2018-19

वार्षिक प्रतिवेदन
Annual Report

भाकृअनुप
ICAR

NBPGR

भाकृअनुप–रा.पा.आ.स. ब्यूरो
पूसा कैम्पस, नई दिल्ली - 110012

ICAR - NBPGR
Pusa Campus, New Delhi - 110012

ISSN 0971-2577

वार्षिक प्रतिवेदन

ANNUAL REPORT

2018-2019

भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो
ICAR-National Bureau of Plant Genetic Resources
(भारतीय कृषि अनुसंधान परिषद्)
(Indian Council of Agricultural Research)
पूसा परिसर, नई दिल्ली–110 012
Pusa Campus, New Delhi-110 012

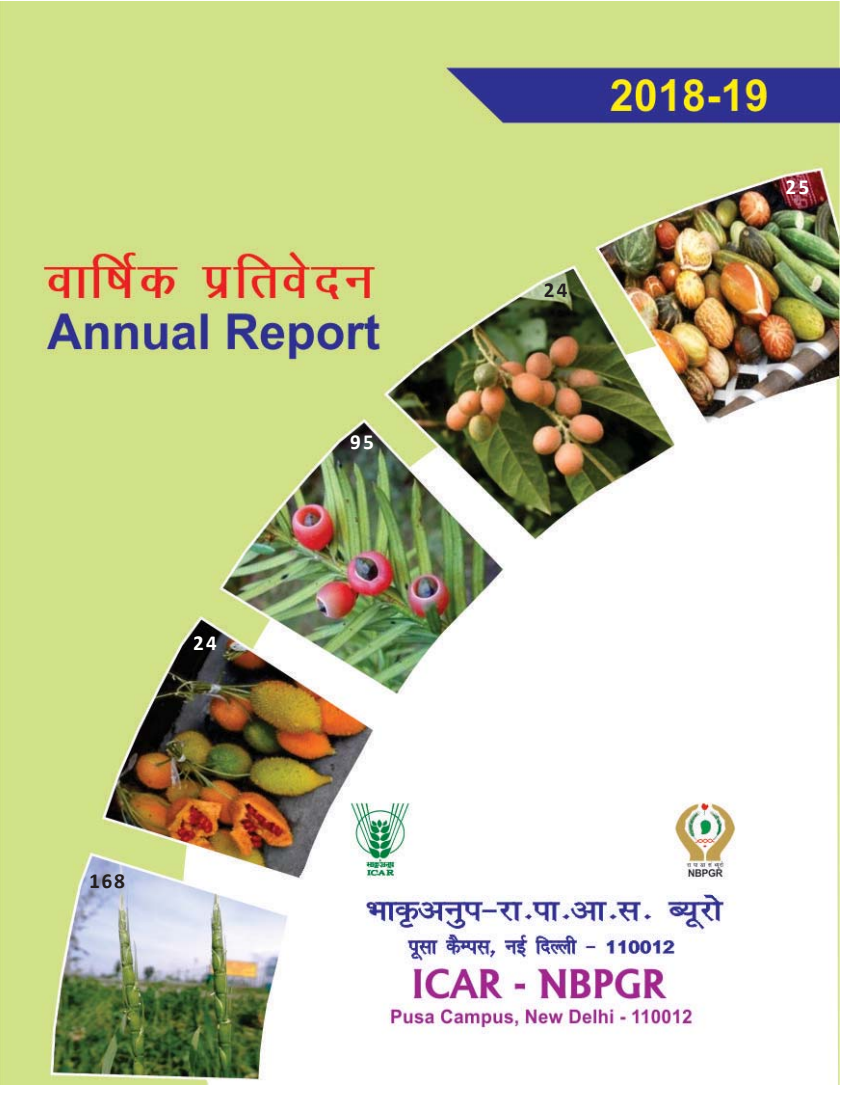
ICAR-NBPGR Annual Report 2018-19

Published by
Dr Kuldeep Singh, Director

Supervision
Pratibha Bramhi

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

Photos on Cover Page
1. Pg 168: *Aegilops tauschii* ssp. *tauschii*
2. Pg 24: *Momordica subangulata* var. *renigera*
3. Pg 95: *Taxus baccata*
4. Pg 24: *Stixis sauveolens*
5. Pg 25: melons from Alwar, Rajasthan



