCR/JV-16
Seed yield/plant (g)	4.17-40.90	15.91±0.34	41.89	IC427178, JCR/JV-24, P-3122
100-seed weight (g)	4.0-30.0	14.82±0.22	30.14	JCR/JV-44, IC-381541, 6443/P-8304

Fig. 16.3. IC16552 of buckwheat identified for early flowering & maturity

from 26.5-66.40 cm, mean seed yield/plant was 52.28g. The promising accessions were identified *viz*., IC7958 (early maturing, 100 days), IC7957 (plant height, 298.4 cm and higher seed yield/plant, 126.70 g) and IC258332 (higher seed vol. (g/10ml), 7.52 g).

In french bean, mean pod length was 13.72 cm and it ranged from (7.3-21.05 cm), no. of pods/plant was 14.18 (4.0-31), days to maturity 95.76 days (74-150 days) and 100-seed wt. 30.94 g (12.54-61.40 g). The French bean accessions, EC500715 and IC405482 showed high no. of pods/plant and high 100-seed weight respectively (Fig. 16.4).

Fig. 16.4. IC405482 of french bean identified for high seed weight

In pea, mean pod length was 6.66 cm and ranged from (3.45 to 14.9 cm) and mean 100-seed weight was 14.82 g (4.0 to 30.0g) and plant height, had mean value 120.7 cm and ranged from (42.26-199.2 cm). The promising accessions identified namely, JCR-JV-29 and EC838141 showed superiority for pod length and number of seeds per pod and No. of cluster per plant respectively. (Fig. 16.5).

Fig. 16.5. JCR-JV-29 of pea found superior for pod length and number of seeds per pod

16.4 Identification of resistant source against bean common mosaic virus (BCMV) disease

Bean common mosaic virus (BCMV) is one of the destructive viral disease that affects rajmash production significantly in major rajmash growing areas of northern plain and hilly regions of India. Hence, identification of BCMV resistant sources is foremost in crop breeding programme. We screened more than seventy genotypes against BCMV disease by using two susceptible (Jawala Uday, & IC341339) and resistant (Amber and Arun) check varieties at ICAR-NBPGR, Regional Station Shimla, over two consecutive season (*Kharif* 2018 &19). Genotypes were classified based on percent disease

incidence (PDI) reaction using 0 to 4 BCMV rating scale. The results exhibited that genotypes *viz*., IC360831, GPR203, IC340947, ET4515, EC540173 and BLF101 showed highly resistant and stable across the location and greenhouse condition (Fig. 16.6). These genotypes will be utilized as a donor parents for BCMV disease resistance breeding programme (Table 16.3).

Fig. 16.6. Common bean germplasm screening against BCMV

16.5 Germplasm characterization and evaluation of horticultural crops

In horticultural crops, total 131 germplasm accessions comprising of apple (30), pear (25), plum (18), peach (25), apricot (21), *Rubus* spp. (4) and hazelnut (8) were evaluated for various pomological traits, which resulted into the identification of some promising germplasm accessions. In apricot, accession IC558065 (Fig. 16.7) identified as early maturity type (3 weeks early). Accession has been sent for multi-location evaluation at Dr YS Parmar UHF Nauni University main campus. In peach, one accession, EC280769 identified for high fruit weight ranged from 120 g to 140 g per fruit with juicy and excellent aroma with cream colour pulp.

Fig. 16.7. IC558065, Early maturing apricot

Table 16.3: Categorization of French bean accession based on BCMV PDI disease reaction

Disease reaction	No. of Genotypes	Genotypes belonging to different category
HR	7	IC361279, EC150250, IC341051, IC340947, IC338795, ET4515, and IC360831
R	10	IC391581, IC341435, IC417352, Kailash, IC391488, IC341346, EC500232, IC356063, BLF101 and IC400401
MR	7	IC382655, IC419784, IC356024, Triloki, ET8409, EC541703 and ET84490
S	11	IC361279, IC340911, IC361279, IC393166, IC360865, NO3107, IC25537, EC14920, IC3613493, IC417353 and IC341404
HS	28	IC356011, IC341339, IC392636, IC340920, GPR204, IC261277, IC356008, IC356051, IC417350, EC564795, Jawala, EC565693, IC278480 NO3160A, IC340848, IC419767, IC338730, Baspa, IC383620, IC356057, IC360868

Different *Rubus* species (Fig. 16.8) were evaluated for various pomological traits. Accession IC209731 reported with red coloured fruit with highest fruit weight (20.0 g/10 fruits) and TSS 14.5 (°B). Details of evaluation are given below in Table 16.4.

A total of 8 accessions of Hazelnut (*Corylus avellana*) were evaluated for various horticultural traits as shown below (Fig. 16.9) Accession IC558093 recorded with highest nut weight (42.0 g/10 fruits) and kernel weight (16.66 g/10 kernels). Details of evaluation are given below in Table 16.5.

Likewise, total 9 persimmon accessions were characterized for various pomological traits. Out of 9 accessions, 4 were identified as non-astringent type. The details of various characters are given in the Table 16.6.

16.6 Establishment of newly introduced kiwifruit germplasm in FGB

The newly introduced 27 accessions of Kiwi germplasm (USA, 2019-20) were established through grafting in seedling rootstock in the FGB at ICAR-NBPGR Shimla, out of which 22 accessions were successfully planted. These accessions were transplanted in new kiwi block with proper training structure model. Two plants of each accession were planted and trained in the T-bar trellis system for further evaluation (Fig. 16.10).

16.7 Germplasm registration

1. EC718515 (INGR-20088): A wild lentil germplasm accession resistant against rust and powdery mildew

The wild lentil accession EC718515 (INGR20088) belongs to *Lens orientalis* species was identified after preliminary characterization and evaluation of 405 global wild annual lentil collections. The genotype was screened against rust (*Uromyces fabae* (Grev.) Fuckel) and powdery mildew (*Erysiphe trifolii*) under hot spot natural field condition. The same was further validated for confirming stable resistance against rust and powdery mildew. An accession EC718515 (INGR20088) has been reported resistant against rust and powdery mildew diseases. The germplasm has its significant value for enhancing genetic gains of cultivated varieties.

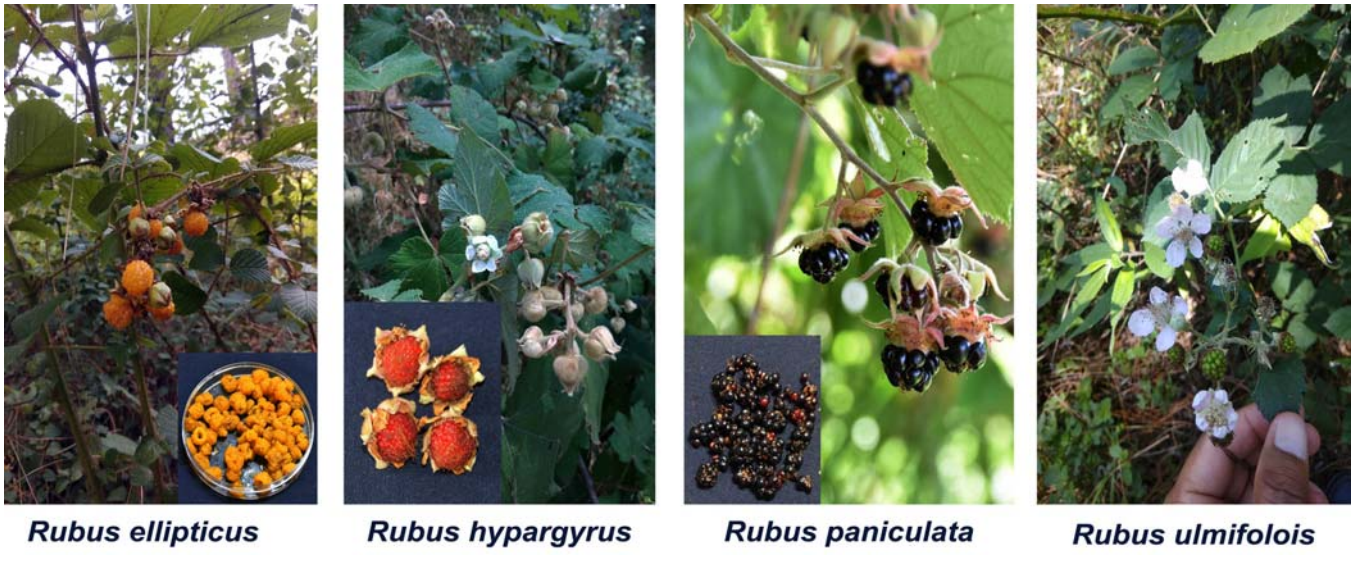


Fig. 16.8. Variability in *Rubus* species

Table 16.4: Evaluation of *Rubus* species

Accession no.	Species	Date of full bloom	Date of harvesting of fruit	Fruit weight 10 no. (g)	Fruit length (mm)	Fruit width (mm)	TSS (°B)	Colour
IC349943	*Rubus paniculata*	30.03.2020	15.06.2020	6.00	9.51	6.7	16.60	Purple
NBPGR/SML-101	*Rubus ellipticus*	05.04.2020	16.06.2020	10.00	13.81	13.32	12.08	Yellow
IC209731	*Rubus hypargyrus*	15.05.2020	20.08.2020	20.00	16.47	8.90	14.50	Red
IC349947	*Rubus almifolius*	10.04.2020	30.07.2020	11.00	16.31	13.33	10.40	Dark Purple

Table 16.5: Evaluation of hazel nut germplasm accessions

Accession no.	Nut length (mm)	Nut width (mm)	Shell thickness (mm)	Nut weight 10 no. (g)	Kernel length (mm)	Kernel width (mm)	Kernel weight 10 no.(g)
IC558119	15.26	20.08	2.07	15.00	10.60	7.58	6.10
EC515307	27.03	20.90	1.84	17.06	19.05	13.15	11.00
EC515321	19.06	18.84	1.39	13.82	13.18	14.40	10.20
EC515315	24.13	19.10	1.79	15.17	19.50	14.32	12.20
EC515324	19.02	20.39	1.54	12.00	14.87	13.72	12.10
EC515312	25.06	24.94	2.59	30.00	18.09	17.49	6.00
IC558093	21.62	24.07	1.62	42.00	15.89	16.11	16.66
IC20040	13.81	15.53	1.90	15.00	10.20	10.48	5.00

Table 16.6: Evaluation of persimmon germplasm accessions

Accession no.	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	TSS (°B)	Days taken for fruit maturity	Shape of fruit	Taste of fruit
EC552665	263.40	76.89	79.08	23.17	149	Oblong	Astringent
EC552664	142.20	48.19	69.24	16.50	158	Round	Non-Astringent
IC415417	109.00	69.35	64.93	18.03	143	Round	Astringent
EC732219	309.00	87.12	83.32	29.50	144	Oblong	Astringent
EC452161	124.60	46.74	64.13	17.40	151	Round	Astringent
D. lotus (Church)	7.60	17.11	14.23	25.20	157	Round	Non-Astringent
IC349965	17.60	18.45	17.19	20.70	142	Round	Non-Astringent
IC555292	97.00	36.82	30.01	28.70	175	Oblong	Astringent
EC28539	127.00	55.17	69.13	13.90	160	Round	Non-Astringent

2. EC718266 (INGR-20089): A wild lentil germplasm accession resistant against rust disease

The wild lentil accession EC718266 (INGR20089) belongs to *Lens nigricans* species was identified after preliminary characterization and evaluation of 405 global wild annual lentil collections. The genotype was screened against rust (*Uromyces fabae* (Grev.) Fuckel) disease. It was further validated for confirming stable resistance against the disease. The germplasm

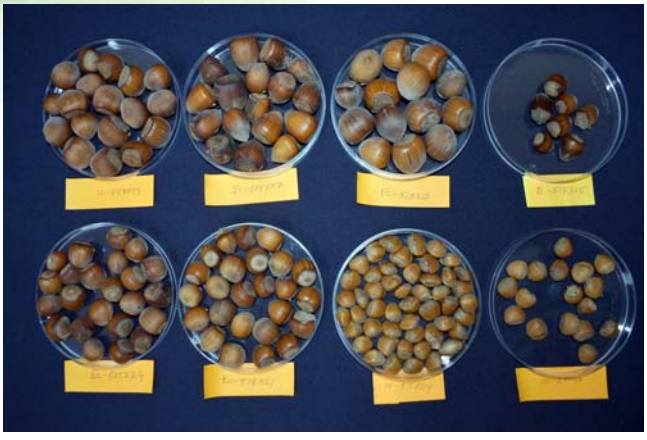


Fig. 16.9. Variability in hazel nut germplasm

Fig. 16.10. Newly established Kiwi block

has its significant value for enhancing genetic gains of cultivated varieties for introgressing resistance against rust.

3. IC278744 (INGR-20091): A common bean germplasm accession resistant against white mold (*Sclerotinia sclerotiorum*)

The common bean (*Phaseolus vulgaris* L.) germplasm accession IC278744 (INGR20091) was collected from Chhogtali Sirmour Himachal Pradesh and screened against white mold disease. The genotype was validated for confirming stable resistance against the pathogen. The above mentioned important trait has its significant value for enhancing genetic gains while planning future common bean genetic improvement programme.

4. EC271515 (INGR-20090): A common bean germplasm accession resistant against white mold (*Sclerotinia sclerotiorum*)

The common bean (*Phaseolus vulgaris* L.) germplasm accession EC271515 (INGR20090) was introduced from CIAT Columbia and screened against white mold disease. It was validated thrice under controlled screening environment. The above mentioned trait has its promising value for enhancing genetic gains while planning future common bean genetic improvement programme.

16.8 Germplasm conservation

Germplasm sent to LTS: A total of 496 accessions of various crops comprising of amaranth (28), chenopod (13), rice bean (116), french bean (48), pea (105), paddy (1), wheat (30) and maize (155) were sent to the National Gene Bank for long term storage.

Medium term storage: A total of 13,012 accessions of various seed crops are conserved in MTS at ICAR-NBPGR Shimla.

Crop	No of acc.
French bean	4353
Amaranth	3270
Buckwheat	1000
Pea	1505
Wheat	109
Finger millet	410
Rice bean	332
Foxtail millet	278
Chickpea	258
Cowpea	228
Chenopod	199
Adzuki bean	169
Proso millet	160
Soybean	144
Maize	136
Horse gram	150
Paddy	108
Barnyard millet	71
Barley	44
Meetha karela	42
Urd	30
Cuphea	16
Total	**13012**

Field gene bank: A total of 1,043 germplasm accessions of perennial crops such as fruits, medicinal and aromatic plants including other economic plants conserved in the field gene bank at NBPGR Shimla.

Crops	Accessions
Apple	241
Peach	52
Pear	87
Plum	49
Apricot	38
Cherry	4
Walnut	115
Hazelnut	20
Pecan nut	50
Almond	11
Kiwi	30
Persimmon	9
Pistacia	1
Chinese ber	7
Hops	2
Citrus	4
Pine-apple guava	2
Fig	7
Olive	6
Crataeagus	3
Chest nut	2
Viburnum	3
Rubus spp.	20
Quince	10
Grape	41
Mespilus spp.	2
Mulberry	4
Rose	35
Pomegranate	90
M&AP	27
Ornamentals	51
Other economic plants	22
Total	**1043**

16.9 Germplasm supply

Crop germplasm comprising of 1842 seed samples of agricultural crops were supplied to the various researchers across the country.

- **Seed crops:** French bean (567), Buckwheat (91), Amaranth (949) & Chenopod (220).
- **Scion wood:** Apple (50), Apricot (16), Pear (15), Peach (), Plum (18), Walnut (2), Persimmon (2), Kiwi (6) & Grapes (25)

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

On-going projects

PGR/GEV/BUR/SHM-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of pseudo cereals, pulses, and other lesser known hill crops (Mohar Singh, Rahul Chandora, Badal Singh (wef 06-10-2020) and Narender Negi)

PGR/GEV/BUR/SHM-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of temperate fruits, vegetables and medicinal and aromatic plants. (Mohar Singh, Narender Negi, Rahul Chandora and Badal Singh (wef 06-10-2020)

Externally funded ad-hoc research projects

Mainstreaming of Farmer Varieties in Himachal & Uttarakhand. (Mohar Singh and Rahul Chandora)

Survey, mapping, development of cultivation techniques, evaluation of selected germplasm and economics of *Fritillaria roylei* Hook. F., (Kakoli) an important plant of Ashtavarga Group of Medicinal and Aromatic Plants. (Rahul Chandora and Narender Negi)

Integrated genomic strategy for accelerating domestication of Rice bean (*Vigna umbellata*). (Mohar Singh)

Collection, characterization and evaluation of *Bunium presicum* and endangered plant species. [Narender Negi and Rahul Chandora (Co-PIs)]

Mainstreaming agricultural biodiversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability (Mohar Singh, Rahul Chandora)

Bridging genetic variability and phenotypic diversity for sustainable utilization and conservation of underutilized crops from North-Western Himalayan region (N-PDF) (Nikhil Malhotra & Mohar Singh)

17 REGIONAL STATION, SRINAGAR

Summary: In line with Aichi targets regarding maintenance and conservation of genetic diversity of cultivated plants and their wild relatives, an exploration and germplasm collection programme mostly on temperate fruits and wild edible fruits including vitis species was undertaken from various areas of Kashmir and 63 diverse germplasm accessions belonging to 21 genera and 26 species of 19 cultivated and 44 wild ones were collected. Active interaction with locals during this exploration programme helped in collecting valuable germplasm and in documenting associated ITK. While several unique accessions have been collected some were collected for the first time. 251 germplasm accessions comprising of faba beans (28), wheat (106), barley (108) and *Allium* (9) were characterized for their agro-morphological traits as per the minimal descriptors during *Rabi* 2019-20. Besides, 64 accessions of faba beans including 15 entries under IVT were evaluated during *Rabi* 2019-20 under All India Coordinated Research Network on Potential Crops. 282 accessions of different crops were supplied to different indenters/researchers for research purpose. Under TSP "PGR/Farmer Rights Awareness Camp cum Biodiversity Fair" was organized at Nagbal Budgam, Kashmir in which 200 tribal farmers including 28 women participated. On the occasion scientists interacted with farmers about values, conservation and sustainable use of biodiversity in general and traditional crops in particular and their relevance to the livelihood and nutritional security of tribal people especially under prevailing climatic conditions. 200 seed packets of cool-season perennial tall fescue forage grass were distributed among the farmers during the event.

17.1 Germplasm exploration and collection

Two (02) exploration programmes, one on temperate fruits and wild edible fruits and other on multicrops including vitis species for root stock were assigned to the station as per NEP 2020-21. However, due to COVID-19 pandemic, the two were combined and a single 8-day exploration and germplasm collection programme was undertaken mostly during the month of September, 2020 from different areas of Kashmir including areas of Kokernag and Pahalgam in Anantnag, areas of Shopian and Kulgam, areas of Tral in Pulwama, Dachigam National Park in Srinagar and areas of Lar, Valivar, Chuntvar, Anderwan, Narnaag and Gotlibagh in Ganderbal. 63 diverse germplasm accessions belonging to 21 genera and 26 species of 19 cultivated and 44 wild ones were collected. 47 accessions of wild/cultivated fruits belonging to the species of *Malus*, *Pyrus*, *Prunus*, *Rubus*, *Zizyphus*, *Elaeagnus*, *Crataegus*, *Cotoneaster*, *Berberis* and *Vitis*; 9 accessions of legumes belonging to *Vicia sativa*, *Vigna* sps., *Glycine max* and *Phaseolus coccineus* and one accession each of cherry tomato *Lycopersicon esculentum*, wild vegetable *Allium consanguineum*, oil seed *Eruca sativa*, medicinal plant *Podophyllum hexandrum*, forage grass *Sorghum arundinaceum*, goat grass *Aegilops tauschii* subsp. *tauschii* and opium poppy *Papaver somniferum* were collected. Active interaction with locals during this exploration programme helped in collecting valuable germplasm and in documenting associated ITK. While several unique accessions have been collected some were collected for the first time. Forage grass *Sorghum arundinaceum* and hawthorn species *Crataegus laevigata* have been collected for the first time from the region. In fruits, four species of *Prunus,* three species of *Crataegus* and nine accessions of *Crataegus pseudoheterophylla,* eight accessions of *Zizyphus jujuba* subsp. *spinosa* were collected indicating variability existing in these species in the region. One unique collection of *Zizyphus jujuba* subsp. *spinosa* SHEIKH/SR/SA-983 (Fig. 17.1B) bearing fruits which were comparable to thorn less cultivated type *Zizyphus*

Fig. 17.1. Active interaction with locals during exploration programme has helped in collecting valuable germplasm and in documenting associated ITK, if any (A), unique collections SHEIKH/SR/SA-983 of *Zizyphus jujuba* subsp. *spinosa* (B), SHEIKH/SR-993 of *Phaseolus coccineus* (C) and SHEIKH/SR/SS-975 of *Crataegus songarica* (D)

jujuba subsp. *jujuba* in fruit size, color and taste was collected, which could be a wild progenitor of later. Also one and unique collection of *Phaseolus coccineus* (SHEIKH/SR-993) with black seeds had been collected during this exploration (Fig. 17.1C). Particularly important was a collection of *Crataegus songarica* (SHEIKH/SR/SS-975) with comparatively tastier, softer, dark red fruits collected from Ganderbal area (Fig. 17.1D). Locally called as 'Adeang', its fruits are believed to be good for stomach ailments. A collection of barberry (*Berberis lyceum*) (SHEIKH/SR/SS-970) having insect resistant seed kernels was collected locally called as 'Sumbal' in remote Ganderbal areas, its fruits taken orally and the peeled root skin tied over affected area is believed to fix bone fractures.

17.2 Germplasm supply

During the period under report, 97 accessions of barley germplasm, 23 accessions of faba beans and 26 accessions of rapeseed mustard were supplied under MTA to Division of Plant Breeding & Genetics, SKUAST (K) Wadura Campus for research purpose. 23 faba bean germplasm accessions were also supplied to Dryland Agriculture Research Station, SKUAST (K) Budgam. Seeds of 104 barley accessions multiplied at the station were supplied to the Division of Germplasm Evaluation, ICAR-NBPGR New Delhi for biochemical analysis. Bulbs of nine (09) garlic accessions were supplied to Tissue Culture and Cryopreservation Unit, ICAR-NBPGR New Delhi. During TSP programme organized by the station, 200 seed packets of cool-season perennial tall fescue forage grass were distributed among more than 200 tribal farmers.

17.3 Germplasm characterization

Characterization of faba bean (*Vicia faba*) germplasm: 28 local germplasm accessions of faba beans collected from various districts of Kashmir were characterized along with three checks (Rebaya 40, HFB-1 and Vikrant) for their agro-morphological traits during *Rabi* 2019-20 as per the minimal descriptors using randomized block design, based on different traits superior genotypes were identified (Table 17.1). Good variability was recorded in seed shape, size and colour in these local germplasm accessions of faba beans (Fig. 17.2).

Characterization of wheat and barley germplasm: 214 germplasm accessions of wheat and barley were characterized for their agro-

Fig. 17.2. Diversity in seed shape, size and color observed in local faba bean (*Vicia faba*) germplasm

Table 17.1: Agro-morphological characterization of 28 local germplasm accessions of faba beans (*Vicia faba*)

Trait	Range	Mean	Mean check values		
			Rebaya 40	HFB-1	Vikrant
Plant height (cms)	61.8 - 92.5	82.8	66.6	67.4	65.4
Pod length (cms)	5.7 - 10.5	8.1	5.4	4.6	4.1
Pod width (cms)	1.4 - 2.1	1.7	2.0	1.1	1.4
No. of pods/node	1.1 - 2.0	1.5	1.9	1.8	1.9
No. of seeds/pod	2.3 - 3.8	2.9	3.0	3.1	3.0
Seed yield/plant (g)	15.675 - 66.525	43.158	33.600	24.495	24.500
100-seed weight (g)	41.854 - 111.253	69.474	56.141	26.935	31.927

morphological traits as per the minimal descriptors during *Rabi* 2019-20 under rain fed conditions using augmented block design and based on different traits promising genotypes were identified in both of these crops (Table 17.2). The year experienced drought like situation with scanty rainfall. In wheat, 106 germplasm accessions were characterized together with five checks viz., WR-544, HD-2967, C-306, Raj-3765 and local check HS-240 while in barley, 108 germplasm accessions were characterized along with two checks Jyoti and DL-36.

Characterization of *Allium cepa* var. *aggregatum* and *Allium cepa* var. *proliferum* germplasm: Nine genotypes belonging to *Allium cepa* var. *aggregatum* and *Allium cepa* var. *proliferum* were sown in second week of October 2019 and harvested in last week of June, 2020. The experiment was carried out in randomized block design with three replications. The weight of the clumps of bulbs was recorded after air drying for a month. Number of bulbs/clump was also recorded in each genotype. The weight of the clump in *Allium cepa* var. *aggregatum* varied from 24.400 g - 43.520 g with 2.8 - 5.8 bulbs/clump (Table 17.3). Two genotypes viz., IC0622314 and SHEIKH/SR-Pran 8 with higher bulb weight belong to *Allium cepa* var. *proliferum* group. On an average two underground bulbs per plant were recorded in these two genotypes (Fig. 17.3A). Instead, cluster of 8-10 aerial bulbils were formed in these two (Fig. 17.3B). The aerial

Table 17.2: Promising accessions identified for some important traits in wheat and barley

Crop/Traits	Range	Mean	Best check value	Promising accessions
Wheat				
Plant height (cms)	46.8 - 150.4	107.8	125.1 (C-306)	EC-10596, EC-540810, IC-423451, IC-535518
Flag leaf length (cms)	19.8 - 36.6	29.3	34.5 (Raj-3765)	IC-617422, KV-2, IC-539341, IC-401979
Flag leaf width (cms)	1.5 - 2.7	1.9	2.2 (Raj-3765)	KV-2, IC-539531, IC-514389, IC-540810
Spike length (cms)	6.0 - 18.0	9.9	11.5 (HS-240)	KV-4, KV-2, IC-539314, EC-178631
Seed yield/ plant (g)	3.350 - 28.960	11.463	21.280 (WR-544)	EC-514389, EC-0637488, EC-529446, EC-0597850
Barley				
Plant height (cms)	54.2 - 126.7	101.9	103.3 (Jyoti)	EC-492331, EC-328964, EC-578672, IC-445980
No. of seeds/ spike	11.6 - 48.8	26.5	28.4 (Jyoti)	IC-0634056, IC-138279, IC-533001, IC-138143
Seed yield/ plant (g)	4.175 - 35.880	16.665	24.850 (Jyoti)	IC-82719, EC-450390, EC-0667560, IC-138119
100-seed weight (g)	2.800 -6. 900	4.418	5.450 (DL-36)	EC-492317, IC-138120, IC-547712, EC-492331

Table 17.3: Characterization of *Allium cepa* var. *aggregatum* and *Allium cepa* var. *proliferum* genotypes

S. No.	Genotype	Clump weight (g) ± SE	No. of bulbs/clump ± SE
1	IC413349	24.400 ± 3.0	2.9 ± 0.3
2	IC413372	30.550 ± 2.7	5.2 ± 0.5
3	IC413391	27.110 ± 1.9	2.8 ± 0.2
4	IC420717	27.930 ± 1.7	3.6 ± 0.2
5	IC420718	30.020 ± 2.2	3.6 ± 0.3
6	IC0622314	68.880 ± 5.8	2.1 ± 0.09
7	IC0622315	43.520 ± 3.2	5.8 ± 0.3
8	SHEIKH/SR-Pran 8	55.650 ± 4.4	2.3 ± 0.2
9	SHEIKH/SR-Pran 9	27.100 ± 2.0	3.1 ± 0.3

Fig. 17.3. Underground clumps in *Allium cepa* var. *aggregatum* and *Allium cepa* var. *proliferum* (A) and aerial bulbil clusters in *Allium cepa* var. *proliferum* (B)

bulbils have the ability to germinate on the plant itself and are the means of propagation.

Evaluation of faba beans (*Vicia faba*) under AICRN trial (hills): As a cooperating centre of All India Coordinated Research Network on Potential Crops, 64 entries including 15 entries under IVT along with 6 checks (Rebaya 40, HFB-1, Vikrant, Aguadulce, Hama 2 and Hudeiba 93) were evaluated using augmented block design at the station during *Rabi* 2019-20 and the data generated has been submitted to the concerned project coordinator well in time.

17.5 Germplasm conservation

26 germplasm accessions of multi-crops including temperate fruits and wild edible bushes collected from different parts of Jammu & Kashmir have been conserved under LTS at National Gene Bank.

17.6 Germplasm maintenance

More than 155 apple plants belonging to 51 different accessions both exotic and indigenous have been planted at the farm this year for evaluation and maintenance.

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

18 REGIONAL STATION, THRISSUR

Summary: During the year under report, 402 samples were collected in four germplasm exploration missions covering Kerala, Andaman group of Islands, and Tamil Nadu besides three short trips, covering Kerala and Tamil Nadu. A fine grid survey and scion collection of 68 mango germplasm was also done. A total of 185 collections comprising 128 accessions of *Solanum* species, 9 of wild banana and 48 of field bean were characterized, and 74 of small bitter gourd, 13 of bitter gourd, 20 of greengram, 12 of blackgram and 41 of cowpea were evaluated. Three hundred and eleven accessions comprising 98 direct deposit of voucher samples and 213 multiplied samples of various crops and their wild relatives were sent for LTS. The station holds13,636 accessions in different crops/ perennial horticultural plants and their wild relatives, of which 10,859 are in the MTS and 2,777 in the FGB. A total of 926 accessions in various species/taxa were supplied to 25 user agencies under MTA. A field day on horsegram, an SCSP programme at Kottanellur village, Thrissur, Kerala and two TSP programmes at four tribal hamlets of the Nicobar Islands and two villages in Erode district Tamil Nadu were conducted. A new subspecies of *Abelmoschus* was described. Eight research papers, three book chapters and five popular articles were published.

18.1 Germplasm exploration and collection under National Exploration Plan

Three explorations were conducted under National Exploration Plan 2020-21 through which collected 308 samples as detailed below in Table 1 (SDG 2; Aichi 6,7,13).

In addition, three single-day collection trips to Peruvanmala, Kalasamala and PoomalaofThrissur District and one to Chulanur Peafowl Sanctuary in Palakkad district, Kerala exclusively for collection of *Sesamum laciniatum* and two 2-3 days trips to Malakkappara of Thrissur Dist and Sathyamangalam Forest Division, Erode district, Tamil Nadu were also undertaken and collected57 samples of crops/ CWRs.

18.2 Germplasm exchange and domestic supply (SDG 2; Aichi 6,7,13)

18.2.1 Supply to user agencies

Under Material Transfer Agreement (MTA), 926 accessions of germplasm of various crops/ species were supplied to 25 user agencies, comprising eight ICAR institutes (208 accs.), 8 State Agricultural Universities (260accs.) and 11 other agencies (458 accs.).

18.2.2 Supply to ICAR-NAGS

One accession (IC626380) of tree cotton (*Gossypium barbadense* var. *acuminatum*) was sent to ICAR-CICR, Nagpur, for use in breeding programmes by scientists working in the AICRP network.

18.2.3 Germplasm receipt

43 accessions in taro and sweet potato; were received from other ICAR Institutes.

18.2.4 Germplasm utilisation and feedback on supplied germplasm

Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes was done in the Department of Plant Breeding and Genetics, College of Horticulture, KAU, Thrissur. One hundred exotic accessions of rice introduced from IRRI, Philippines were evaluated in augmented block design along with five checks

Table 18.1: Exploration and collections

Trip No.	Area Covered	No. of samples collected
1	**Andaman group of Islands, Saddle Peak in North Andaman Island, Ross and Smith Island, Little Andaman, Havelock Island and selected pockets in South Andaman**	**159 samples in 102 species/taxa**
	Unique collections *1. Dioscorea nummularia* (JPNAJ/20-61, lamina with violet-tinged lower surface) *2. Luffa aegyptiaca* f. *sylvestris* (JPNAJ/20-68 – wild form of sponge gourd) *3. Mangifera andamanica* (JPNAJ/20-72) *4. Garcinia andamanica* (JPNAJ/20-17) *5. Garcinia dulcis* (JPNAJ/20-99) *6. Oryza meyeriana* var. *ind andamanica* (JPNAJ/20-102) *7. Artocarpus camansi* (JPNAJ/20-118, bread nut, a new crop) *8. Etlingera linguiformis* (JPNAJ/20-120, rhizomes used for fever treatment by Karens) *9. Diospyros crumenata* (JPNAJ/20-126, potential edible fruit) 10. Pigeonpea (JPNAJ/20-41, small-sized black-skinned perennial type) 11. Ginger – (JPNAJ/20-47, rhizome with close internodeand pale bluish flesh; JPNAJ/20-121, 'white ginger' (revered by Karens) *12. Piper wallichii*– JPNAJ/20-51 (woody stem used as spice) 13. Turmeric (JPNAJ/20-34 - highly aromatic)	
2	**Coimbatore, Erode and Salem Districts of Tamil Nadu**	**104 samples in 20 taxa**
	1. Curry leaf – landrace – 'Chenkambu'/ Sankambu – unique with red midribs, glossy leaves and high vegetative yield *2. Kumkumapoo avarai/ Pattani avarai*- a unique landrace of lablab said to have a yield of 1000 kg per acre and round seeds resembling that of garden pea, hence the name *Pattani avarai* 3. Rice landrace- *Chembola* (STR-20/63), Foxtail millet- Red grained (STR-20/74 and STR-20/78), *Cheliavarai*- STR-20/28 – a lignosus type field bean collection suitable for winter season cultivation.	
3	**Wayanad District of Kerala and Nilgiris district of TamilNadu**	**45 samples in 18 taxa**
	1. LMA/20-31 – *Cajanus heynei,* a rare CWR species of pigeon pea 2. LMA/20-33 – *Cajanus grandiflorus* – first time collected from Southern Peninsular India	

viz., PTB 39 (Jyothi), Jaya, Thulasi, PTB 60 (Vaisakh) and Manurathna. Accessions EC 207747, EC204970, EC204999, EC205042, EC205047, EC205192, EC2052015, EC205223, EC205333, EC415392, EC415403, EC415407, EC415413, EC415420, EC415421, EC415422, EC415445, EC415452 were identified as superior when quantitative and qualitative traits were considered together.

Over 25 seedlings of *Manilkara littoralis* (JPJ/19-252, JPNAJ/20-9) and *Syzygium samarangense* (JPJ/18-112) were collected from A&N islands supplied to social forestry department for planting in Chavakkad beach, Thrissur as part of coastal bioshield plantation were performing well.

Musa balbisiana var. *andamanica* collection (JPJ/19-313, IC630992) was confirmed resistant to panama wilt under lab conditions by Banana Research Station, Kannara (KAU).

18.3 Germplasm characterization (SDG 1.5; Aichi 2, 6,7,14)

18.3.1 Field bean (*Lablab purpureus*)

A total of 48 accessions (36- lignosus; 12- typicus) collected from south and northeast India

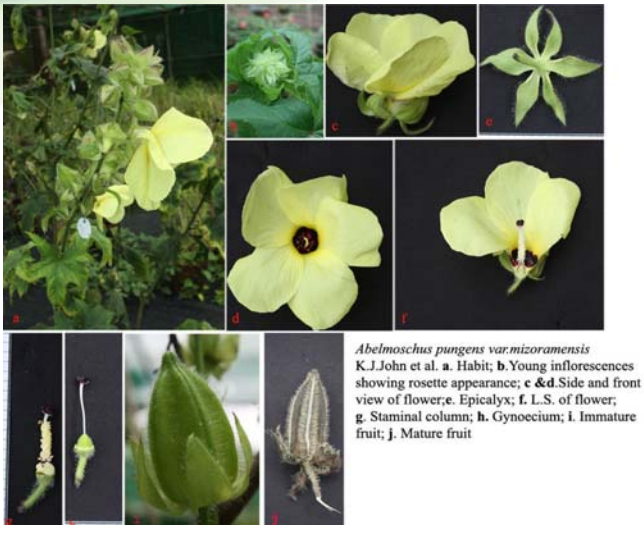

Abelmoschus pungens var.mizoramensis K.J.John et al. **a**. Habit; **b**.Young inflorescences showing rosette appearance; **c &d**.Side and front view of flower;**e**. Epicalyx; **f**. L.S. of flower; **g**. Staminal column; **h**. Gynoecium; **i**. Immature fruit; **j**. Mature fruit

Fig. 18.1. *Abelmoschus pungens* var. *mizoramensis* K.J. John et al. described from Mizoram, Northeast India

Fig. 18.2. Teasel gourd variety - ArkaBharath, a clonal selection from JB/11-178A (collected from Santhir Bazar, South Tripura Dist of Tripura), released by ICAR-IIHR, Bengaluru

Fig. 18.3. *Artocarpus camansi* (JPNAJ/20-118) cultivated by Karen tribes in Middle Andaman

Fig. 18.4. *Cajanus albicans* (LPTS/20-24) collected from Sathyamangalam Tiger Reserve Forest, Erode Dist., Tamil Nadu

Fig. 18.5. *Cajanus grandiflorus* (LMA/20-33) – a first-time collection from South Peninsular India

were grown for initial seed increase and characterization (11-qualitative and 10-quantitative characters). It was observed that a significant number of germplasm from Tamil Nadu exhibited sensitivity to photoperiod and indeterminate growth habit. While typicus (vegetable) group was mentioned as producing flat pods, two accessions (JJK/ Misc. 19-12 and STR/20-84A) in this group had dorsally gibbous pods, and another collection (SATN/Misc./20-11) had mature seeds with long axis more or less oblique to the suture.