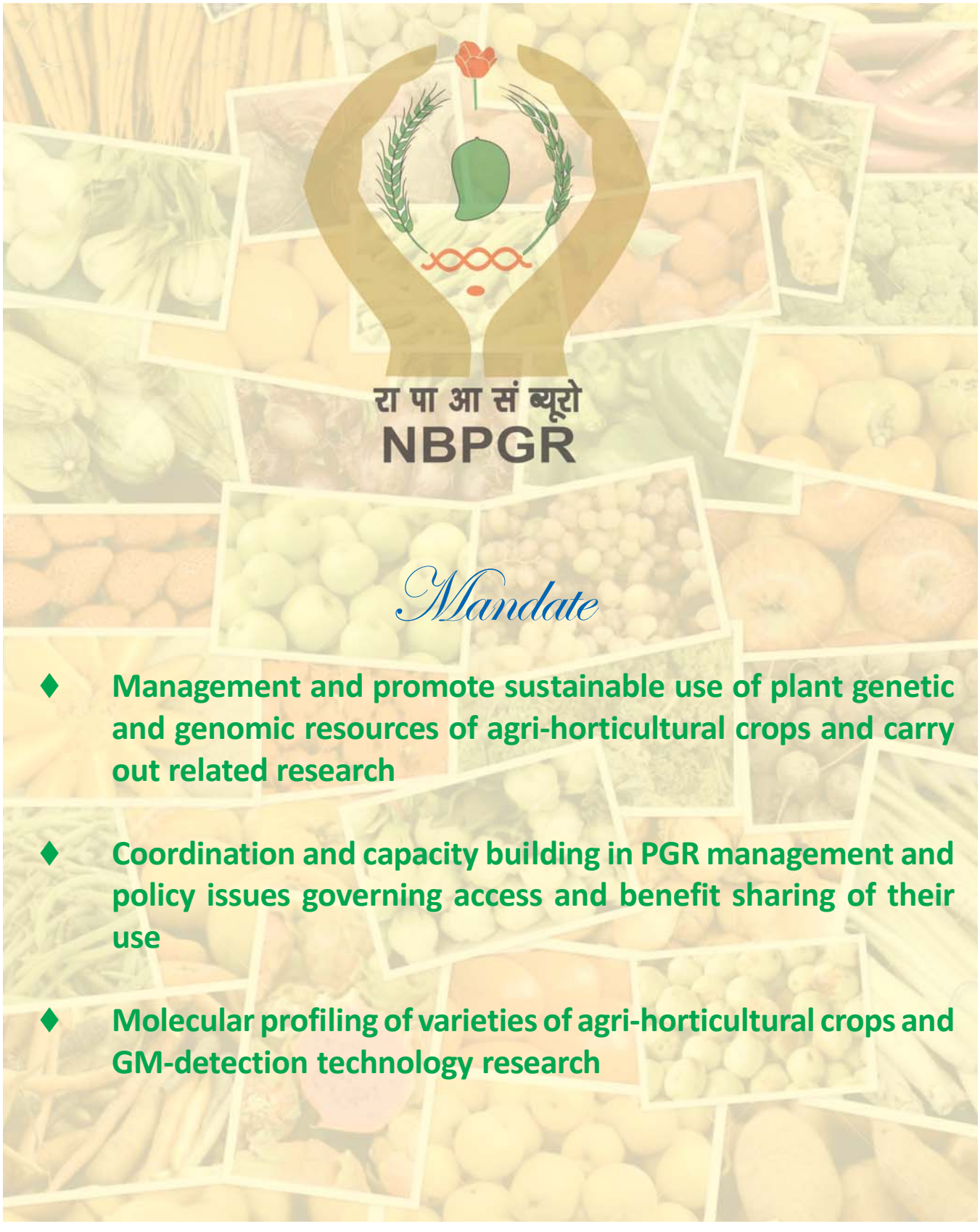
Website: www.nbpgr.ernet.in

Printed at: Yugantar Prakashan Pvt. Ltd. (India), New Delhi-110 064

ISSN 0971-2577

Citation: ICAR-NBPGR (2019) Annual Report 2018-2019, ICAR- National Bureau of Plant Genetic Resources, New Delhi, India, 230p.