18.3.2 Brinjal and *Solanum* spp.

A total of 128 germplasm accessions, including 10 wild species of *Solanum* collected from peninsular and northeast India, were grown for characterization/ purification and initial seed increase / taxonomic authentication. Seventy accessions belonging to *Solanum melongena* complex (brinjal, wild form-*S. insanum* and their spontaneously introgressed forms) were characterized for 21 qualitative and eight quantitative characters, as per ICAR-NBPGR descriptor. It was found that all the characters studied exhibited significant variation, except the characters such as 'pendent' fruit position and 'light yellow' seed colour. While *Solanum incanum* being now unanimously agreed as distinct species (from *S. melongena*) with well-defined distribution range (northwest India westwards), efforts were made to delineate *S. insanum* accessions from brinjal. It was found that morphological characters of *S. insanum*, its spontaneous introgression with brinjal and cultivated brinjal lie on the same spectrum of continuous variation. In fact, most of the (wild) germplasm accessions from various parts of India designated as *S. insanum* or *S. incanum* represent naturally introgressed populations between *S. insanum* and *S. melongena*. Out of 47 taxonomic characters reported useful in delineating these two taxa, it was found that only a few characters namely more prostrate and prickly nature, shorter calyx and calyx lobe (<2 cm and <6 mm, respectively) 'acute' calyx lobe apex, shorter anther (<5.5 mm long), shorter fruit pedicel length (<3 cm), shorter fruit diameter (<2.5 cm) and greenish mesocarp pulp would be of use in distinguishing *S. insanum* from brinjal and their introgressed forms. Herbarium studies at BSIS herbarium, Kolkata also supported these views. This further indicates that *S. insanum* should no longer be kept as distinct species, but should be subsumed under *S. melongena* with a varietal rank, i.e. var. *insanum* (L.) Prain.

Fig. 18.6. *Cajanus heynei* (LMA/20-31) –a rare species of Cajanus

Fig. 18.7. Cowpea (NR/18-42): a collection from Karnataka with distinctly erect pods, pinkish bifid tip and being used as black gram substitute

18.3.3 *Musa* spp.

Characterization of nine collections of wild banana comprising *Musa indandamanensis*, *M. acuminata, M. balbisiana* var. *andamanica, M. kattuvazhana, M. hirta* and *M. haekkinenii* are

in progress. *M. indandamanensis* was found highly susceptible to Rhizome weevil whereas *M. balbisiana* var. *andamanica* (IC630992) was found resistant to Rhizome weevil and Panama wilt and the results were confirmed by raising in sick plots at farmers field near Angamaly, Kerala.

18.3.4 Potential new economic plants (SDG 2; Aichi 7)

Wild edible leafy vegetables from A&N Islands; *Gnetum gnemon* (JPJ/19-232), *Champereia manillana* (JPJ/19-253), *Gymnema latifolia* (JPJ/19-317), *Acrostichum aureum* (JPJ/18-111) and *Diplazium esculentum* (JP/17-86) were established in the FGB with the latter two replicated in farmer's fields.

18.3.5 New initiative(SDG 2; Aichi 7)

An adaptive trial plot of Payum (*Garcinia speciosa*, a wild edible mangosteen like fruit of Nicobar Islands) was established with 50 seedling plants and three clonal collections along with related edible *Garcinia* species like *G. madruno, G. humilis, G. lanceifolia, G. kydia, G. gardneriana, G. cowa, G. succifolia, G. hombroniana, G. schomburgkiana, G. nervosa* and *G. intermedia. G. speciosa* does not have exacting soil and water requirements, and niche specificity like mangosteen and selected plus tree showed TSS value of 20 with prolific bearing.

18.3.6 Success stories(SDG 2; Aichi 6,7,13)

RET, CWR, *Oryza meyriana* var. *ind andamanica* (JPNAJ/20-102), collected from Saddle Peak National Park, North Andaman and sponge gourd progenitor *Luffa aegyptiaca* f. *sylvestris* collected from Little Andaman (JPNAJ/20-68) were regenerated and conserved. Morphologically distinct populations of *Abelmoschus pungens* collected from across Mizoram were described and published as a new CWR entity; *Abelmoschus pungens* subsp. *mizoramensis*.

18.4 Germplasm evaluation (SDG 1.5; Aichi 2, 6,7,14)

18.4.1 Pulses

Preliminary characterization was made in recently collected pulses germplasm comprising 20 of greengram, 12 of blackgram and 41 of cowpea using minimal descriptors of ICAR-NBPGR. Accessions with distinct morphological characters are given in Table 18.2.

18.4.2 Bitter gourd and wild forms (*Momordica charantia* var. *muricata*)

Thirty four wild, 40 semi-domesticated and 13 cultivated bitter gourd accessions were characterized and evaluated for 51 traits. Wide variability was observed for fruit shape, colour, fruit ends, ribs, density and nature of tubercles, seed colour, seed sides, ends, surface sculpturing and shape among different small and cultivated bittergourds. The majority of the accessions (33 accessions) showed rhomboid fruits followed by elliptical (24), spindle (18) and cylindrical shaped fruits (7) whereas few showed fruit shapes like globose (2), pyriform (1) and uniformly cylindrical (1). Variation was observed for fruit colour and majority of the accessions produced green colour fruits (43) followed by dark green (23), whitish green (12), white (5), light green (3) and olive green (1). Both ends of the fruit were pointed for most of the accessions (74) whereas both ends were round in NJ/15-misc-1C and the blossom end was whip like in JH/mis-19-118. Mostly the fruit ribs were broken for majority of accessions (58) whereas four accessions showed continuous ribs (HJ/19-61, JH/mis-19-117, SBJ/01-177B and SBJ/01-51A) out of which JH/mis-19-117 is a wild type bittergourd. Tubercles were recurved in 2

Table 18.2: Pulses collections with distinct morphological characters

S. No.	Characters	Collections
	Greengram (*Vigna radiata*)	
1	Synchronous flowering	NR/ 18-17, NR/ 18-37, LSR/18-25, LSR/18-143
2	Light green flushy growth and racemes along or beneath the canopy, flowers yellow in colour with purplish tinge at the tip	NR/ 18-45, NR/ 18-103, NR/18-114, LSR/18-89 and LSR/ 18-99
3	Deep purple pigmentation on flowers and pods. The green pods had a purplish tip and pigmentation through lateral edge	NR/ 18-103, LSR/ 18-89
4	Long drooping pods	NR/18-23, NR/18-61, NR/18-67, NR/18-104, LSR/18-25, LSR/18-143 and NR/18-37
	Blackgram (*Vigna mungo*)	
1	Light green large fleshy leaves with dense foliage	STR/20-20
2	Sessile or sub-sessile, solitary or cluster of two flowers at the axils besides the normal stalked racemes. The mature pods were straw coloured and the seeds were olive green in colour	KP/18-187
	Cowpea (*Vigna unguiculata*)	
1	Twining plant habit, erect pod bearing, 3-4 short pods in clusters, Seeds black similar to blackgram in size and shape except hilum which is sunken unlike protruding as in blackgram and used as blackgram substitute by the farmers of Karnataka	NR/18-42, NR/18-63

Fig. 18.8. Curry leaf (STR/20-3) - land race – 'Chenkombu'/ Sankhambu – unique with red midribs, was having glossy leaves with high vegetative yield

Fig. 18.9. Field view of Horsegram germplasm

accessions. The seed colour of accessions varied from white (16), brownish tan (21), cement (13), straw (24) to greyish buff (13). The seed sides were either dented (52) or invaginated (35) and seed ends were either clearly subtridentate (51) or feebly subtridentate (36). Majority of the accessions (54) showed markedly sculptured seed surface whereas 34 accessions showed feebly sculptured seed surface. The results for the important quantitative characters are given in Table 18.3.

Table 18.3: Statistical parameters for fruit characters in 87 accessions of cultivated and small bittergourds

No. of accns		Wild 34	Semi-domestic ated 40	Cultivated 13
Fruit weight (g)	Min	5.13 (JH/mis-19-118)	7.67 (JJNS/15-62A)	84.34 (SBJ/01-51A)
	Max	20.33 (JP/17-22D)	86.75 (JPNAJ/20-mis-28A)	158 (JH/mis-19-111)
	Mean	12.28	48.99	117.4
No. of fruits per plant	Min	10 (JJNS/15-66E)	9.45 (JP/17-22A)	10.17 (SBJ/01-191C)
	Max	135 (HJ/19-83F)	88.64 (SBJ/01-191B)	38.96 (SBJ/01-190E)
	Mean	33.83	17.42	17.82
Yield per plant (g)	Min	61.00(JJNS/15-66E)	80.50 (JJNS/15-62A)	911.61 (SBJ/01-191C)
	Max	2070.00(HJ/19-83F)	4051.91 (SBJ/01-177B)	4412.22 (SBJ/01-190E)
	Mean	430.23	1075.89	2069.95

Fig. 18.10. Fruit variability in *Momordica charantia* var. *muricata*

Fig. 18.11. Green gram (NR/18-37): a collection from Karnataka with very long pods, 13-15 seeds per pod and synchronous maturity

Fig. 18.12. *Manilkara littoralis* (JPNAJ/20-9), a wild relative of sapota, acts as shelterbelt in coastal areas in Little Andaman (inset: fruits)

Fig. 18.13. Habit of *Musa indandamensis* in Little Andaman

18.4.3 Biochemical characterization (SDG 2; Aichi 6,7,13)

Preliminary evaluation of 170 accessions of coloured rice for six biochemical characters such as amylose, protein, total dietary fibre, starch, oil and phenol was done. Of these, twenty three accessions of landraces of Kerala (IC567717, IC567720, IC567723, IC567728, IC567734, IC567735, IC567738BB, IC567754, IC567758, IC567760, IC567767AA, IC567788, IC567790, IC86463, IC324580, IC324589, IC324589AA, IC324594, IC324612, IC324685, IC203745, IC413597 and IC413609 were superior for protein content. Data on morphological characters were recorded as per DUS descriptors, in a joint evaluation involving KAU, Thrissur.

18.5 Externally funded projects

18.5.1 Generating genomic resources for facilitating genetic enhancement on selective *Vigna* species and Horsegram

18.5.1.1 Large scale evaluation of Genetic Resources of horsegram(SDG 1.5; Aichi 2,6,7,14)

A total of 2,144 accessions of horsegram germplasm collected from different regions of India were evaluated in augmented design with seven checks (AK 21, AK 38, HGGP, PHG 9, DPPI 2278, PAIYUR 1, BIRSA KULTHI) in 23 blocks. The genotypes were assessed on 19 morphological traits (8 quantitative and 11 qualitative traits). The highest number of pods per plant over the best check DPPI2278 (132) was shown by 23 accessions. IC553492 (251), IC320969 (201), IC55062 (184), IC470167 (181) and IC139423 (180) had the highest number of pods per plant. A total of 47 genotypes out yielded the best check PHG9 with 12g, and the highest yielding accessions includes IC553492 (27.11g), IC342125 (20.84g), IC139423 (20.45g), IC470170 (19.79g) and IC470167 (19.67g). Twenty one accessions excelled the check AK 21 with highest hundred seed weight of 5g and the accessions include IC15724 (5.81g), IC360587 (5.64g), IC360588 (5.54g), IC372629 (5.51g) and IC361192 (5.44g). Seed coat colour polymorphism was noticed among the genotypes and the whole germplasm were grouped into 16 seed color categories. The genotypes were screened against YMV resistance under natural epiphytotic conditions, in 1-9 arbitrary scale. Seven genotypes *viz*., IC43515, IC123026, IC123027, IC123028, IC139371, IC139374 and IC139392 were found free of any symptoms even at pod maturation stage, indicating possible resistance against YMV.

18.5.1.2 Inter-specific hybridization in *Vigna*

Seven accessions of *V. radiata* were crossed as female parent with seven accessions of *V. stipulacea* and one of *V. trilobata*. Seed setting was obtained in 19 crosses and were studied for 72 morphological traits using modified IPGRI descriptors. F1s of three crosses were having distinct morphological traits. The F1 of cross between *Vigna radiata* x *V. stipulacea* had flushy and robust growth and sub-sessile leaves in contrast to the parents.

18.5.2 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 (SDG 2; Aichi 6,7,13)

Procured seed samples of five accessions of spine gourd from various parts of India to strengthen the Momordica germplasm of the station. A full set was transferred to ICAR-NBPGR, Regional Station, Shillong. Multiplied and characterized seven wild bitter gourd accessions of NE origin for 22 quantitative traits. KP/PKS-1136, a collection from Arunachal Pradesh was observed to be a semi-domesticated type, has recorded maximum values for fruit

Fig. 18.14. *Oryza meyeriana* var. *ind andamanica* (JPNAJ/20-102), a niche-specific taxon, localised in Saddle Peak NP at c. 400m (inset: a single grain)

Fig. 18.15. Seed variability pigmented rice landraces of Kerala evaluated biochemically

Fig. 18.16. Taxonomically authentic sample of *Sesamum prostratum*, a highly niche specific species collected from Coasts of Viluppuram Dist., Tamil Nadu

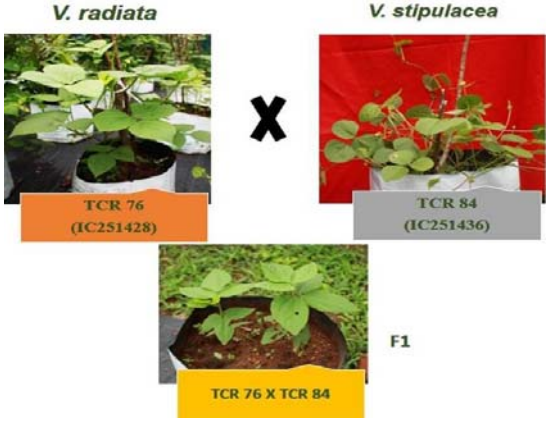


Fig. 18.17. F1 of cross between *Vigna radiate* x *V. stipulacea*

Fig. 18.18. Superior accessions in horsegram

Fig .18.19. Programme under Tribal Subproject conducted at Ittarai Village, Erode Dist., Tamil Nadu

length, width, no. of seeds, seed length, width and thickness and single fruit weight, where fruits might have undergone selection during domestication whereas HJ/19-61 is a wild type which has recorded minimum values for fruit length (4.65 cm), fruit width (1.60 cm), flesh thickness (0.25 cm), seed width (0.90 cm) and single fruit weight (5 g).

Newly collected 23 accessions of wild and semi-domesticated bitter gourd of NE origin were multiplied and characterized during *Kharif*-2020 for 18 quantitative and 17 qualitative characters. Maximum values recorded for single fruit weight (218.40 g), fruit length (22.06 cm), fruit circumference (17.04 cm) were observed in JH/mis/19-110, a semi-domesticated type of bitter gourd. For *ex-situ* regeneration,teasel gourd terminal cuttings were used and showed a regeneration success of 53.29 percent.

To study the dormancy mechanism induced by cold storage, seeds of eleven accessions of wild bitter gourd of NE origin were treated with KNO3 (2%) and GA3 (100 ppm) and from the results, GA3 (51.21 %) showed higher percentage of germination compared to KNO3 (38.50%).

18.5.3 Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery (SDG 1.5; Aichi 2,6,7,14)

18.5.3.1 Exploration and collection

Coastal tracts of Tamil Nadu were explored and collected 37 samples of crops/ CWRs which include taxonomically authentic sample of *Sesamum prostratum*; a highly niche specific species from Viluppuram Dist., Tamil Nadu. Also, surveyed the severity of phyllody in sesame and its related species in and around Vriddhachalam and collected four infected samples during this trip.

A total of 360 wild sesame germplasm accessions from all over India (mainly from NGB) were grown for morphological characterization/ purification/taxonomic confirmation. While 82 of them designated as *Sesamum malabaricum* or *S. mulayanum* turned out to be cultivated taxon; *S. indicum* and seven to be *S. radiatum*, only 51 and 44 accessions were, in fact, belonging to *S. malabaricum* and *S. mulayanum*, respectively. This field experimental work along with herbarium study at Madras Herbarium (MH) Coimbatore and field study at Kerala and coastal Tamil Nadu, revealed the distinct identity of *S. mulayanum* (from *S. malabaricum*) and *S. laciniatum* (from *S. prostratum*), which also corresponds to their distinct geographic distribution. Size of extrafloralnectaries, one of the widely used characters to distinguish *S. malabaricum* and *S. indicum*, was not found tenable in the present study. Comprehensive crossing attempts (both direct and reciprocal) made using two accessions of *S. mulayanum*, three of *S. malabaricum* and one each of *S. radiatum* and *S. laciniatum* with four sesame varieties (VRI-1, VRI-3, TMV-4 and TMV-7) resulted in getting fruit set in 33 cross combinations, setting percentage varied from 15 to 91%.

18.6 Germplasm multiplication (SDG 2; Aichi 6,7,13)

Multiplied 72 accessions of small bitter gourd, 16 of bitter gourd, 40 of *Solanum* species, 18 of red gram, 41 of cowpea, 20 of green gram, 14 of black gram, 285 of rice, 48 of lablab, four of *Ocimum sanctum*, two of *Andrographis paniculata*, three of *Eclipta alba* and one each of *Sidaacuta, Ocimum basilicum, Corchorus olitorius, Leucasaspera, Oryza meyeriana* var. *ind andamanica*, *Solanum americanum*, *Luffa aegyptiaca* and French bean.

Fig. 18.20. Seed variability in horsegram

Fig. 18.21. Character variation in *Solanum melongena* complex (extreme right 2 accessions – *S. insanum*)

Fig. 18.22. Field day on horsegram at Thrissur station on 09.01.2020

Fig. 18.23. QRT team visited Regional station, Thrissur on 08.01.2020

18.7 Germplasm conservation (SDG 2.5; Aichi 13,18)

18.7.1 Sent for long-term storage at NGB

311 accessions comprising of collected (98 voucher samples) and multiplied (213 samples) germplasm were deposited at NGB, which include okra (12), Chinese spinach (1), cucumber (42), Oriental pickling melon (2), *Dioscorea belophylla* (1), *Eclipta alba* (1), Finger millet (1), lablab (13), bottle gourd (5), bitter gourd (17), small bitter gourd (56), wild sesame (1), *Sesbania sericea* (1), *Solanum* sp. (16), green gram (8), black gram (16) and cowpea (1).