Contents



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

It is with pride that I present this Annual Report 2018-19 to all our patrons and stakeholders. Envisioning the importance of a single window platform for efficient management of plant genetic resources at the national level, the Division of plant introduction was upgraded as National Bureau of Plant Genetic Resources in 1976 with New Delhi as its Head quarters. Presently, with 10 regional stations / base centres, we cater to the needs of various stakeholders. The year gone by was extremely satisfying in terms of successfully accomplishing our national responsibilities: plan, execute and coordinate all PGR management and utilization activities *viz*., exploration and collection; exchange; quarantine; characterization and evaluation; DNA fingerprinting, genomic resources' generation and GM detection; *ex situ, in situ*, *in vitro* & cryo conservation.

We not only continued playing the pivotal role in PGR management as presented in numbers in the next page, but also expanded our portfolio by adding new dimensions to our research programs and schemes to cover the scientific landscape. Several strategic externally funded projects were launched during the year that could redefine the scientific thinking and create new oppurtunities for NBPGR. Our stakeholder and beneficiary base has increased overtime globally and most notably the outreach in terms of TSP/ MGMG/field days has amplified in the last few years.

The journey of ICAR-NBPGR as an institution fulfils the aspirations of its collaborators to justify the premise of its formation, nevertheless, we strive to reinvent ourselves to remain relevant with the changing era. This intention is the foundation of endeavour to modernize the National Genebank, minimize the collection-conservation gap, and *en masse* characterization/evaluation of genebank germplasm, especially, utilizing the genomic tools. I am sure the tactical initiatives, set into motion during the year would continue to define the future course for several years down the line.

The real strength of NBPGR is its people and their intellectual efforts and resourcefulness. I place here my appreciation to all the HoDs, OICs, scientists, technical, administrative and supporting staff for their co-operation, competence and allegiance. Contributions of the contractual staff are immense and are placed on record with gratefulness. Special thanks to Drs Manjusha Verma, Sherry R Jacob, R Parimalan, Bharat Gawade, Vartika Srivastava and Kuldeep Tripathi for compiling the annual report for 2018-19.

I take this opportunity to acknowledge the guardianship of ICAR for demonstrating confidence and providing fiscal support. I express my supreme gratitude to Dr T Mohapatra, the Hon'ble Secretary, DARE and Director General, ICAR; Dr AK Singh, DDG (Crop Science); and Dr DK Yadava, ADG (Seeds), ICAR for their unrelenting guidance and motivation in envisioning new intitatives and gratifying the core mandate of ICAR-NBPGR.

Looking forward to the support and guidance of our patrons and using our past as a launchpad, we embark upon the future to deliver our best in the years to come.

May 20, 2019
New Delhi

Kuldeep Singh
Director

ICAR-NBPGR this year in numbers

List of Acronyms

ABD	Augmented Block Design
µM	Micro Molar
ACC.	Accession
AEBAS	Aadhar Enabled Biometric Attendance System
ArMV	*Arabis mosaic virus*
AVRDC	Asian Vegetable Research and Development Centre
BGM	Botrytis Grey Mould
BRICS	Brazil, Russia, India, China and South Africa
BWC	Biological Weapons Convention
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
CLRV	*Cherry leaf roll virus*
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
GFLV	*Grapevine fanleaf virus*
GHU	Germplasm Handling Unit
GMO	Genetically Modified Organism
GPA	Global Plan of Action
GST	Goods and Service Tax
HPV	*High plains virus*
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
MCMV	*Maize chlorotic mottle virus*
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
NBRI	National Botanical Research Institute
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
OYVMD	Okra Yellow Vein Mosaic Disease
PBL	Port Blair
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
TSV	*Tobacco streak virus*
UIDAI-RD	Unique Identification Authority of India- Registered Devices
UPGMA	Unweighted Pair Group Mean Average
URP	Universal Rice Primers
V	Vitrification
WEUP	Wild Economically Useful Plants
WIEWS	World Information and Early Warning System
WRA	Weed Risk Assessment
YMD	Yellow Mosaic Disease
ZE	Zygotic Embryo

कार्यकारी सारांश

आईसीएआर–नेशनल ब्यूरो ऑफ प्लांट जेनेटिक रिसोर्सेज (आईसीएआर–एनबीपीजीआर) द्वारा 21 संस्थागत वित्त पोषित कार्यक्रमों के तहत और 39 बाह्य वित्त पोषित परियोजनाओं के तहत विभिन्न पीजीआर पहलुओं पर वर्ष 2018–19 के दौरान महत्वपूर्ण उपलब्धियों; पादप जननद्रव्य संग्रहय खोज और जननद्रव्य एक्सचेंज; पादप जननद्रव्य संगरोध; जननद्रव्य लक्षण वर्णन और मूल्यांकन; एक्स सीटू, इन सीटू और जननद्रव्य इन विट्रो संरक्षण; डीएनए फिंगरप्रिंटिंग, जीनोमिक संसाधनों और जीएम विशलेषण को यहां संक्षेप में प्रस्तुत किया गया है:

पादप जननद्रव्यों का संग्रह और खोज

विभिन्न अन्वेषणों के माध्यम से देश भर के 24 राज्यों के 109 जिलों से विभिन्न कृषि–बागवानी फसलों, फसल जंगली प्रजातियों (सीडब्ल्यूआर) और अन्य आर्थिक संयंत्रों के कुल 3,287 जननद्रव्य एकत्र किए गए। इनमें से 1,538 इकाइयां आईसीएआर– एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा 16 अन्वेषणों के माध्यम से एकत्र की गईं। इसके अलावा, कुल 690 हर्बेरियम नमूनों (84 अप्रकाशित कर सहित) को संसोधित किया गया और नई दिल्ली के नेशनल हर्बेरियम ऑफ कल्टिवेटेड प्लांट्स (NHCP) में जोड़ा गया।

अकोला स्टेशन ने दो अन्वेषण किए और मध्य प्रदेश से विभिन्न औषधीय, क्षेत्र और सब्जियों की फसल के कुल 164 जननद्रव्य एकत्र किए गए। **कटक** स्टेशन द्वारा किए गए दो अन्वेषणों के माध्यम से असम और ओडिशा से 204 जननद्रव्य सहित विविध फसलों और उनके सीडब्ल्यूआर एकत्र किए गए। इसके अतिरिक्त, केंद्र के हर्बेरियम में 1300 हर्बेरियम नमूने एकत्रित हैं। गौरतलब है कि बाढ़ सहिष्णु चावल और काले गिरी चावल एकत्र किए गए थे। **जोधपुर** स्टेशन ने दो सहयोगी अन्वेषण किए और विभिन्न कृषि–बागवानी फसलों के 175 जननद्रव्य एकत्र किए गए। **रांची** स्टेशन द्वारा बिहार में एक सहयोगी अन्वेषण से विभिन्न फसलों के दो सौ उनचालीस जननद्रव्य संग्रह एकत्र किए गए। **शिलांग** स्टेशन ने मेघालय में दो अन्वेषण किए और कुल 92 जननद्रव्य एकत्र किए गए। **शिमला** स्टेशन द्वारा दो अन्वेषण किए गए और हिमाचल प्रदेश और जम्मू और कश्मीर से 192 जननद्रव्य एकत्र किए गए। कश्मीर की किश्तवाड़ और लोलाब घाटी में तीन मल्टी–क्रॉप जर्मप्लाज्म एक्सप्लोरेशन श्रीनगर स्टेशन द्वारा किए गए और फसलों और सीडब्ल्यूआर के 151 अद्वितीय जननद्रव्य एकत्र किए गए। कर्नाटक और ग्रेट निकोबार बायोस्फीयर रिजर्व को कवर करने वाले तीन अन्वेषण कार्यक्रम **त्रिशूर** स्टेशन द्वारा किए गए थे और 419 जननद्रव्य एकत्र किए गए।