18.7.2 Sent for conservation in tissue culture and cryo=preservation facility

A total of thirteen samples comprising one accession each of *Zingiberneesianum*, *Z. wightianum*, *Pouteria campechiana*, *Aegle marmelos*, *Amorphophallus* sp., *Musa balbisiana*, *Piper sarmentosum* (JPJN-19/13), *P. wallichii* (IC567278), three of wild *Piper betle*-JPJ/18-113, JPJ/18-6 and JPJ/18-54 (all A&N

collections), one each of wood apple (*Limonia acidissima*- Coll. No. LPTS/20-22), Common Mader (*Rubia cordifolia*- Coll. No.LPTS/20-028) and Orange climber (*Toddalia asiatica*- Coll. No. LPTS/20-029) collected from Erode Dist, and *Citrus sinensis* (KP/PR/20-10 and Ber (KP/PR/10-22) from coastal tracts of Tamil Nadu and male flower buds of wild Musa comprising *M. kattuvazhana*, *M. acuminata, M. hirta* and *M. balbisiana* var. *andamanica* were sent for *in-vitro* / cryo preservation.

18.7.3 On-farm conservation (SDG 2.3; Aichi 7)

Fifty eight farmers were supplied germplasm of 60 crop plants comprising red guava, *Artocarpus chama*, Beejakela, Bael, red bullock heart, *Garcinia speciosa*, Teasel gourd, Taro, Burmese fish tail palm, *Citrus* sp., papaya, *Piper sarmentosum*, kokum, *Raphaloblastaaugustata*., *Dracandromelon dao*, *Knema andamanica*, cucumber, vegetable cowpea, sweet gourd, *Flacourtia montana*, *Solanum nigrum* etc.

18.7.4 MTS at ICAR-NBPGR RS, Thrissur

A total of 10,859 comprising 9,193 of different crop/CWRs of this station and 1,656 accessions received from RARS, Pilicode and ICAR-IARI, Wellington were maintained. Three hundred and forty three voucher samples collected were also maintained.

18.8 Germplasm maintenance (SDG 2.5; Aichi 13,18)

- **Field genebank:** A total of 2,777 accessions in 364 species belonging to 177 genera were maintained in field and pots under the shade, net, mist and poly houses.
- Established permanent plots for conservation of 54 seedligs/clones in five accessions of *Garcinia speciosa* - a potential tropical wild fruit, 37 curry leaf collections, 39 citrus, 24 moringa, 343 accessions in 75 species of economically important plants from A&N Islands.

Research Programme (Code: Title, **Programme Leader,** Co-PI)

PGR/ DGE-BUR-THR-01.01: Plant genetic resources management of field crops and their wild relatives **(M Latha,** Joseph John K., K Pradheep, Suma A, S Mani and A Indiradevi)

PGR/ DGE-BUR-THR-01.02: Plant genetic resources management of spices and their wild relatives, medicinal and other economic plants **(K. Pradheep**, Joseph John K., Suma A, S Mani and A Indiradevi)

PGR/ DGE-BUR-THR-01.03: Plant genetic resources management of vegetables, fruit crops, tropical tubers and their wild relatives (**Suma A.,** Joseph John K, M Latha, K Pradheep, S Mani and A Indiradevi)

19 TRAININGS AND CAPACITY BUILDING

19.1 Trainings organized in 2020

Kavita Gupta conducted five days online training on *Pest Risk Assessment* under FAO TCP/NEP/3702 *Building capacities to improve and sustain forest health to enhance the resilience of forests and livelihoods of forest dependent communities in Nepal* from November 23-27, 2020.

Kavita Gupta conducted five days online training on *Phytosanitary Standards* under FAO TCP/NEP/3702 *Building capacities to improve and sustain forest health to enhance the resilience of forests and livelihoods of forest dependent communities in Nepal* from December 7- 10, 2020.

Three days online training programme for farmer's on "Modern techniques on nursery and orchard management in Apple" from 03.12.2020 to 05.12.2020 in collaboration with ICAR-IARI, Shimla was organized. A total of around 60 apple farmers from three district viz, Kinnaur, Lahaul-Spiti and Shimla were benefitted from this training.

19.1.1 Trainings organized in 2020 by RS Bhowali

S. No.	Title of programme	Duration	Venue
1.	Awareness-cum-sensitization program	29th February 2020	Village Bhumiadhar (Nainital)
2.	Importance and Conservation of Agro-biodiversity	5th March 2020	Nagari Gaon (Nainital)
3.	Agro-biodiversity fair	13th March 2020	Village Ghuna (Nainital)

19.2 Trainings undertaken during 2020

Name of employee	Title of training programme	Place and Period
Scientific staff		
AnithaKodaru	Analysis of Experimental Data using SAS (Online)	ICAR-NAARM, Hyderabad Nov. 9-17
Archana Raina	Science Administration and Research Management (Online)	ASCI, Hyderabad Dec. 7-18
B Parameswari	Advanced Bioinformatics Tools and its Applications in Agriculture	NAARM, Hyderabad Sep. 14-19
Chithra Devi Pandey	Emerging Trends in Seed Production Technology and Quality Control Framework for Effective Seed Supply Chain of Horticulture Crops (Online)	UHS, Bagalkot, (Karnataka) Dec. 28-Jan. 6
Era Vaidya Malhotra	Advanced Bioinformatics Tools and its Applications in Agriculture (Online)	NAARM, Hyderabad Sep. 14-19
Era Vaidya Malhotra	Science Communication for Smart Scholars (Online)	ICAR-CIFE, Mumbai, May 12-25

Name of employee	Title of training programme	Place and Period
Jameel Akhtar	Pre- and Post-harvest Disease Management of Horticulture Crops through Improved Technologies and Value Addition to Enhance Farmers'Income	GBPUA&T, Pantnagar Feb. 5-25
Jameel Akhtar Pardeep Kumar	Online training on '*Application of GIS Tools*' organized by	OnlineDivision of Germplasm Exploration, ICAR-NBPGR, New Delhi 3 & 24September, 2020.
Jameel Akhtar	Online training programme on 'Space Technology and Machine Learning for Agriculture'	OnlineNational Agricultural Higher Education Project organized by CAAST Centre for Agricultural Market Intelligence, Anand Agriculture University, Anand 28-29October, 2020
Jameel Akhtar, T Boopathi	E-course on'Crop Pest Diagnosis (English) v2.0'	OnlineCAB International Academy, Nosworthy Way, Wallingford, Oxfordshire OX10 8DE, UK 26 April to 9 May, 2020
Jyoti Kumari	Advanced Bioinformatics Tools and its Applications in Agriculture (Online)	NAARM, Hyderabad Sep. 14-19
K Pradheep	Workshop on Translational Approach of Botanical Code (In Person)	Department of Botany, University of Calcutta, 10-12 February 2020
K Pradheep	Science Communication for Smart Scholars (Online)	ICAR-CIFE, Mumba, iMay 5-18
K Pradheep	Analysis of Experimental Data using SAS(Online)	ICAR-NAARM, Hyderabad Nov. 9-17
Kartar Singh	GIS tools and techniques in mapping of plant genetic resources and conservation	Virtual training under UNEP-GEF project on 03.09.2020 and 24.09.2020.
Kavita Gupta	MDP on Priority Setting and Evaluation of Agricultural Research Projects (Online)	ICAR-NAARM, Hyderabad Oct. 12-17
Kavita Gupta	Emerging Trends in Seed Production Technology and Quality Control Framework for Effective Seed Supply Chain of Horticulture Crops	UHS, Bagalkot, (Karnataka) Dec. 28-Jan. 6
Kavita Gupta	MDP on Priority Setting and Evaluation of Agricultural Research Projects	Online mode ICAR-NAARM, Hyderabad, 12-17 October, 2020
Lalit Arya	Breeding Approaches for Enhancing Genetic Gains in Grain Legumes and Dryland Cereals	CRP-GLDC, NASC Complex, Pusa, New Delhi, Dec. 10-14
Mahesh C. Yadav,	Adoption of Early Sown Wheat and High Throughput Phenotyping	BISA, Jabalpur, Mar. 5-6th
Mamta Arya	Role of GIS tools and techniques in plant genetic resources – mapping diversity and conservation	Online mode 3.09.2020
Manjusha Verma	Advanced Bioinformatics Tools and its Applications in Agriculture(Online)	NAARM, Hyderabad Sep. 14-19
Mool Chand Singh	ABC of Scientific Writing (Online)	ICAR-NRRI, Cuttack, Aug. 18-Sep. 2
N Sivaraj	Science Administration and Research Management (Online)	ASCI, Hyderabad, Dec. 07-18

Name of employee	Title of training programme	Place and Period
P Pranusha	Analysis of Experimental Data using SAS (Online)	ICAR-NAARM, Hyderabad Nov. 9-17
PP Thirumalaisamy	Recent molecular approaches for plant disease diagnosis'.	S.V. Agricultural College, Tirupati, ANGRAU17th December, 2020 Virtual
Raj Kiran	Five days online training on 'Pest Risk Analysis'	Online National Institute of Plant Health Management, Hyderabad, 29 June-3 July, 2020
S R Pandravada	Geospatial Analysis using QGIS and R	ICAR-NAARM, Hyderabad Feb. 27-Mar. 3
Sandhya Gupta	Emotional Intelligence at Workplace for Women Scientists/ Technologists (Online)	COD, Hyderabad Nov. 23-27
Sangita Bansal	Science communication for smart scholars (Online)	ICAR-CIFE, Mumbai, May 28-Jun. 8
Sangita Bansal	Science Administration and Research Management for Scientists (Online)	ASCI, Hyderabad Sep. 28-Oct. 9
SC Dubey	Science Administration and Research Management for Scientists (Online)	ASCI, Hyderabad, Sep. 28-Oct. 9
Suma A	Science Communication for Smart Scholars (Online)	ICAR-CIFE, Mumbai, May 12-25
Vartika Srivastava	Science Communication for Smart Scholars(Online)	ICAR-CIFE, Mumbai, May 12-25
Vijay Singh Meena	Non-conventional approaches for genetic improvement of perennial horticultural crops	ICAR-IARI, New Delhi Jan. 17- Feb. 06
Vikender Kaur	Coordinated Trial Conduction, Data Recording and Reporting under AICRP on Wheat and Barley	IIWBR, Karnal Feb. 3-5
Z Khan	Five days online training on 'Pest Surveillance'	Online mode National Institute of Plant Health Management, Hyderabad, 7-11December, 2020
Zakaullah Khan	Pest Surveillance (Online)	NIPHM, Hyderabad, Dec. 7-11
Technical staff		
Anang Pal	Motivation, Positive Thinking andCommunication Skills for Technical Officers (T-5 and above) of ICAR Institutes (Online)	ICAR-NAARM, Hyderabad Dec. 17-22
Arun Kumar Sharma	Repair and Maintenance of Office, Residential Building including Guest Houses	ICAR-CIAE, Bhopal Jan. 21-23
Braham Prakash	Capacity Building Program for CJSC Members of ICAR Institutes/HQs	ICAR-NAARM, Hyderabad Jan. 27-31
BS Panwar	Motivation, Positive Thinking andCommunication Skills for Technical Officers (T-5 and above) of ICAR Institutes (Online)	ICAR-NAARM, Hyderabad Dec. 17-22
Ravinder Kumar	Automobile Maintenance, Road Safety and Behavioural Skills	ICAR-CIAE, BhopalJul. 26-Aug. 1
SSS		
Anant Swaroop	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
D Kalamma	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18

Name of employee	Title of training programme	Place and Period
Dalip Singh	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
E. Satyanarayan	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
G N Chary,	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
G Narsimha,	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
G Rajamani,	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Inder Singh	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
M. B. Keshwa Raju	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
M. Shankar	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
M. Srinivas	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Mangat Ram	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Md Saleem Uddin	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Mohd. Mazhar Pasha	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
N Srinivas,	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Om Prakash	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
P Gandhi,	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Paras Ram	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Ram Kalit Rai	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Rohit	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Rukmani	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Sanjeev Paswan	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Satya Narayan Thakur	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Shankar Das	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Sharda Devi	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Sukh Dev	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Sunil Kumar	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Suresh Ram	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Yatish Chandra	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18
Yogesh Kumar	Skilled Upgradation of Skilled Supporting Staff	ICAR-NBPGR, New Delhi Mar. 16-18

19.3 Capacity building

19.3.1 Deputations abroad

19.3.2 Participation in seminars / conferences / symposia / workshops / meetings

Name	Title of seminars / conferences / symposia / workshops / meetings/Webinar	Place and Period	Mode virtual/ In-person
D. P. Wankhede	National Virtual Conference – 2020. Current Trends and Challenges in Plant Biochemistry & Biotechnology. The Society for Plant Biochemistry and Biotechnology (SPBB)	BITS Pilani, K.K. Birla Goa Campus (20-21st Nov 2020)	Virtual
Gurinderjit Randhawa & Monika Singh	One CGIAR Global Webinar Series on Genome Editing in Agriculture: Innovations for Sustainable Production and Food Systems *Webinar 1: Genome Editing in Agriculture: Innovations for Sustainable Production and Food Systems – 22 Sept 2020* *Webinar 2: Applications of Genome Editing in Agriculture: CGIAR Focus on Crop Improvement – 29 Sept 2020* *Webinar 3: Applications of Genome Editing in Agriculture: CGIAR Focus on Livestock and Aquaculture – 6 Oct 2020* *Webinar 4: Regulation and Genome Edited Plants – 13 Oct 2020* *Webinar 5: Path to Commercialization for Genome Edited Crops – 20 Oct 2020*	ICRISAT and CGIAR (20-24 Aug 2018)	Virtual
Gurinderjit Randhawa, Monika Singh & Kushaldeep Kaur Sodhi	Webinar on Global Impact of Biotech Crops: Economic and Environmental Effects, 1996-2018	ISAAA(15 Oct 2020)	Virtual
Gurinderjit Randhawa & Monika Singh	Webinar on Gene Editing for Agriculture, Society and Sustainable Development: Prospects and Perspectives	TIGS Science Serving Society and BCIL (15 Dec 2020)	Virtual
K.M. Rai	Invited Lecture: Diversification of Horticultural crops	ICAR-CITH, RS, Mukteshwar on 12.02.2020	In-person
K.M. Rai	Invited Lecture: Crop varieties and their wild relatives in Uttarakhand	G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Katarmal, Almora, Uttar-akhand on 13th February 2020.	In-person
K.M Rai	Invited Lecture on kiwi cultivation in Uttarakhand	Uttarakhand Council of Biotechnology, Pantnagar on 21st December, 2020	Virtual
Kartar Singh	Gave oral presentation of an abstract entitled "Differential expression pattern of pathogenicity inducing effect or genes in *Xanthomonasaxonopodis*pv. *punicae* with pomegranate" to the "IPS 7th International conference on Phytopathology in Achieving UN Sustainable Development Goals"	16-20thJanuary 2020, ICAR-IARI, New Delhi.	
Kartar Singh	Participated in webinar conducted by Devra Jarvis on "Course on On-farm conservation of Agro-biodiversity"	9th December, 2020	
Kartar Singh	Participated in e-National Oilseed Brainstorming meet	23-25th September 2020	

Name	Title of seminars / conferences / symposia / workshops / meetings/Webinar	Place and Period	Mode virtual/ In-person
Lalit Arya	Webinar on "Pandemics and Hunger: Mainstreaming Millets for Addressing Food and Nutritional Security"	University of Hyderabad (8 Jun 2020)	Virtual
Mamta Arya	International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities 2020	Bhopal, 10– 12th February, 2020	In-person
Mamta Arya	22nd RAC of ICAR-NBPGR	ICAR-NBPGR, 23-24 July 2020	Virtual
Mamta Arya	Formation and Effective Functioning of FPO	ICAR-RCER Patna, 18th August 2020	Virtual
Mamta Arya	National Webinar on Implementation of Access to Plant Genetic Resources and Benefit Sharing	ISPGR, New Delhi on 27th August 2020	Virtual
Mamta Arya	Regional Coordination Committee Meeting (Uttarakhand) under UNEP-GEF	ICAR-NBPGR RS Bhowali, 8th Sep 2020	Virtual
Mamta Arya	National Mission on Biodiversity and Human Well-Being: Enhancing biodiversity, augmenting human well-being	Biodiversity Collaborative 14th Sep 2020.	Virtual
Mamta Arya	Global Food Supply Chains: An Early Assessment of Covid-19 Impacts	FAO under CSIS on 2nd October 2020.	Virtual
Mamta Arya	Technical Meeting of Uttarakhand Region" under UNEP-GEF project	ICAR-NBPGR, 15th October 2020	Virtual
Mamta Arya	Review Meeting of UNEP-GEF project	ICAR-NBPGR, 7th November 2020	Virtual
Mamta Arya & K.M Rai	31st IRC of ICAR-NBPGR bureau from in the online mode through zoom platform	ICAR-NBPGR, 5-7 August 2020	Virtual
Monika Singh	International Web-Conference on "New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development (NTAEBSID-2020)"	Agro Environmental Development Society (AEDS), National Agriculture Development Co-operative Ltd., Baramulla and Babasaheb Bhimrao Ambedkar University, Lucknow (21-22 June, 2020)	Virtual
Monika Singh	Webinar on "Pandemics and Hunger: Mainstreaming Millets for Addressing Food and Nutritional Security"	University of Hyderabad (8 Jun 2020)	Virtual
Neelam Shekhawat	Participated in the National Webinar on Abiotic Stress in Agriculture: Geospatial Characterization and Management Options organized by ICAR-National Institute of Abiotic Stress Management, Baramati, India	August 27, 2020.	
Pragya	Indian Horticulture Summit organised by Society for Horticultural Research and Development, at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chtrakoot		Feb 14-16, 2020
Pragya	National Web Conference on Enhancing Vegetable Productivity through Recent Techniques organized by BAU, Sabour		September 9-10, 2020
Pragya, S K Yadav	National Webinar on Boosting Immunity through Horticulture organized by Society for Horticultural Research and Development Ghaziabad, UP		September 1-9, 2020
Pragya, Vandana Tyagi	NBA UNDP Webinar Series BDA, 2002, Part 2 (BDA Rules, 2004)		August 19, 2020
Pragya, Pratibha Brahmi, SK Yadav, Vandana Tyagi	National Webinar on Access to PGR and Benefit Sharing NBPGR, New Delhi (organized by ISPGR in collaboration with CIAT, TAAS, PPVFRA , NBA		August 27, 2020

Name	Title of seminars / conferences / symposia / workshops / meetings/Webinar	Place and Period	Mode virtual/ In-person
Pratibha Brahmi. Vandana Tyagi	Brainstorming Session on Revision of BD ACT, 2002, BD Rules, 2004 and ABS Guidelines, 2014, NBPGR, New Delhi organized by NAAS, New Delhi		September 1, 2020
R C Mishra	National Webinar on "Implementation of Access to plant genetic resources and ring (ABS)	27th August 2020	Virtual
R C Mishra	Meeting on Community Seed Bank Attended Meeting on National Mission on Biodiversity and Human Well-being on 14th Sept' 2020 Attended "EFC Meeting of ICAR-NBPGR, All India Network Project on Potential Crops, CRP on Agro-biodiversity under the chairperson of DDG (Crop Science) on 16th Sept' 2020 Attended XXV Meeting of ICAR-Regional Committee organized by ICAR-NRRI, Cuttack through web casting from Krishi Bhawan, New Delhi under the chairmanship of Director General, ICAR & Secretary, DARE, New Delhi on 8th Oct' 2020.	31st August 2020	
	Attended Meeting on "Rabi Pilot initiatives and Revitalizing Rainfed Agriculture" with RRA Network Attended a Meeting with Chairman and volunteers of Sambhav NGO, Nayagarhon	27th Oct' 2020 17th November 2020	
Rakesh Singh	"Next Generation Technological Interventions to Boost Horticultural Sector in India towards Self Sufficiency". Webinar organised by Indian Academy of Horticultural Sciences (IAHS) (formerly the Horticultural Society of India).	New Delhi, 6th November, 2020	Virtual
Rakesh Singh	Fututre Prospetives in Agriculture Education.Webinar organised by NAHEP (ICAR)-CAAST, IARI.	New Delhi, 5th September 2020	Virtual
Rakesh Singh	National Webinar on Implementation of Access to Plant Genetic Resources and Benefit Sharing (ABS)Organized by: Indian Society for Plant Genetic Resources (ISPGR), New Delhi, India Alliance of Bioversity International and International Center for Tropical Agriculture (CIAT), Delhi Office, India	New Delhi, August 27, 2020	Virtual
Vandana Tyagi	Training on GIS Tools and Technology in mapping of PGR, NBPGR, New Delhi		September 3, 2020
Vandana Tyagi	International Roundtable on achieving global food security through instrumentalities of plant variety and other related disciplines (patent, trade secret, ABS and regulatory framework) organised by DPIIT-IPR CHAIR & CIPRA, National Law school of India University, Bangalore		March 5-6, 2021
Vijay Singh Meena	Attended webinar on Farmers Constraints in Dragon Fruit Cultivation"	September 1, 2020.	
Vijay Singh Meena	Attended National Webinar on 'Abiotic Stress in Agriculture: Geospatial Characterization and Management Options'	27th August, 2020	
Vijay Singh Meena	Attended webinar on Biological Diversity Act 2002 - Part II (BD Rules)	19th August, 2020	
Vijay Singh Meena	Attended webinar on Promoting potential minor fruit crops: A sustainable new venture for north eastern India	15-16th October,2020.	