जननद्रव्यों का आदान प्रदान

2018 के दौरान 56,183 परिग्रहणों (1,58,117 नमूनों) का आयात किया गया जिसमें जननद्रव्य के 37,515 परिग्रहण (38.229 नमूने) और CGIAR नर्सरी की 18,668 प्रविष्टियाँ (1,19,888 नमूने) शामिल हैं। एनबीपीजीआर / आईसीएआर मुख्यालय द्वारा या भारत में आईसीएआर संस्थानों / एसएयू / अन्य विश्वविद्यालयों में कार्यरत वैज्ञानिकों से अनुमोदित, अंतर्राष्ट्रीय सहयोगात्मक अनुसंधान परियोजनाओं के अनुसार अनुरोधों के आधार पर 2018 के दौरान कुल 1558 नमूनों का निर्यात किया गया। पुनर्जनन / गुणन / आकारिकीय लक्षण वर्णन / प्रारंभिक मूल्यांकन / टैक्सोनोमिक पहचान / डीएनए फिंगरप्रिंटिंग / व्यवहार्यता परीक्षण के लिए 61,544 नमूनों की आपूर्ति की गई।

राष्ट्रीय आपूर्ति: सामग्री हस्तांतरण समझौते (एमटीए) के तहत अनुसंधान कर्ताओं से प्राप्त अनुरोधों के आधार पर फसल सुधार कार्यक्रमों में उपयोग के लिए विभिन्न फसलों के 21,909 नमूनों की आपूर्ति राष्ट्रीय उपयोगकर्ताओं को की गई। इसके अलावा, विभिन्न संस्थानों को अनुसंधान उद्देश्यों के लिए 61544 नमूनों की आपूर्ति की गई।

प्रमुख जननद्रव्य आयात

गेहूं: डबल अगुणित और जिप 4–पीएच उत्परिवर्ती रेखाएं (यूके), हेरिटेज गेहूं की किस्में (कनाडा), और डिटेलोसेंट्रिक जेनेटिक स्टॉक (मैक्सिको)।

धान: निमेटोड प्रतिरोधी और उच्च जिंकयुक्त (फिलीपीन्स)।

मक्का: बड़ी गिरी और जंगली प्रजातियाँ (मेक्सिको)।

तिल: फिलोडी प्रतिरोधी (तुर्की)।

Safflower: हाई अल्फा टोकोफेरोल, फाइटोफ्थोरा रोट, वर्टिसिलियम विल्ट और स्ट्राइप्ड रस्ट (USA) के लिए प्रतिरोधी।

सीबकथॉर्न: सुपीरियर क्वालिटी और उत्तम स्वाद वाली बेरीज (रूस)।

भिक्षु फल: चीनी की तुलना में 300 गुना अधिक मीठा (चीन)।

केला: जंगली प्रजाति (बेल्जियम)।

पादप जननद्रव्य संगरोध

मुख्यालय में 1,08,525 आयातित जननद्रव्य (बीज और वनस्पति प्रचार) के लिए संगरोध प्रसंस्करण किया गया था और 2,925 नमूनों में से 998 संक्रमित नमूनों का निस्तारण किया गया था और बाकी को अस्वीकार कर दिया गया था। ओरिजा सैटिवा (1648) में तिल्लेटिया बार्कलेयाना, ग्लाइसिन में पेरोनोसोस्पोरा मैन्शुरिका (21), पापवर में डेंड्रिफिएन पेनिसिलमेटम (3), फफूंद रोगजनकों, वायरस, खरपतवार और कीट प्रकोपों के कारण अस्वीकृति हुई। विदेशी फलियां के जननद्रव्य (1,898) के लिए पोस्ट–एंट्री संगरोध (पीईक्यू) ग्रीनहाउस में किया गया और वायरस मुक्त पौधों से बीजों को इंडेंटर्स को जारी किया गया। 2018 के दौरान तीस ऑन–साइट PEQ निरीक्षण किए गए। 1,748 नमूनों में निर्यात के लिए कुल 7 फाइटोसैनेटरी प्रमाणपत्र जारी किए गए। 164 आयात ट्रांसजेनिक नमूनों में टर्मिनेटर जीन की अनुपस्थिति सुनिश्चित की गई, मक्का में एक विदेशी वायरस पाया गया और सभी को पहले रिलीज होने से बचाया गया। 15,804 नमूनों का बीज स्वास्थ्य परीक्षण [रोगजनकों (संक्रमित/अस्वीकृत)]: कवक (745/12), नेमाटोड (207/0), और कीट (1159/93) के परिणामस्वरूप बाकी नमूनों का दीर्घकालिक संरक्षण हुआ। बीज स्वास्थ्य परीक्षण के लिए प्राप्त 82 क्रायो–संरक्षित नमूनों (या क्रायो–संरक्षण के लिए) में, 2 नमूने अलग–अलग कवक से संक्रमित पाए गए और सभी को उबार लिया गया। ब्रूकिड्स और कैल्सिड्स के छिपे हुए संक्रमण का पता लगाने के लिए कुल 1721 नमूनों को एक्स–रे रेडियोग्राफी में उजागर किया गया और 147 नमूनों को संक्रमित पाया गया था, जबकि कीटों के संक्रमण को 1012 नमूनों में नेत्रहीन दर्ज किया गया था। इसके अतिरिक्त, **हैदराबाद** स्टेशन में, 51,278 नमूनों (44,159 आयातय 7,119 निर्यात) को संगरोध के लिए संसोधित किया गया और 65 फाइटोसैनेटरी प्रमाण पत्र जारी किए गए। 11,491 संक्रमित आयात नमूने निस्तारित किए गए थे और 115 निर्यात नमूनों को अस्वीकार किया गया। कुल मिलाकर, संगरोध के बाद 29,499 नमूने जारी किए गए थे। 6,951 नमूनों के लिए पी ई क्यू आई किया गया।

जननद्रव्य लक्षण वर्णन और मूल्यांकन

2018 के दौरान, कृषि–बागवानी फसलों की विशाल संख्या (18,087) का मूल्यांकन एवं पुनर्जनन किया गया। गेहूं के लिए प्रारंभिक स्क्रीनिंग (150 . 31), बैंगन की जंगली प्रजाति (*सोलनम इंकानम*) (12), भिंडी (130), सब्जी और दलहनी फसलें (430) विभिन्न जैविक तनावों के लिए मूल्यांकित की गईं। अजैविक तनाव के लिए गेहूं (959) और जौ (220) के कुल 1,179 परिग्रहणों का मूल्यांकन किया गया था। कृषि–बागवानी फसलों (1,104), औषधीय और सुगंधित पौधों (160) का मूल्यांकन क्रमशः गुणवत्ता और फाइटो–रासायनिक मापदंडों के लिए किया गया था। सीआरपी–एबी के तहत, कृषि–संबंधी लक्षणों, जैविक और अजैविक तनावों के लिए, विभिन्न कृषि–बागवानी फसलों (2,701) का मूल्यांकन किया गया। **अकोला** में, विभिन्न कृषि–बागवानी फसलों को क्रमशः रबी 2016–17 (132) और खरीफ 2017 (1819) के दौरान चित्रित/मूल्यांकन किया गया था। इसके अलावा, विभिन्न फसलों के 2,164 परिग्रहणों को गुणा और पुनर्जीवित किया गया। **भोवाली** में मोर्फो–एग्रोनॉमिक लक्षणों के लिए कुल 1,375 परिग्रहणों का मूल्यांकन किया गया। **कटक** स्टेशन में कुल 3596