19.3.3 Participation in trainings / seminars / webinars

Name of the Scientist (s)	Title of the Training/Seminar/Webinar	Period	Organizers
Anjula Pandey, D P Semwal, RK Pamarthi, PK Malav, S Niveditha	National Webinar on Implementation of Access to Plant Genetic Resources and Benefit Sharing	Aug. 27, 2020	ISPGR, NBPGR, New Delhi
DP Semwal	ICAR-KRISHI Geo-Portal-Challenges and Way Forward	Jan. 9-10, 2020	ICAR-NBSS&LUP, Nagpur, Maharashtra
DP Semwal and Applications -A	"ICAR-KRISHI Geoportal Spatial Data Infrastructure Way forward"	June 2, 2020	IASRI & NBSSLUP, Nagpur, Maharashtra
DP Semwal	National Webinar on Abiotic Stress in Agriculture: Geospatial Characterization and Management Options	Aug. 27, 2020	NIASM, Baramati, Maharashtra
DP Semwal	Future Perspective in Agriculture Education	Sept. 5, 2020	PG School ICAR-IARI, New Delhi
RK Pamarthi	National Workshop on Intellectual Property Management in Agriculture	Nov. 28, 2020	ICAR-IIAB, Ranchi
RK Pamarthi, S Niveditha, PK Malav	Two days National Level E-Workshop On Recent Trends in Plant Taxonomy	Nov. 25-26, 2020	St. Ann's College For Women, Hyderabad and Botanical Survey of India, DRC, Hyderabad.
S Niveditha	National webinar on "Conservation of Biodiversity: Law, Methods and ABS"	July 29-31, 2020.	KSCSTE-Malabar Botanical Garden & Institute for Plant science, Kozhikode, Kerala
S Niveditha	National webinar on "Plant Taxonomy and Ethnobotany in India- Future and Challenges"	Nov.4-6, 2020	National Museum of Natural history (NMNH), New Delhi.
S. Niveditha	Training Programme on "Analysis of Experimental data using SAS"	Nov. 9-17, 2020	ICAR-NAARM, Hyderabad
SP Ahlawat, RK Pamarthi	IBIN workshop on Bioresources database	Aug. 17-19, 2020	GKVK, Banglore
SP Ahlawat, DP Semwal, RK Pamarthi, PK Malav, S. Niveditha	Role of GIS tools and techniques in plant genetic resources – mapping diversity	Sept. 3 & 24, 2020	ICAR-NBPGR, New Delhi
SP Ahlawat, DP Semwal, S Niveditha	National webinar on "Formation and effective functioning of farmers producer organization"	Aug. 18, 2020	ICAR-Research Complex for Eastern Region, Patna, Bihar

19.3.4 Participation in trainings / seminars / symposia / conference / workshop

Name	Title of Seminars/ Symposia/ Conference/ Workshops/ Training programmes	Place and period
BH Gawade	Interaction meeting with Farmers and Prime Minister's Address & release of PM Kissan Samman Nidhi'	December 25, 2020
Bharat Gawade Chithra Devi Pandey Lalit Arya Manjusha Verma Vinod Kumar Sharma	Brainstorming Session on Network Project on Cucurbits	17 December 2020 at ICAR-NBPGR, New Delhi
Chithra Devi Pandey	Workshop Review meeting on the progress made under CRP on Agrobiodiversity	28stAugust 2020, ICAR-NBPGR, New Delhi
Chithra Devi Pandey	Challenges And Opportunities Of Vegetable Production In Warm Humid Tropics	11-13th November, 2020. College of Horticulture, Kerala Agricultural University.
Chithra Devi Pandey	"Emerging Trends in Seed Production Technology and Quality Control Framework for Effective Seed Supply Chain of Horticulture Crops"	8 December 2020-06 January 2021,College of Horticulture, Bidar, University of Horticultural Sciences, Bagalkot, (Karnataka) India.
Dinesh Chand Sunil Gomashe	Monitoring of Sorghum germplasm trial under CRP on Agro-biodiversity	Sorghum Research Unit, Dr. PDKV, Akola, 07 March
Dinesh Chand, Sunil Gomashe Smita D. Karale	Inspection of ongoing Rajbhasha related activities at Regional Station, Akola	Online mode-by Deputy Director (Rajbhasha), Ministry of Home Affairs, Rajbhasha Division, Regional Implementation office (West), Mumbai, 25 July
Jameel Akhtar	Online Annual Group Meeting of 'AICRP on rapeseed-mustard'	Online, August. 3-4, 2020
Jameel Akhtar	A virtual meeting to develop module for 'Seed Health Standards in compliance with EU countries' held under the Chairmanship of Asstt. Director General (Seeds), ICAR, New Delhi.	Online, September 25, 2020
Jameel Akhtar	National Workshop on 'Modern interventions in environmental Management'	Online organized by ICAR-Indian Institute of Agricultural Biotechnology, Ranchi December 30, 2020
Jameel Akhtar Pardeep Kumar	Webinar on 'Development and validation of rapid molecular methods that meet the challenges of detecting & confirming food pathogens'	Online, Aug. 19, 2020
Jameel Akhtar Raj Kiran Pooja Kumari	International Web Conference "prespective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020)"	Agricultural & Environmental Technology Development Society (AETDS) U.S. Nagar, Uttarakhand, India on October 4-6, 2020
Kavita Gupta Jameel Akhtar Pardeep Kumar	Webinar on 'Biological Diversity Act, 2002: Part II (The Biological Diversity Rules, 2004)"	Online, August. 19, 2020

Name	Title of Seminars/ Symposia/ Conference/ Workshops/ Training programmes	Place and period
Mool Chand Singh	ISWS National Weed Science Conference	ICAR-Central Coastal Agricultural Research Institute, GOA during February 5-7,2020.
Padmavati G Gore	Webinar on Augmented Block Design: Concept and Analysis	28 July 2020
Padmavati G Gore	Training Programme on Analysis of Experimental Data using SAS	09-17 November, 2020. ICAR-NAARM, Hyderabad
	Dr. Julius Uchoi participated virtual online training on GIS on 3rd September. 2020 conducted by ICAR-NBPGR, New Delhi & Bioversity International.	
	Dr. Julius Uchoi Participated online virtual webinar on "Integrated pest and nematode management on Banana" conducted by ICAR-National Research Centre for Banana during 04.08.2020.	
	Dr. Julius Uchoi participated online virtual webinar on Genomics Strategies for Improvement of Abiotic Stress Tolerance in Crop Plants on 27 November 2020, conducted by ICAR-NIASM, Baramati.	
	Dr. Subarna Hajong participated virtual online training on GIS conducted by ICAR-NBPGR, New Delhi & Bioversity International on 3rd September 2020.	
	Dr. Subarna Hajong participated in a Webinar on "Plant Genome Engineering for Agriculture, Food and Nutrition" organised by Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, Madhya Pradesh on 04 August, 2020.	
	Dr. Subarna Hajong participated and presented oral presentation on title "Diversity analysis of Sohphlang (*Flemingia procumbens* Roxb.) accessions of Meghalaya, India, using agro-morphological and molecular markers. In *International Virtual Conference on* "Advances in Agricultural & Food sciences to Face the challenges to environment and Biosecurity" held at Sharda University, Greater Noida, Uttar Pradesh during 16th to 20th January, 2021,	
	Dr. Julius Uchoi participated virtual online training on "Management of Fruit Genetic Resources" during 1-2nd February, 2021 conducted jointly by ICAR-NBPGR, New Delhi & ICAR-IIHR, Bangalore.	
	Dr. Julius Uchoi participated virtual seminars on International Panel on Fruit and Vegetable Genetic Diversity: The Status and Challenges of Conservation, Exchange and Use conducted by PFGRA, FAO, Rome on 16th February, 2021.	
	Dr Vimala Devi S participated and presented Wild rice *Oryza rufipogon*- a new accession from Karnataka in the Ist Indian Rice Congress organized by ARRW, Cuttack at ICAR-NRRI Cuttack during December 8-9, 2020 (Virtual mode).	
SC Dubey V Celia Chalam Kavita Gupta Z Khan J Akhtar Bharat Gawade Pooja Kumari	7th International Conference on "Phytopathology in Achieving UN Sustainable Development Goals" organized by Indian Phytopathological Society	Division of Plant Pathology, ICAR-IARI, New Delhi, India on January16 -20, 2020

Name	Title of Seminars/ Symposia/ Conference/ Workshops/ Training programmes	Place and period
SC Dubey V Celia Chalam Kavita Gupta Jameel Akhtar Pardeep Kumar	National webinar on 'Plant genetic resources: access and benefit sharing'	Online organized by Indian Society of Plant Genetic Resources, New Delhi, August. 27, 2020
SC Dubey	Webinar on 'Forecasting and plant disease management' Jameel Akhtar	Online organized by Indian Phytopathological Society (Mid-East Zone, Aligarh)August. 4, 2020
SC Dubey Jameel Akhtar Pardeep Kumar BH Gawade Pooja Kumari	Indian Phytopathological Society Delhi Chapter Zonal Symposium (virtual) on "Modern trends in systematics and bio-prospecting of fungi"	Indian Phytopathological Society, Delhi Zone December 16, 2020
SP Singh	XXX Group Meet (Kharif 2019) of AICRN on Potential Crops (Online web meeting)	ICAR-NBPGR, New Delhi-110012, June 11, 2020
Sherry Rachel Jacob	International Plant Physiology Virtual Conference on "Prospects of Plant Physiology for Climate Proofing Agriculture"	Dec 6-7, 2020
Sherry Rachel Jacob	International Web conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	Dec 28-30, 2020
Sherry Rachel Jacob Veena Gupta	UNDP-NBA webinar series	May, 2020 onwards
Sherry Rachel Jacob Chithra Pandey Veena Gupta	International Webinar on Information and Exchange on the new EU Plant Health Regulation	Dec 14, 2020
Sherry Rachel Jacob	National Webinar on Implementation of Access to Plant Genetic Resources and Benefit Sharing'	Aug 27, 2020
Sherry Rachel Jacob	Webinar by Devra Jarvis on "Course on On farm Management of Agrobiodiversity	Dec 9, 2020
Sherry Rachel Jacob	Farm Bills 2020: Understanding the Implications Veena Gupta	Sep 26, 2020
Sunil Gomashe	International e-conference on Genetics and Plant Breeding Research in post COVID-19 Era	Online mode by Department of Genetics and Plant Breeding Ch. Charan Singh University, Meerut, 13-14 June
Sunil Gomashe	International Web-Conference on New trends in agriculture, environmental and biological sciences for inclusive development	Online mode- by Agro Environmental Development Society (AEDS), Rampur, Uttar Pradesh, 20-22 June
V Celia Chalam	IVS International Conference on "Evolution of Viruses and Viral Diseases"	Indian National Science Academy, New Delhi, February 18 to 20, 2020

Name	Title of Seminars/ Symposia/ Conference/ Workshops/ Training programmes	Place and period
V Celia Chalam	Covid-19 and genebanks about the relationship between COVID-19, genebanks and the conservation of seeds	World Agroforestry, IITA, Crop Trust, May 13, 2020
V Celia Chalam	Plant Viruses II Workshop	American Society of Virology June 16, 2020
V Celia Chalam	International E-Conference on "Multidisciplinary Approaches for Plant Disease Management in Achieving Sustainability in Agriculture"	College of Horticulture, Bengaluru, October 6-9, 2020
V Celia Chalam	One CGIAR Global Webinar Series on Genome Editing in Agriculture: Innovations for Sustainable Production and Food Systems	CGIAR, September 22, 2020; September 26, 2020 ; October 6, 2020 ; October 13, 2020; October 20, 2020
V Celia Chalam	International Webinar on Pulses to keep soil alive and protect biodiversity	Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, December 4, 2020
V Celia Chalam Kavita Gupta SP Singh Jameel Akhtar BH Gawade Pooja Kumari Pardeep Kumar Raj Kiran	International Webinar on "Information and Exchange on the new EU Plant Health Regulation" with special reference for seeds	DAC & Farmers Welfare, Govt. of India, New Delhi, December 14, 2020
V Celia Chalam	Gene Editing for Agriculture, Society & Sustainable Development: Prospects and Perspectives	TIGS, Delhi, December 15, 2020
V Celia Chalam	Global Status of Commercialized Biotech/GM Crops for 2019 for Latin America	ISAAA, USADecember 18, 2020
V Celia Chalam	Webinar on Transboundary Pests Threats to Biosecurity and Biosafety Issues	Virtual by S.V. Agricultural College, Tirupati, ANGRAU, A.P., December 21, 2020

20 GENERAL INFORMATION

Summary: In total, 123 scientific, 72 technical, 41 administrative/finance and 59 supporting staff personnel were in position at ICAR- NBPGR including regional stations, as on December 31. During the year, 23 promotions, 01 transfers and 11 retirements were effected across all staff categories. The scientific staff were bestowed with 06 young/best scientist awards, 05 scientists with other recognitions. Dissemination of research outputs in the form of peer-re- viewed research articles (121), books (08), book chapters/manual chapters (77), popular articles (15), TV talks (07), reports (10), training manuals (07), and *e*-publications (04). As a part of outreach activities, the institute organized 05 field days and 21 PGR awareness-cum- biodiversity fair programmes.

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-54	Member
The Director (Agri.), Dte. of Agriculture, Haryana Krishi Bhawan, Sector-21, Panchkula, Haryana-134112	Member
The ADG (Seed), ICAR, Krishi Bhawan, New Delhi-110001	Member
The Head, Plant Pathology Division, ICAR-IARI, New Delhi-12	Member
Dr RC Bhattacharya, Principal Scientist, ICAR- NIPB, 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, Karnal Haryana	Member
Dr PK Singh, Principal Scientist, NBAGR, Karnal	Member
Sh Mukesh Maan, Village Alipur, Narela, Delhi	Member
Sh Sanjay Maruti Patil, BAIF Office, Amrai Campus, Jauhar, District Palghar, Maharashtra	Member
The Comptroller, ICAR-IARI, New Delhi-110012	Member
The Sr. Admn. Officer ICAR-NBPGR, New Delhi-110012	Member Secretary

20.2 Research advisory committee (RAC)

Dr SK Sharma, Ex-Vice-Chancellor, CSK-HPKV, Palampur, Himachal Pradesh	Chairman
Dr Sujata Arora, Advisor, Ministry of Environment, Forest & Climate Change, New Delhi	Member
Dr Pritam Kalia, Emeritus Scientist, ICAR-IARI, New Delhi	Member
Dr DK Yadava, ADG (Seed) acting, ICAR, New Delhi	Member
Dr SR Yadav, Emeritus Scientist, Professor, Dept of Botany, Shivaji Univ. Kolhapur, Kolhapur, Maharastra	Member
Dr SR Bhat, Emeritus Scientist, NRCPB, ICAR-IARI, New Delhi	Member
Dr VV Ramamurthy, Emeritus Scientist, ICAR-IARI, New Delhi	Member
Dr Kuldeep Singh, Director, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr SC Dubey, Principal Scientist & Head DPQ, ICAR-NBPGR, New Delhi	Member Secretary

The XXI meeting of the RAC of ICAR-NBPGR was held on July 15-16, 2020 at New Delhi under the Chairmanship of Dr SK Sharma, EX-Vice-Chancellor, CSK-HPKV, Palampur. The members of RAC provided general and division specific recommendations.

20.3 Institute research council (IRC)

The 31st 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 17-19, 2020. The Principal Investigators / OICs / scientists of the respective regional stations presented the progress report of the institute projects operational at headquarters and various regional stations / base centres. HoDs and OICs of units / RS / BC made the presentations followed by the PIs of the respective projects.

20.4 Institute joint staff council (IJSC)

Elected members of IJSC for different categories: Technical Staff: Sh Satya Prakash (Secretary, Staff Side) and Sh Braham Prakash (TO); Administrative staff: Mr Yogesh Kumar (Assistant); Skilled Supporting Staff: Sh Yatish Chandra and Sh Braham Dev Paswan. Office side members were: Dr Rakesh Bhardwaj, Dr SP Ahlawat, Dr Anuradha Aggarwal, Dr Amit Kumar Singh and Sr AO.