संस्कारित चावल, जंगली चावल, हिबिस्कस सबदरिफा, तुलसी, कुकुमस, भिंडी प्रजातियां शामिल हैं। इसके अलावा, लवणता सहिष्णुता के लिए चावल (216) का मूल्यांकन किया गया। L-Dopa के लिए Mucuna pruriens के फाइटोकेमिकल मूल्यांकन द्वारा 7.09% की L-Dopa वाले एक काले बीज वाले परिग्रहण (IC-599290) की पहचान की। **हैदराबाद** में, 1,020 अभिलक्षणों की विशेषता / मूल्यांकन / गुणा किया गया। 106 अन्वेषण वाउचर नमूनों को गुणा किया गया और एनजीबी में दीर्घकालिक संरक्षण के लिए भेजा गया। **जोधपुर** में, खरीफ 2018 के दौरान, विभिन्न फसलों के 360 परिग्रहणों का मूल्यांकन किया गया। **शिलांग** स्टेशन पर कृषि–बागवानी फसल जननद्रव्य (1427) का गुणा किया गया। **शिमला** में, विभिन्न फसलों (1,765) की विशेषता और मूल्यांकन किया गया। इसके अतिरिक्त, बागवानी फसलों, सेब (24), खुबानी (15), आलूबुखारा (10), आड़ू (26) और अखरोट (49) के कुल 124 जननद्रव्य की विशेषता और विभिन्न पोमोलॉजिकल लक्षणों का मूल्यांकन किया गया। **श्रीनगर** में, रबी 2017–18 के दौरान रबी गेहूं (209) और जौ (107) के 316 नमूनों को उनके कृषि–रूपात्मक लक्षणों के लिए चित्रित किया गया। **त्रिशूर** में, कृषि–बागवानी फसलों के 624 संग्रह विभिन्न आर्थिक लक्षणों के लिए मूल्यांकित किए गए।

एक्स सीटू एवं इन सीटू जननद्रव्य संरक्षण

31 दिसंबर 2018 को एनजीबी में कुल जननद्रव्य होल्डिंग 4,39, 717 है। इस वर्ष के दौरान, 4,764 को संवर्धित किया गया और 7,160 को जोड़ा गया; (अधिसूचित किस्मों और विभिन्न फसलों की विशिष्ट पंजीकृत जर्मप्लाज्म मिलाकर)। अन्य प्राथमिकता वाली गतिविधियां थीं: विभिन्न अनुसंधान उद्देश्यों के लिए बीज (10,041) और वितरण (62,556) का आकलन करना। बीज वाएबिलिटी समीकरण फिटिंग और गणना के लिए एक खुला स्रोत सॉफ्टवेयर 'viability metrics' सांख्यिकीय प्रोग्रामिंग भाषा 'आर' के ऐड–ऑन पैकेज के रूप में विकसित किया गया। NBPGR के स्टेशनों में एमटीएस / एफजीबी सुविधाओं पर संरक्षित किए जा रहे जर्मप्लाज्म की संख्या नीचे दी गई तालिका में दी गई है:

स्टेशन	एफजीबी	एमटीएस
अकोला	02	20838
भवाली	1251	11266
कटक	591	
हैदराबाद	776	37927
जोधपुर	752	36410
रांची	917	
शिलांग	690	1207
शिमला	1023	12565
श्रीनगर	65	
त्रिशूर	1813	6493