20.5 Prioritization monitoring and evaluation (PME) cell

PME cell coordinated all scientific activities such as project proposals (8), manuscripts (48)/ abstracts (95); training/ fellowship proposals (38) 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 conference and the regional committee meetings. Also, inputs for various documents/issues/reports of CGIAR projects/foreign-aided projects/parliament questions/audit paras, or any such information as and when required for the council/ any other agencies.

PME Cell

Dr Kavita Gupta	OIC
Dr Vandana Tyagi	Co-nodal officer
Dr SK Kaushik	HRD nodal officer
Dr S Rajkumar	Member
Dr J Aravind	Member
Dr Sushil Pandey	IRC member secretary
Dr Rakesh Bhardwaj	Nodal officer Krishi Portal

FMS-MIS at ICAR-NBPGR

Five management modules *viz.*, financial, project (project and scheme code generation for RPP-I, submission of RPP II and RPP III), procurement & stores (indent raising), human resource (training information, applying leaves) and payroll (information related to transfer and joining of employees) were supported through FMS-MIS.

HRD Activities

Annual Training Plan (ATP) of all the staff members of the Bureau for the year 2020-21 was prepared based on the training needs assessment and submitted to the Council. During the reporting period, fourteen scientists and three 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 information on HRD activities was compiled in the form of six-monthly report, annual report, impact assessment proformae 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 a centralized 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 electronic form was ensured on transfer and superannuation of 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 2020

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 Kishore 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
	UU & UEP		
14	Dr SK Kaushik	Principal Scientist	Genetics & Plant Breeding
15	Dr Vinay Mahajan	Principal Scientist	Genetics & Plant Breeding
16	Dr Hanuman Lal Raiger	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

S. No.	Name	Designation	Discipline
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	Sh Nand Lal Meena	Scientist	Biochemistry
41	Dr Sapna	Scientist	Biochemistry
	GERMPLASM CONSERVATION DIVISION		
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 Chithra Devi Pandey	Principal Scientist	Seed Science & Technology
47	Dr Sushil Pandey	Principal Scientist	Seed Science & Technology
48	Dr Sherry Rachel Jacob	Senior Scientist	Seed Science & Technology
49	Dr Vimla Devi	Senior Scientist	Genetics & Plant Breeding
50	Sh J Aravind	Scientist	Plant Genetics
51	Dr Padmavati G Gore	Scientist	Economic Botany & PGR
	PLANT QUARANTINE DIVISION		
52	Dr SC Dubey	Head	Plant Pathology
53	Dr V Celia Chalam	Principal Scientist	Plant Pathology
54	Dr Kavita Gupta	Principal Scientist	Agril. Entomology
55	Dr Moolchand Singh	Principal Scientist	Agronomy
56	Dr Zakaullah Khan	Principal Scientist	Nematology
57	Dr Jameel Akhtar	Principal Scientist	Plant Pathology
58	Dr Surendra Pal Singh	Principal Scientist	Agril. Entomology
59	Dr Boopathi T	Senior Scientist	Agricultural Entomology

S. No.	Name	Designation	Discipline
60	Dr Gawade Bharat Hanamant	Scientist	Plant Nematology
61	Dr Pardeep Kumar	Scientist	Agril Biotechnology
62	Mrs Raj Kiran	Scientist	Plant Pathology
63	Ms Pooja Kumari	Scientist	Plant Pathology
64	Sh Bharat Raj Meena	Scientist	Plant Pathology
	TISSUE CULTURE AND CRYPRESERVATION UNIT		
65	Dr Anuradha Agrawal	Principal Scientist & Incharge	Economic Botany
66	Dr Rekha Chaudhury	Principal Scientist	Economic Botany
67	Dr Sangita Bansal	Principal Scientist	Agricultural Biotechnology
68	Dr Ruchira Pandey	Principal Scientist	Economic Botany
69	Dr Neelam Sharma	Principal Scientist	Economic Botany
70	Dr Sandhya Gupta	Principal Scientist	Economic Botany
71	Dr Vartika Srivastava	Scientist	Fruit Sciences
72	Dr Gowthami R	Scientist	Genetics & Plant Breeding
73	Dr Era Vaidya Malhotra	Scientist	Agricultural Biotechnology
74	Dr Subhash Chander	Scientist	Economic Botany & PGR
	DIVISION OF GENOMIC RESOURCES		
75	Dr Gurinderjit Randhawa	Principal Scientist & Head (Act.)	Plant Physiology
76	Dr Soma Sunder Marla	Principal Scientist	Biotechnology
77	Dr MC Yadav	Principal Scientist	Genetics / Cytogenetics
78	Dr Mukesh Kumar Rana	Principal Scientist	Plant Breeding
79	Dr Rakesh Singh	Principal Scientist	Biotechnology
80	Dr Ambika Baldev Gaikwad	Principal Scientist	Biotechnology
81	Dr Lalit Arya	Principal Scientist	Plant Biochemistry
82	Dr Manjusha Verma	Principal Scientist	Plant Biochemistry
83	Dr Sundeep Kumar	Principal Scientist	Biotechnology
84	Dr Rajesh Kumar	Principal Scientist	Plant Biotechnology
85	Dr Amit Kumar Singh	Senior Scientist	Biotechnology
86	Dr R Parimalan	Senior Scientist	Biotechnology
87	Dr S Rajkumar	Senior Scientist	Genetics / Cytogenetics
88	Dr Yasin Jeshima K	Scientist	Genetics
89	Sheel Yadav	Scientist	Biotechnology – Plant Science
90	Dr Monika Singh	Scientist	Agril. Biotechnology
91	Dr Wankhede Dhammaprakash Pandhari	Scientist	Plant Genetics
	NBPGR, Regional Station, Hyderabad		
92	Dr Anitha Kodaru	Principal Scientist & Incharge	Plant Pathology
93	Dr SR Pandrawada	Principal Scientist	Economic Botany

S. No.	Name	Designation	Discipline
94	Dr Kamla Venkateswaran	Principal Scientist	Economic Botany
95	Dr Natarajan Sivaraj	Principal Scientist	Economic Botany
96	Dr Parameswari Balasubramanium	Senior Scientist	Plant Pathology
97	Dr P Pranusha	Scientist	Plant Genetics
98	Dr Prasanna Holajjer	Scientist	Nematology
99	Dr Bhaskar Bajaru	Scientist	Plant Pathology
	NBPGR, Regional Station, Akola		
100	Dr Dinesh Chand	Principal Scientist	Economic Botany & PGR
101	Dr Sunil Sriram Gomashe	Senior Scientist	Genetics & Plant Breeding
	NBPGR, Regional Station, Bhowali		
102	Dr Mamta Arya	Scientist & OIC	Plant Genetics
103	Dr Krishna Madhav Rai	Scientist	Fruit Science
	NBPGR, Regional Station, Cuttack		
104	Dr Diptiranjan Pani	Principal Scientist	Economic Botany
105	Dr RC Mishra	Principal Scientist	Economic Botany
	NBPGR, Regional Station, Shimla		
106	Dr Mohar Singh	Principal Scientist	Plant Breeding
107	Mr Badal Singh	Scientist	Economic Botany & PGR
108	Mr Rahul Chandora	Scientist	Economic Botany & PGR
109	Dr Narender Negi	Scientist	Fruit Sciences
	NBPGR, Regional Station, Thrissur		
110	Dr Joseph John K	Principal Scientist	Economic Botany
111	Dr M Latha	Principal Scientist	Plant Breeding
112	Dr K Pradheep	Principal Scientist	Economic Botany
113	Dr Thirumalaisamy 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	Scientist	Genetics & Plant Breeding
120	Dr Shephalika Amrapali	Scientist	Economic Botany & PGR
121	Reshmi Raj KR	Scientist	Genetics & Plant Breeding

S. No.	Name	Designation	Discipline
		NBPGR, Regional Station, Shillong	
116	Dr Harish GD	Scientist & Incharge	Genetics & Plant Breeding
117	Dr Julius Uchoi	Scientist	Horticulture-Fruit science
118	Dr Subarana Hajong	Scientist	Economic Botany & PGR
	On deputation		
119	Dr RK Tyagi	Principal Scientist	Ecomomy Botany
120	Dr JC Rana	Principal Scientist	Genetic & Plant Breeding

(ii). Technical staff in position as on 31st December 2020.

S. No.	Name	Designation
		Division of Plant Exploration and Germplasm Collection
1	Dr NS Panwar	Chief Technical Officer
2	Smt Rita Gupta	Senior Technical Officer
3	Sh Om Prakash 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
11	Sh Naresh Kumar	Technical Assistant
12	Dr Sadhna	Technical Assistant
		Division of Germplasm Evaluation
13	Dr 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

S. No.	Name	Designation
	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 Conservation	
27	Dr AD Sharma	Chief Technical Officer
28	Dr 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
	Library	
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)

S. No.	Name	Designation
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 Khusvinder Kumar	Senior Technician (Driver)
	Regional Station, Akola	
53	Sh Rakesh Lathar	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 Gunashekharan	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	Mr Dharam Raj Meena	Technical Assistant
64	Mrs Chanchal Gaina	Technical Assistant
	Base Centre, Ranchi	
65	Sh AK Gupta	Senior Technical Officer
66	Ashwini Kumar	Technical Assistant
67	Sh Narendra Ram	Technical Officer (Driver)
	Regional Station, Shimla	
68	Sh Joginder Singh	Senior Technical Assistant
69	Sh Dayal Singh	Senior Technical Assistant
70	Sh Ram Chander	Technical Assistant
	Regional Station, Thrissur	
71	Sh S Mani	Assistant Chief Technical Officer
72	Sh R Ashokan Nair	Assistant Chief Technical Officer
73	Smt A Indra Devi	Assistant Chief Technical Officer

(iii). Administrative staff in position as on 31st December 2020.

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 Mahabir Singh Yadav	Assistant
16	Smt Madhu Chawla	Assistant
	Stores	
17	Smt Poonam Singh	Administrative Officer
18	Sh Dinesh Sharma	Assistant
	Purchase	
19	Sh Avdesh Kumar	Assistant Administrative Officer
20	Sh Sanjay Dangwal	Assistant
	Audit Section	
21	Sh KK Sharma	Senior Finance & Accounts Officer
22	Sh Mahesh Kumar	Finance & Accounts Officer
23	Sh Surender Kumar	Assistant Administrative Officer
24	Smt Bharti Sharma	Assistant
25	Sh Prabal Dasgupta	Assistant

S. No.	Name	Designation
	Pension & Records	
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 and 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
	Regional Station, Thrissur	
43	Sh S Bhadra Kumar	Assistant Administrative Officer

(iv). Skilled supporting staff in position as on 31st December 2020.

S. No.	Name
	Director's Cell
1	Sh Surender Kumar
2	Sh Hari Chand Paswan
	Division of Plant Exploration and 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 Braham 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 Kishore
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

S. No.	Name
	Establishment
27	Sh Roshan Lal
	Experimental Farm, Issapur
28	Sh Dhir Singh
29	Sh Mahabir Singh
	Regional Station, Akola
30	Sh SR Pacherwal
31	Sh RC More
32	Sh RP Barsse
33	Sh AD Godlinga
34	Sh MB Nikose
	Regional Station, Bhowali
35	Sh Anand Kumar
36	Sh GC Arya
37	Smt Tulsi Devi
	Base Centre, Cuttack
38	Sh Sarangdhar Barik
	Regional Station, Hyderabad
39	Mohd. Mazhar Pasha
40	Sh M Shankar
41	Sh E Satyanarayan
42	Sh MB Keshwa Raju
43	Sh M Srinivas
	Regional Station, Jodhpur
44	Sh DS Rajpurohit
	Base Centre, Ranchi
45	Sh Vijay Kumar
	Regional Station, Shimla
46	Sh Paras Ram
47	Sh Rohit
48	Sh Sukhdev
49	Sh Dalip Singh
50	Sh Inder Singh
	Regional Station, Shillong
51	Sh AK Deka
	Regional Station, Thrissur
52	Sh MK Prakassen

20.7 Staff transferred / superannuated / new appointments/ promotions

20.7.1 Appointments/Joining

Dr Badal Singh, Scientist, joined after completion of Ph.D from IARI, New Delhi on Oct. 06, 2020.

20.7.2 Retirements

Sh Subhash Rameshwar Pacherwal, (SSS) Sweeper at RS, Akola superannuated on Oct. 31, 2020.

Sh Joginder Singh, STA (Driver), RS, Shimla superannuated on April 30, 2020.

20.7.4 Promotions

Sh Ram Chander, RS, Shimla promoted from Technical Assistant (T-3) to Sr. Technical Assistant (T-4) w.e.f. Feb. 02, 2019.

Sh Bhadra Kumar, AAO, Thrissur promoted as AO and transferred to ICAR-CMFRI, Kochi July 23, 2020.

20.8 Award/ honours/ prizes during 2020

Dr Gurinderjit Randhawa elected as NAAS Fellow 2020 by National Academy of Agricultural Sciences, New Delhi.

Dr Gurinderjit Randhawa elected as PAS Fellow 2020by Punjab Academy of Sciences, Patiala, Punjab

Dr Monika Singh 'Scientist of the Year Award 2020' in the field of Agricultural Biotechnology during International Web-Conference on "New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development (NTAEBSID-2020)", 21-22 June 2020 by Agro Environmental Development Society (AEDS)

Dr Sunil Shriram Gomashe was conferred with Young Scientist Award 2020 by Agro Environmental Development Society (AEDS), Rampur, Uttar Pradesh during the International Web-Conference on "New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development (NTAEBSID-2020)" held on 21-22 June, 2020 in virtual mode.

Dr R Parimalan received Dr APJ Abdul Kalam best scientist award-2020', organized by Bose Science Society, Pudukkottai.

Dr R Parimalan conferred with Fellow of the Indian Society of Plant Genetic Resources, on Aug. 07, 2020.

Dr Yasin JK received Outstanding women scientist award – Received in an International Women Science Congress held at Chennai on March 08, 2020

Best poster award in National Seminar was awarded to Yousuf N, Dar SA, Lone AA, Dar ZA, Shikari AB, Sofi PA, Jacob SR, Neelam S, Nagaratna TK and Gulzar S (2020) Elucidating the genetic diversity of maize landraces in Jammu and Kashmir using phenotypic and molecular approaches. Presented in National seminar on 'Maize for crop diversification under changing climate scenario', held at Ludhiana during 9-10 February, 2020.

Sherry Rachel Jacob, Pratibha Brahmi, Veena Gupta and Kuldeep Singh (2020) Green Heritage Rights- an analysis of biodiversity policies and its implications on management of Indian plant genetic resources , was awarded the best oral presentation award at the International Web Conference on "Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2020)" during 28–30 December, 2020.

Sherry Rachel Jacob, Senior Scientist was awarded the Women Scientist Award by Astha Foundation, Meerut, UP on Dec. 30, 2020.

Sultan Sheikh M., K. Pradheep, Susheel Kumar Raina, and Sudhir Pal Ahlawat 2019 received Dr. RK Arora Best paper Award (2019) conferred by ISPGR, New Delhi for the paper "Collecting Plant Genetic Resources from Gurez, An Underexplored Remote Valley of Jammu & Kashmir State of India." *Indian Journal of Plant Genetic Resources* 32, no. 2 (2019): 174-180.

Celia Chalam V was awarded Fellow, Indian Phytopathological Society

Jameel Akhtar was awarded Outstanding Scientist Awardduring online 11th International Scientist Awards on Engineering, Science and Medicine held in Kolkata, India on Oct. 17-18, 2020

T. Boopathi, Senior Scientist received the Scientist Award-2020 for contribution to the Agricultural Entomology by the Dr. B.V. David foundation, Madanandapuram, Chennai, Tamil Nadu, India.

BH Gawade received 'Young Scientist Award' from Society For Biotic And Environmental Research (SBER), Khowai, Tripura for contribution in the field of Plant Nematology and Plant Quarantine.

Pardeep Kumar was awarded with Young Scientist Award during the 2nd National Conference held virtually on Advances in Sustainable Agriculture on 26-28 September, 2020.

Pooja Kumari received Young Scientist Award during International Web Conference prespective on Agricultural and Applied Sciences in COVID-19 Scenario organised by Agricultural & Environmental Technology Development Society (AETDS) U.S. Nagar, Uttarakhand, India on October 4-6, 2020.

Other Recognitions

Gurinderjit Randhawa: Member of Scientific Panel on Genetically Modified Organisms and Foods of Food Safety and Standards Authority of India (FSSAI).

Gurinderjit Randhawa: Member of Biotechnology for Food & Agriculture Sectional Committee, FAD 23 of Bureau of Indian Standards (BIS), New Delhi.

Gurinderjit Randhawa: Member of Special STAG of Department of Biotechnology of experts for reviewing the programme of Punjab Agricultural University, Ludhiana "Centre of excellence in development and integration of advanced genomic technologies for targeted breeding in agri-horticultural crops".

Jameel Akhtar has been nominated as Editor, Indian Phytopathology by Indian Phytpathological Society, New Delhi for the period 2020-22.

Jameel Akhtar was conferred 'Reviewer Excellence Award' by Agricultural Research Communication, Karnal on Jul. 13 & Sep. 9, 2020 and by Indian Phytpathological Society, New Delhi on Jun. 29, 2020.

Joseph John K, Principal Scientist, Co-Chaired Genetic Resources session of the AICRP-Floriculture on 14th Dec 2020.

Joseph John K, Principal Scientist under took a floristic survey of sixteen sites in West coast in Thrissur District for identifying suitable species for raising a bio-shield plantation promoted by Social Forestry Department.

Veena Gupta participated as subject matter expert in 38 AICRPCN Group Meet of Directorate of Medicinal and Aromatic Plants at Anand held during 2-11-2020 to 5-11-2020 on virtual mode.

Mool Chand Singh was nominated, Member, National Steering Committee to organize National Weed Science Conference at ICAR - Central Coastal Agricultural Research Institute, GOA during 5-7 February 2020.

Mool Chand Singh was elected Councilor (North Zone) for the Indian Society of Weed Science, ICAR-Directorate of Weed Research, Jabalpur (MP).

V Celia Chalam is recognized as Member, APS Collections and Germplasm Committee, American Phytopathological Society, USA

V Celia Chalam is recognized as Expert Member, Accreditation Panel, National Certification System for Tissue Culture-raised Plants, DBT, Govt. of India

V Celia Chalam, Judge in Technical Session 4 (Prof. M.J. Narsimhan Merit Academic Award Contest and APS-IPS travel award for PhD students for Delhi Zone) Virtual Symposium on "Modern trends in systematics and bio-prospecting of fungi" on December 16, 2020.

V Celia Chalamwas Co-Chair, Scientific Programme Committee, 7th International Conference on Phytopathology in Achieving UN Sustainable Development Goals", held on January 16-20, 2020 at ICAR-IARI, New Delhi.

V Celia Chalam nominated as Member, National Advisory Committee and Member, Programme Committee-Plant Virology, IVS International Conference on "Evolution of Viruses and Viral Diseases", held on February 18-20, 2020 at INSA, New Delhi.

Veena Gupta acted as expert member for Departmental Promotion Committee of Central Council for Research in Ayurvedic Sciences, Ministry of Ayush, 26-05-2020

Veena Gupta acted as Subject Matter Expert member for the promotion of scientists of Indian Council for Forestry Research and Education, Dehradun, 21-12-2020 to 23-12-2020.

Deputations

Pratibha Brahmi participated in the 8th International Meeting on heat and drought tolerant orphan legumes related to the collaborative research project on Evaluation of stress tolerant orphan legumes for dryland farming systems across sub-Saharan Africa and India from January 28-29, 2020

Invited Lectures

Joseph John K, Principal Scientist and Dr Suma. A, Scientist jointly delivered an invited talk online via google meet on "Crop Wild Relatives Conservation and Plant Breeding Research" in a webinar organised by K E College Mannanam, Kottayam Dist for the UG and PG students of Dept. of Botany.

Joseph John K, Principal Scientist participated in a panel discussion in a Webinar entitled " Agro-biodiversity for Food and Health Security" – a webinar organised by Kerala State Biodiversity Board on 26May 2020.

Joseph John K, Principal Scientist participated in a panel discussion in a Webinar entitled " Genetic Diveristy of Jackfruit" – a webinar organised by Department of Botany, St. Albert's College, Ernakulam on 06 July 2020.

Joseph John K, Principal Scientist participated in a panel discussion in a Enwenar Series – 04 under Genome Saviours – 9 entitled " Genetic Diversity in Jackfruit" – a webinar organised by Nature Agro-Biodiversity Action and Technology Transfer Initative (NAATI) on 16 October 2020.

M Latha Principal Scientist & Officer in charge participated in a panel discussion in a Enwenar Series – 10 under Genome Saviours – 9 entitled " Diversity in Pulses – For Food and Nutritional Security" – awebinar organised by Nature Agro-Biodiversity Action and Technology Transfer Initative (NAATI) on 27 November 2020.

R Parimalan Delivered an award lecture during National Youth Science Congress 2020, at PCAS, Pudukkottai, entitled 'Grain C4 photosynthesis in C3 crop plants – will it help scaling-up productivity?' on 28th February 2020, for the 'Dr APJ Abdul Kalam best scientist award-2020', organized by Bose Science Society, Pudukkottai.

Rakesh Singh (2020) Application of DNA markers in Germplasm characterization. In:NAHEP-CAAST Training for M. Sc. & Ph.D. Students on "Pre-breeding and Molecular breeding Approach: Two important pillars for the vegetable and crop improvement" from 11th February 2020 to 24th February 2020 at ICAR-National Institute for Plant Biotechnology, New Delhi.

Rakesh Singh (2020) Molecular mapping for horticultural traits in fruit crops. In: Winter School Course on "Non-conventional Approaches for Genetic Improvement of Perennial Horticultural Crops" from 17th January to 6th February, 2020 at Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi.

Sherry Rachel Jacob (2020) Predicting the quality of stored seeds. Lecture delivered in the Training programme on "Quality Seed Production", organized by National Seed Corporation during 2-5 March, 2020.

Vartika Srivastava delivered lecture on "Palms crypreservation" in five days vocational training programme on "Problems and Prospects in Palms Tissue Culture & Cryopreservation" under NHEP, March 2-6, 2020 organised by JAU, Junagarh.

Veena Gupta delivered lecture in training programme on "Management of Trait specific Germplasm at National Genebank, ICAR-NBPGR" on 30-07-2020 in Training Programme " Training of Trainers on Good Agriculture and Collection Practices (GACP) for Medicinal Plants, 29 July to 1 August, 2020 (Online) organised by ICAR-DMAPR, Anand and sponsored by NMPB, New Delhi.

Veena Gupta delivered lecture in Research in Plant Sciences Webinar: 6 on "Biodiversity Conservation—Why and How...??? to students of botany, pharmacy and agriculture organised by Department of Botany, K J Somaiya College of Science and Commerce, Somaiya, Vidhyavihar, Ghatkoppar, Mumbai on 28-05-2020.

Veena Gupta delivered Webinar on "Registration of Germplasm at ICAR-NBPGR - Procedures and Guidelines" organised by Dr YSR Horticultural University, Andhra Pradesh on 31-07-2020.

Veena Gupta delivered Webinar on "Nutritive Germplasm of Vegetable Crops" organised by the Brahma Singh Horticulture Foundation , New Delhi , on 24-10-2020.

Veena Gupta delivered a Webinar on "Challenges and oppurtunities of vegetable production in warm humid tropics", organised by Department of Vegetable Science, College of Horticulture, Kerala Agricultural University, and Indian Society of Vegetable Science on 13-11-2020.

Yasin JK Delivered "Young science leader" series lecture – 2020 in "Young science leader" series lectures organised by Indian Science associations

Yasin JK Delivered a lecture on "SMART Agriculture for Nutritional Security" in an online International conference on "Climate smart agriculture for sustainable food and nutritional security" July 2020

Yasin JK Delivered a lecture on "Generation of Genomic Resources and Usage of Bioinformatic tools" in a Conference webinar series, organized by VOC college, TNAU, India during June 2020

Yasin JK Delivered a lecture on "Applications of bioinformatics in Agricultural research" in a Conference: webinar series, conducted by JSA college of agriculture, TNAU, India during June 2020.

Yasin JK Delivered a lecture on "Recent trends in Bioinformatics for plant science scholars" in a Conference Webinar series conducted by Alagappa University, India during May 2020.

Best paper/poster/oral presentations

BH Gawade received Best Oral Presentation Award for paper entitled "Detection and identification of plant parasitic nematodes during international exchange of vegetative propagules and rooted germplasm" during 7th International Conference on 'Phytopathology in achieving sustainable development goals' organized at ICAR-IARI on Jan. 16-20, 2020.

Jameel Akhtar was conferred Best Oral Presentation Award for the paper entitled 'Conventional techniques of seed health testing: pivotal in disease-free import and safe conservation of plant genetic resources in National Genebank, India by Indian Phytopathological Society, New Delhi during Technical Session 17 on International Trade and biosecurity of *7th International Conference on Phytopathology in achieving sustainable development goals*' organized at ICAR-IARI during Jan. 16-20, 2020.

Pooja Kumari received best oral presentation award on "Characterization of aflatoxigenic

Aspergillus flavus associated with aflatoxin B1 (AFB1) production of maize kernel in India" by Pooja Kumari, Robin Gogoi and Meena Shekhar presented during 7thInternational conference on"Phytopathology in Achieving UN Sustainable Development Goals"organised byIndian Phytopathological Society on January 16-20, 2020, ICAR-IARI, New Delhi, India.

Pooja Kumari received Oral Presentation Award on paper "Screening for okra yellow vein mosaic disease resistance in wild okra (*Abelmoschus moschatus* ssp. *moschatus*) germplasm in India" by Pooja Kumari, SP Singh, KK Gangopadhyay, VC Chalam and SC Dubey during International Web Conference prespective on Agricultural and Applied Sciences in COVID-19 Scenario organised by Agricultural & Environmental Technology Development Society (AETDS) U.S. Nagar, Uttarakhand, India on October 4-6, 2020.

Raj Kiran wasconferred Best Oral Presentation Award for paper entitled 'Status of seed-borne fungi in some indigenous millet germplasm in India' by Agricultural & Environmental Technology Development Society, U.S. Nagar, UK, India during Online International Conference 'PAAS-2020' organized online during Oct 4-6, 2020.

Yasin JK received Best Poster Award (2020) by College of Horticulture, University of Horticultural Sciences, Bagalkot, India

20.9 Publications

20.9.1 Research Papers

Akhtar J, B Singh, R Kiran, P Kumar, M Shekhar, Sadhana S, Pandey, S Lenka and SC Dubey (2020) Studies on infection indexing and distribution profiling of seed-borne fungi of sorghum germplasm in India for safe and healthy long-term conservation. *Indian Journal of Plant Genetic Resources* 23(3): 337-349.

An Underutilized Ancient Legume of India. Accepted for publication in Indian Journal of Traditional Knowledge (IJTK).

Anjula P, Subarna H., Padmavati G Gore, S Nivedhitha, Rita Gupta and GD Harish (2020). Note on True Seed and Tuber Characteristics of Soh-phlang (*Flemingia procumbens* Roxb.). Indian J. Plant Genet. Resour. 33(2): 235–239.

Annapurna K, K Pengani, JK Yasin, S Paul, S Tyagi, G Venkadasamy, M Sharma, and S Lakshmi Karivaradha Rajan (2020). Genome assembly of Azotobacter chroococcum strain W5, a free living diazotroph from India. Microbiology Resource Announcements. 9 (20): e00259-20

Boopathi T, Singh SB, Dutta SK, Dayal V, Singh AR, Chowdhury S, Ramakrishna Y, Aravintharaj R, Shakuntala I. and Lalhruaipuii K 2020. *Harmonia sedecimnotata* (F.): Predatory potential, biology, life table, molecular characterization, and field evaluation against *Aphis gossypii* Glover. *Scientific Reports*, 10:3079. https://doi.org/10.1038/s41598-020-59809-3.

Brahmi P, Tyagi V and Pragya. 2020. Introduction of Heeng germplasm by NBPGR leads to its successful cultivation in India. Indian Journal of Plant Genetic Resources 33(3): 381-383.

Chaurasia S, Singh AK, Songachan LS, Sharma AD, Bhardwaj R and Singh K (2020) Multi-locus genome-wide association studies reveal novel genomic regions associated with vegetative stage salt tolerance in bread wheat (*Triticum aestivum* L.). Genomics, 112: 4608-4621

Elangovan M, A Annapurna, R Patil, S Pandey, CD Pandey (2020) Characterization of Sorghum [*Sorghum bicolor* (L.) Moench] Germplasm for Agro-Morphological Traits. Indian Journal of Plant Genetic Resources 33 (2), 172-178

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Gawade BH, A Sirohi, Z Khan and SC Dubey (2020). Plant Resistance to Nematodes as Induced by DL-â-Amino Butyric Acid: A Review. *Journal of Plant Health Issues*, 1(3), 098-101.

Gupta, S and Pradheep, K (2020). Diversity, conservation and use of underutilized and minor fruits in India: an overview. Acta Horticulturae 1297: 51-60.

Gupta V (2020). Conserving trait specific germplasm of medicinal plants–catering to needs of pharmaceutical industries. Journal of Plant Development Sciences Vol. 12(7): 443-448. 2020.

Hajong S and R Kapoor (2020). An amalgam of pathogenic and beneficial endophytic fungi colonizing four *Dendrobium* species from Meghalaya, *India. J Basic Microbiol.* 60: 415–423.

Hajong S, GD Harish, DL Biate and J Uchoi (2021). Ka Community Seed Bank: Ka rukom ban ri kyndong ha kaba khambitdor ia ki spah symbai ba bunjait bad bun rukom jong ka jaitbynriew", ICAR-NBPGR RS Shillong, February 2021 (translated to Khasi by Jessica Dohtdong).

Hajong S, KS Devi, RL Darnei, DL Biate, A Pandey, GD Harish and J Uchoi (2021). Diversity analysis of Sohphlang (*Flemingia procumbens* Roxb.) accessions of Meghalaya, India, using agro-morphological and molecular markers. *In*: Sovenir & Abstracts, *International Virtual Conference on* "Advances in Agricultural & Food sciences to Face the challenges to Environment and Biosecurity" held at Sharda University, Greater Noida, Uttar Pradesh during 16 to 20 January, 2021, p. 184.

Henry, RJ, Furtado, A and Parimalan, R. 2020. Pathways of photosynthesis in non-leaf tissues. Biol., 9: 438.

Jacob, S, Mishra, A, Kumari M, Bhatt K, Gupta, V and K Singh. (2020). A Quick Viability Test Protocol for Hemp (*Cannabis Sativa* L.) Seeds. Journal of Natural Fibers. 1-6. 10.1080/15440478.2020.1764451.

Joghee N, C Manjunatha, J Radhamani, AK Thakur, R Yadav, A Kumar, ML Meena, RK Tyagi, DK Yadava and D Singh (2020). Identification of New Source of Resistance to Powdery Mildew of Indian Mustard and Studying Its Inheritance. The Plant Pathology Journal 36 (2) 111

John JK, Krishnaraj MV, Pradheep K, Patil P, Harish GD and KV Bhat (2020). A new variety of *Abelmoschus pungens* (Malvaceae) from Indo-Burma Biodiversity Hotspot. Journal of the Indian Association for Angiosperm Taxonomy (RHEEDEA).

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Joseph John K, Pradheep K, Jaisankar I, VA Muhammed Nissar and BA Jerard (2020). Logistics planning for planr genetic resources collecting from Nicobar Islands of India. Indian J. Plant Genet. Resour. 33 (2): 132-145.

Joseph John K, MV Krishnaraj, K Pradheep, P Patil, GD Harish and KV Bhat (2020). A new variety of Abelmoschuspungens (Malvaceae) from Indo-Burma Biodiversity Hotspot. Rheedea 30(2): 270–277.

Kak A and V Gupta (2020) Plant Germplasm Registration Notice. *Indian J. Plant Genet. Resour.* **32** (2): 240-272.

Koulagi R, S Banerjee, BH Gawade, AK Singh, PK Jain, Shelly Praveen, K Subramaniam and A Sirohi (2020). Host-delivered RNA interference in tomato for mediating resistance against *Meloidogyne incognita* and Tomato leaf curl virus. *Plant Cell, Tissue and Organ Culture* **143,** 345–361. https://doi.org/10.1007/s11240-020-01921-3.

Krishnan Veda, D Mondal, H Bollinedi, S Srivastava, SV Ramesh, M Latha, B Thomas, A Singh, AK Singh and S Praveen (2020). Cooking fat types alter the inherent glycaemic

response of niche rice varieties through resistant starch (RS) formation. International Journal of Biological Macromolecules. 162: 1668-1681

Kumar C, R Kumar, SK Singh, AK Goswami, A Nagaraja, R Paliwal and R Singh (2020). Development of novel g-SSR markers in guava (*Psidium guajava* L.) cv. Allahabad Safeda and their application in genetic diversity, population structure and cross species transferability studies. PLoS ONE 15(8): e0237538.

Kumar P, SC Dubey, J Akhtar, R Kiran, K Nair and H Bhati (2020) Genetic characterization and population structure analysis of *Colletotrichum capsici* isolates causing fruit rot of chilli using molecular markers. *Indian Journal of Plant Protection* 48(1&2): 64-73.

Kumar R, C Kuma, R Paliwal, DR Choudhury, I Singh, A Kumar, A Kumari and R Singh (2020). Development of Novel Genomic Simple Sequence Repeat (g-SSR) Markers and Their Validation for Genetic Diversity Analyses in Kalmegh [Andrographis Paniculata (Burm. F.) Nees]. Plants 9(12):1734.

Kumar S, J Kumari, N Bhusal, AK Pradhan, N Budhlakoti, DC Mishra, D Chauhan, S Kumar, AK Singh, M Reynolds, Singh GP, Singh K and Sareen S (2020). Genome-wide association study reveals genomic regions associated with ten agronomical traits in wheat under late-sown conditions. Front. Plant Sci.10.3389/fpls.2020.549743

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Kuwardadra SI, CD Pandey, A Paliwal and GJ Randhawa (2020). Screening brinjal (*Solanum melongena* L.) accessions conserved in the National Genebank collected from states adjoining Bangladesh for adventitious presence of EE1 event. Indian J. Agric. Sci.90 (8):1603-1610.

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Laskar Rafiul Amin, Nilofer Sheikh, Subarna Hajong & Taj Uddin Khan (2020). Optimization of EMS and DES treatments for induction of mutation in quantitative traits of maize. *Plant Cell Biotechnology and Molecular Biology*. 21 (43&44):134–143.

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Malav PK, A Pandey, V Gupta, A Kumar, KC Bhatt, Archana P Raina, J Akhtar, AB Gaikwad, OS Ahlawat and RK Dhakad (2020). The diversity in holy basil (*Ocimum tenuiflorum* L.) germplasm from India. *Indian Journal of Agricultural Sciences* 90: 1937-1945

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(2020). Comparative Transcriptome Analysis of Iron and Zinc Deficiency in Maize (*Zea mays* L.). Plants, 9(12), p.1812.

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Meena VS, B Pratap, KC Bhatt, K Pradeep, NL Meena, A Kumar and K Singh (2020). Physico-Chemical Studies on Maroon Coloured Karonda (Carissa carandus) Collected from Uttar Pradesh, India. International Journal of Economic Plants. 7(1):034-037.

Misra RC, DR Pani and SP Ahlawat (2020). *Hibiscus panduriformis* Burm.f. (Malvaceae): A new distributional record from Odisha. *e - planet* 18 (2):142-144.

Misra RC, AP Raina, DR Pani, G Das, AK Mukherjee and SP Ahlawat (2020). Genetic diversity, extent of variability and indigenous traditional knowledge of *Mucuna* Adans. (Fabaceae) in Odisha, Eastern India.(Accepted for publication in *Genetic Resources and Crop Evolution*).

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20.9.9 Plant Germplasm Reporter/Brochure

20.9.10 Registration Notices

20.9.11 Participation in Radio/ TV programmes

Vijay Singh Meena attended live phone on DD Kisan on *Naye baggon ki dekhbhal* on 08.09.2020.

Suma A delivered a Radio Talk on 22 Oct on "Imporance of PGR Conservation and role played by ICAR-NBPGR" during the Programme - *Vayalum Veedum*(Farm & Home)aired by All India Radio, Thiruvananthapuram.

MC Singh participated as an expert in Hello Kisan- a live TV programme on DD-Kisan channel, 03 times during 2020.

MC Singh participated as an expert in Kisan Ki Baatprogramme on All India Radio, 02 times during 2020.

20.10 Organization of Germplasm Field Days

Field day on Horse gram diversity at RS Thrissur (SDG1.4; Aichi 2,6,7)

A Germplasm Field Day was organised on 09th January 2020 under the DBT project on Characterization and Evaluation of Genetic Resources of Minor Pulses for Crop Improvement. About 25 participants comprising scientists and students from Kerala Agricultural University, University of Agricultural Science, Bangalore and ICAR-Indian Institute of Pulses Research Regional Centre, Dharwad participated in the event. A total of 2300 accessions from the genebank were grown and displayed in the field. Earlier the QRT team comprising Dr. M.P. Pandey, Chairman QRT, along with the members also visited the horsegram field and admired the uniqueness of the germplasm in terms of more number of pods and its erect habit suitable for machine harvesting.

20.11 PGR awareness, MGMG and TSP

PGR conservation awareness programmes conducted under TSP scheme at NBPGR, PS Thrissur

During the 2020, twelve PGR conservation awareness programmes and biodiversity fairs were conducted in 12 villages of 11 states under the Tribal Sub-Plan (TSP) scheme. These programmes were conducted in in biodiversity rich remote tribal areas having limited resources with farmers. In these areas, farmers are cultivating mostly traditional landraces. However, these genetic resources are eroding rapidly due to the replacement by the high yielding improved varieties and reach of seed business companies. Through these programmes, efforts are made to create awareness to conserve local biodiversity. A total of 1,442 farmers were benefitted by these programmes. Inputs of small tools like spade, khurpi, sickle, secateur, shovel, grafting knifes, water cans, sprayers, weeding hoe, tine racks, plastic crates, weeders, biopesticides, seeds of local landraces (Yard-long bean, ash gourd, bitter gourd, cucumber, brinjal and amaranth), vegetable mini kits and saplings of different crops (mango, litchi, guava, custard apple) were distributed to the beneficiaries.

NBPGR Base Centre-Cuttack organised a PGR visit programme to Sambhav-Sabarmati N.G.O., Rohibanka, Nayagarh, Odisha with their on-going activities and facilities related to the sustainable agriculture, organic/ traditional farming, biodiversity management and on-farm conservation of plant genetic resources on 17th Nov 2020.

NBPGR Base Centre-Cuttack organized the facilities to watch the national event "Interaction with farmers and release of PM-Kisan Samman Nidhi telecasted on 25.12.2020 at 12 PM" inside the office campus and about 20 persons comprising scientists, staff and farmers participated for viewing the telecasted programme.

Table 20.1. Details of PGR awareness programmes conducted at various centres

Sl. no	State	District	Block	Village	Farmer/ beneficiaries	Programme date
1	A & N	Nicobar	Nancowri group island	Kamorta & Munak Island	81	29th Jan. 2020
2	Assam	Dhemaji	Silapathar	Simen Chapori	85	19th Dec. 2020
3	Arunachal Pradesh	Anjaw	Hayuliang	Hayuliang	100	20th Mar. 2020
4	Himachal Pradesh	Kinnaur	Ricongpeo	Chitkul	125	29th Octo. 2020
5	Jammu & Kashmir	Budgam	Charar-e-sharief	Nagbal	200	26th Sep. 2020
6	Jharkhand	Khunti	Rania	Rania	151	22nd Feb. 2020
7	Meghalaya	Rebhoi	Mowhati	Umpowin	100	28th Jan. 2020
8	Rajasthan	Alwar	Rajgarh	Digawad	111	15th Octo. 2020
9		Udaipur	Jhadol	Biroti	154	29th Octo. 2020
10	Telangana	Bhadradri Kothagudem	Pinapaka	Battupalli	120	28th Feb. 2020
11	Tamilnadu	Erode	Talavedi	Ittarai	65	02nd Dec. 2020
12	Uttarakhand	Dehradun	Chakarata	Maindrath	150	17th Mar. 2020
	TOTAL				**1442**	

NBPGR Base Centre-Cuttack apprised a group of farmers of Itipur village of Khurda district, Odisha under MGMG programme to watch the event on 25.12.2020 at 12 PM. Advisory services were provided to the farmers of Itipur and Jaypur Patana, Khurda district, Odisha for rice transplantation, plant protection measures, diseases/ pest &weed management, optimum use of straw including preparation of bio-compost. Regular use of mask, hand wash and maintaining social distance were advised. Awareness on "Swachhata activities" was created among the school teachers and children of Jaipur Patana U.P school, of cluster 18 of Khurda district, Odisha. Distributed two promising rice varieties (3kg each of CR Dhan-502 and CR Dhan-504) developed by ICAR-NRRI, Cuttack to the farmers of Radhakrishnapur village. Advisory on selection and availability of seeds of promising rice varieties developed at ICAR-NRRI was given to 3 farmers of Radhakrishnapur cluster villages of Cuttack, Odisha. Advisory services on cultivation and plant protection measures of supplied two rice varieties was provided and feed back about the performance was received.

Organization of PGR awareness programme under SCSP Plan at RS-Jodhpur

Organization of PGR awareness programme under SCSP Plan at RS Jodhpur: 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 Uttamber village of Baleshar tehsil in Jodhpur District, Rajasthan on 07-03-2020. The main purpose of the 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.

Visit of students and farmers for PGR awareness: A group of 70 school children visited research field of station on 10.01.2020 and observed variability in wheat germplasm accessions. Similarly a group of 30 farmers undergoing training at ICAR-CAZRI visited our station for getting awareness about importance of plant genetic resources in farmer's perspective (Fig. 20.1).

Organization of PGR awareness programme at RS Shillong: NBPGR Regional Station Shillong, Umiam in collaboration KVK, Ri-Bhoi organized Biodiversity Fair cum Plant Genetic Resources Awareness Camp at Umpowin village of Ri-Bhoi District on 28th January 2020. The programme was attended by 100 farmers of Khasi tribal community. Farmers kits containing farm tools were distributed to the participants (Fig. 20.2).

NBPGR Regional Station Shillong: Umiam in collaboration KVK, Anjaw, Arunachal Pradesh organized "Biodiversity Fair cum Plant Genetic Resources Awareness Camp" at Hayuliang village of Anjaw District on 20 March 2020. The programme was attended by 130 farmers of Mizu and Digaru Mishmi tribal community. The DGP, Arunachal Pradesh Mr. R.P Upadhyaya also participated in the programme. Farmers kits containing farm tools were distributed to the participants (Fig. 20.3).

Fig. 20.1. A visit of students and farmers at research farm, Jodhpur

Fig. 20.2. PGR awareness programme conducted at Umpowin (Ri-Bhoi), Meghalaya


Fig. 20.3. PGR awareness programme conducted at Hayuliang (Anjaw), Arunachal Pradesh

PGR Awareness Program under TSP at RS Shimla: One day PGR awareness camp on promotion and conservation of traditional crops was organized on 29th October 2020 at village Chitkul (Last village of India) in Kinnaur District of Himachal Pradesh in collaboration with YSPUHF Krishi Vigyan Kendra (KVK) Sharbo Kinnaur (Fig. 20.4). A total of 125 tribal farmers attended this awareness camp. The prime objective of this programme was to bring awareness among tribal farming community on the benefits of plant genetic resources including crop landraces which are being maintained by them. A farmer kit containing secateur and literature was also distributed to the participants.

Fig. 20.4. PGR Awareness camp at Chitlkul, Kinnaur under TSP

PGR Awareness Program under SCSP at RS Shimla: Two farmer's awareness camps on "Role of fruit diversification & pseudocereals in nutritional security" under SCSP scheme was organized by ICAR-NBPGR, Shimla in collaboration with ICAR-IARI, Shimla & KVK, Kandaghat on 05.202020 & 07.02.2020 at Ananadpur Panchayat, Block Mashobra, (Shimla) and Satrol Panchayat, Block Kandagat, (Solan) (Fig. 20.5). On 27.08.2020 plantation and cleanliness drive was carried out at the North-West boundary of the station which was barren earlier due to its topography and steep slope. Around 70 plants (trees and shrubs) of 15 different species were planted.

Fig. 20.5. Farmer awareness camp under SCSP programme at RS, Shimla

TSP programme at Nicobar Islands 2020 by RS, Thrissur (SDC1.4; Aichi 2,6,7): A programme under Tribal Sub-Plan (TSP) of ICAR at four villages in Nancowrie namely BadaEnakka, Vikas Nagar, Kakana and Munak of Nicobar district was conducted. The islands are very remote, accessible only by ship or helicopter from Port Blair. The programme comprised distribution of agricultural implements like spade, hand fork and khurpi, and assorted seed packets of selected land races of ten vegetables like brinjal, okra, chilli, yard-long bean, bush cowpea, ashgourd, pumpkin, cucumber, oriental pickling melon, Chinese spinach, besides

seed tubers of five landraces of greater yam (Nicobarialoo) to 69 beneficiaries.

TSP programme at Tamil Nadu 2020 by RS, Thrissur (SDC1.4; Aichi 2,6,7): Under the Tribal sub-project, an awareness programme cum distribution of small implements and planting material was held in tribal hamlets of Erode district on 02-12-2020 with the aim of "Enhancing livelihood options and nutritional security of Ittarai and Bejalatti villages". A total of 65 tribal farmers including women belonging to *Irulas* and *Shoagas* communities attended the programme. Sixty five tribal farmers were distributed the inputs like Plastic crates – 3 Nos; weeder – 2Nos; Biopesticides like Psuedomonas and Trichoderma – 1Kg each; Micronutrient mix (*Sampoorna*)- 250g; assorted seed packets comprising landraces of yard long bean, ashgourd, bittergourd, salad cucumber, brinjal, amaranth - 100g.

SCSP programme At Kottanellur village, Thrissur (SDC1.4; Aichi 2,6,7): As part of the SCSP programme, fifteen SC farmer beneficiaries were given an input kit containing assorted seeds of various vegetables, taro, greater yam and drumstick along with manures and fertilizers. Thirty five beneficiaries were delivered the inputs at their doorsteps An exhibition of landrace diversity in Greater Yam, taro, lesser yam, Elephant foot yam ,Ginger and Turmeric maintained by MrVinod, Tuber crops custodian farmer,was held at his homestead farmwhich was appreciated by the QRT members.

Fine grid survey and collection of polyembryonic mangoes by RS, Thrissur: A fine grid survey of variability in local mangoes, mostly polyembryonic forms was undertaken in Kannapuram village of Kannur district, Kerala; a heritage site for mangoes declared by Kerala state biodiversity board. A total of 68 collections were made as scions and established as epicotyle grafts in the nursery.

Extension and Awareness Programmes at RS, Thrissur: Dr. Suma A., scientist delivered an invited talk on "Agro-biodiversity of Kerala- Past, Present and Future perspectives" in connection with the National Science Day Celebrations-NSD-2020 on 20 Feb 2020 at NSS College, Ottappalam. Dr. M. Latha Principal scientist & OIC delivered two online lectures to UG students of TNAU, Coimbatore one on ICAR-NBPGR activities and other on Genetic Resources of *Vigna* species. A webinar involving all the germplasm conservator farmers on the topic "Agro-biodiversity conservation in homesteads – Issues and solutions" was conducted on June 5, 2020. Ten custodian farmers participated and expressed their concerns and shared their views. Dr Suma. A, Scientist of the station delivered a talk on 'Vegetable landraces of Kerala' in a webinar organised by St Sebastian's School Alumni 1997 Batch.

20.12 Exhibitions/fairs organized/ participated

NBPGR Base Centre-Cuttack organised one Exhibition stall and displayed the activities of the centre with genetic diversity of *Ocimum, Mucuna, Abelmoschus, Cucumis, Hibiscus sabdariffa* and M&AP and rice varieties of Odisha in the National workshop on "Rice research and development for doubling farmers' income" at ICAR-N.R.R.I., Cuttack on 28th Feb 2020.

NBPGR Base Centre-Cuttack participated in the National workshop on "Rice research and development for doubling farmers' income" organized by ICAR-NRRI and Directorate of Rice Development, Govt. of India, Patna on 28th Feb 2020.

A group of 25 farmers from Maharashtra visited the centre and was imparted training-cum-demonstration on "plant genetic resources activities and management" on 21st Jan. 2020. 25 published brochures were distributed among the farmers of Maharashtra during their visit.

20.13 Students visiting NBPGR for exposure

A total of 132 students from College of agriculture in Mulade, Maharashtra visited the NBPGR Shimla, station on dated 20.01.2020.

A total of 87 UG and PG students from three colleges namely NEHU, Shillong, St. Joseph college, Irinjalakuda, Thrissur and St. Thomas College Thrissur visited the Thrissur station and they were enlightened with INPGR system and PGR activities of the station. Twenty PG students of Botany Department, St. Joseph College, Kozhikode visited the station and were explained about PGR activities.

20.14 Distinguished Visitors

ICAR-National Bureau of Plants Genetic Resources, Quinquennial Review Team (QRT) comprising Dr. M. P. Pandey, Chairman QRT, Ex-VC, BAU Ranchi & IGKVV, Raipur and Former Director CRRI, Cuttack, Dr. Bhagmal, Member QRT, Senior Consultant TAAS, Ex-Director, IGFRI, Jhansi along with Dr. S. K. Kaushik, Principal Scientist, ICAR-NBPGR New Delhi and Dr. Veena Gupta Head, Division of Germplasm Conservation, ICAR-NBPGR, New Delhi visited ICAR-NBPGR Regional Station Jodhpur on 30.01.2020 (Fig. 11). QRT chairman and members appreciated the work being done by NBPGR Jodhpur team and further suggested improvement in the station activities.

Dr. Kuldeep Singh, Director and Dr. SP Ahlawat Head, Germplasm Exploration Division, ICAR-NBPGR, New Delhi visited NBPGR Shimla on 08.09.2020 during their visit to Lahual valley.

QRT team comprising Dr. M P. Pandey, Chairman, Dr.Bhagmal, Dr. P.S. Naik, Dr. V.S. Gupta, Dr.Kuldeep Singh, Director, ICAR-NBPGR visited RS, Thrissur on 08 January 2020. Technical guidance and seedlings of Andaman bullet wood (*Manilkara litoralis*) was supplied to Social Forestry Department, Thrissur Division, Kerala Forest Department as part ofestablishment of coastal bioshield plantation.

20.15 Vigilance awareness week, Parthenium Day, Indian Constitution Day, International Women's Day celebrations and Swachhata Pakhwada

NBPGR Base Centre-Cuttack organized "Swachhata Pakhwada" inside the campus during 16th to 21st December 2020. January 26 and August 15, 2020, Republic Day and Independence Day celebrated with full of gaiety and fervor at ICAR-NBPGR Headquarters and all regional stations. Around 200-400 local people mostly school students participated in the functions at RS Shillong.

RS, Thrissur organized Hindi Saptah Celebration online via zoom platform on 16/09/2020, with Dr. H. Vikram, Dept. of Pomology, KAU as the Chief Guest who gave a talk on "Agricultural Education in India" in Hindi. The station also celebrated Constitution Day on 26-11-2020 with the active participation of all the staff of the station.

Meteorological data (temperature in degrees Celsius and rainfall in mm) for the year 2020

Station	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Akola	Max temp	27.1	20.7	34.6	40.4	42.9	35.3	32.7	29.6	32.8	33.2	31.9	30.1
	Min temp	13.6	15.0	19.6	24.9	28.0	24.6	23.7	22.6	22.0	19.6	12.5	12.6
	Rainfall	0	0	19.3	4.1	4.1	165.2	264.9	212.8	90.7	32.0	5.5	0.5
Bhowali	Max temp	13.64	14.08	17.78	25.13	29.08	28	25.38	24.6	24.95	24	19.5	15.33
	Min temp	0.68	3.47	6.3	12.08	14.24	16.82	18.38	18.43	18.13	9	8.29	1.62
	Rainfall	75.9	168.9	52.5	50.5	15	145.6	366.8	277.8	158.2	3.5	55.1	102
Cuttack	Max temp	26.7	28.5	32.2	35.0	34.1	33.4	33.6	32.0	32.9	31.1	30.2	28.7
	Min temp	17.8	20.0	24.7	26.6	27.7	27.8	27.9	27.0	26.3	25.2	20.6	16.5
	Rainfall	19.0	42.0	96.0	222.4	228.8	156.4	100.7	449.7	93.2	142.0	0.0	0.0
Hyderabad	Max temp	28.7	32.2	36.7	39.0	41.2	36.8	31.8	29.9	29.7	30.0	29.9	27.8
	Min temp	8.3	14.4	16.8	18.3	21.3	20.0	18.3	17.4	16.7	16.6	17.7	15.8
	Rainfall	25.2	2.0	0.0	43.2	9.0	85.0	60.6	190.8	318.8	129.0	0.0	8.8
Jodhpur	Max temp	24.7	26.1	31.9	40.6	40.6	41.6	37.6	33.6	34.7	34.4	32.5	24.4
	Min temp	10.4	12.3	18	25	27.4	30.5	28.4	26.2	26.4	21	15.8	11.5
	Rainfall	0.9	0	0	2	21.4	54.4	183.1	277.5	70.7	9	1.4	0.3
Ranchi	Max temp	17.22	23.39	32.16	35.39	37.02	36.08	33.84	28.98	28.89	29.78	25.83	18.39
	Min temp	11.07	9.04	13.97	20.17	23.01	25.06	24.69	23.22	23	22.83	16.3	9.15
	Rainfall	0	21	18	22	22	187	199	424	213	167	0	9
Shillong	Max temp	18.8	20.8	24.6	26.2	26.1	27.0	26.7	28.6	27.1	26.9	24.7	21.2
	Min temp	6.5	7.9	11.3	14.3	17.0	20.4	20.9	21.1	20.0	18.1	10.9	8.3
	Rainfall	14.5	54.0	75.4	223.5	578.5	463.5	627.7	197.6	695.2	484.6	79.0	25.4
Shimla	Max temp	11.74	13.34	16.66	23.84	25.62	27.97	23.96	23.65	23.78	21.48	18.4	14.28
	Min temp	2.71	3.63	6.43	12.72	14.26	16.81	16.82	16.6	15.39	11.38	8.36	3.85
	Rainfall	3.37	5.49	2.46	2.08	2.3	3.31	11.53	16.29	3.56	1.23	1.16	0.77
Srinagar	Max temp	7	8.6	14	20.7	25.3	29.8	31	29.8	27.7	23.2	15	8.6
	Min temp	-2.5	0	3.7	8.4	11.6	15	18.3	17.5	12.3	6.4	1.9	-2
	Rainfall	54	69	122	86	68	45	62	68	32	27	39	55
Thrissur	Max temp	34.1	35.5	36.4	36.4	35.0	31.1	30.5	30.2	30.0	31.0	33.0	32.0
	Min temp	22.4	23.2	24.4	24.7	25.2	23.7	23.2	23.1	22.4	21.5	22.0	21.9
	Rainfall	0	0	33.4	44.7	59.6	427.2	563	607.7	587.6	310.3	56.1	7.7
New Delhi	Max temp	21.95	21.5	27.7	36	39.25	39.75	37.3	32.6	33.5	31.25	26.05	16.6
	Min temp	7.5	10.6	12.9	21	25.35	26.85	26.65	26.4	25.2	18.35	13.6	6.75
	Rainfall	52	72.2	10	5.7	45.4	31.2	283.9	227	17.6	41	7.4	66

भाकृअनुप
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