इन विट्रो और क्रायोप्लाज्म का क्रायो–संरक्षण

2018 के दौरान, इन विट्रो संस्कृतियों (1,861) में फल, बल्ब, कंद, मसाले, औद्योगिक फसलों, औषधीय, सुगंधित और दुर्लभ / लुप्तप्राय पौधों को (25±2°C; 16 / 8h) (4–10°C) तहत संरक्षित किया गया। क्रायोजीनेबैंक में फलों, औद्योगिक फसलों, फलियां, बाजरा, चारा, सब्जियां और जंगली प्रजातियों के 13,363 परिग्रहणों को 2018 में बीज, भ्रूण कुल्हाड़ियों, पराग और जीनोमिक संसाधनों के रूप में संरक्षित किया गया, जिसमें 428 नए परिग्रहण शामिल थे। एलियम, बैकोपा, कोलोकोसिया, डायोस्कोरिया, जेंटियाना और हमुलस ल्यूपुलस के क्रायोप्रेजर्वेशन के पूर्व और बाद में सफलता हासिल की गई। एलियम में (8), बी; मोनेरी (2), डी डेल्टोइडिया (4), मूसा (10) और वैक्सीनियम ओवेटम (1) का वर्ष के दौरान इन विट्रो क्रायोबैंकिंग किया गया। आनुवांशिक स्थिरता मूल्यांकन में मूसा और एलियम क्रायोप्रेसर्वड और पुनर्जीवित प्लांटलेट्स के प्रोफाइल में 70–80% समानता का पता चला। ऑर्थोडॉक्स और गैर–रूढ़िवादी बीजों के 45 परिग्रहणों का समय–समय पर परीक्षण (क्रायोस्टोरेज के 15–26 वर्षों के बाद) किया गया।

डीएनए फिंगरप्रिंटिंग, जीनोमिक संसाधनों और जीएम विश्लेषण

सरकारी और निजी क्षेत्र के संगठनों से वेराइटल पुष्टि, बीज शुद्धता और संकर परीक्षण के लिए 195 नमूनों

(20 फसलों) का डीएनए फिंगरप्रिंटिंग किया गया। 2018 के दौरान राष्ट्रीय जीनोमिक्स संसाधन भंडार में कुल 462 जीनोमिक संसाधनों (6 फसलों) को संवर्धित किया गया, जिससे कुल 5936 परिग्रहण (48 फसलें) हो गए। विभिन्न कृषि–बागवानी फसलों (585) में आनुवंशिक विविधता का अध्ययन किया गया। गेहूं में रूट नाइट्रोजन अपटेक और परिवहन के लिए सात उम्मीदवार जीन की पहचान की गई, गेहूं एसोसिएशन पैनल (96) में अनाज के आकार के 23 एसएनपी को जोड़ने के लिए एसोसिएट किए गए। तिल में कैलिक्स विविधता देखी गई। तोरई में सेलिटरी फ्रूटिंग ट्रेट से जुड़ा एक 280 बी नी मार्कर F_2 पॉपूलेशन में खोजा गया। एल सिलिंड्रिका कैरियोटाइपिंग ने 12 मेटा–केंद्रित और 1 उप–मेटाकेंद्रित क्रोमोसोम को चित्रित किया। गेहूं के मिनीकोर सेट (224) को स्पॉट ब्लोच रेजिस्टेंस एसोसिएशन के लिए 35K सरणी का उपयोग करके GWAS किया गया। गेंहू की गर्मी सहिष्णु और अतिसंवेदनशील जीनोटाइप का 12 अनाज और पौधों के लक्षणों के लिए मूल्यांकन किया गया। इसके अतिरिक्त, गेहूं में टर्मिनल गर्मी सहिष्णुता के लिए एक मैजिक पॉपूलेशन विकास पर है। कपास में P35S और cry1Ac जीन को लक्षित करने वाले LAMP परख का विकास किया गया। विभिन्न फसलों के ट्रांसजेनिक (झ 100) की नौ आयातित खेपों को भ्रूणजनन निष्क्रिय करनेवाले जीन के लिए परीक्षण किया गया। आईसीएआर–एनबीपीजीआर में जीएम डिटेक्शन रिसर्च फैसिलिटी एनएबीएल से मान्यता प्राप्त कराई गई (आईएसओ/आईईसी 17025:2005)।

अन्य गतिविधियां

पीजीआर नीति नियोजन इकाई ने **पीजीआर** प्रबंधन मुद्दों पर विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय स्तरों पर नीति निर्माताओं को इनपुट प्रदान किए। कृषि ज्ञान प्रबंधन इकाई (AKMU) ने एक ऑनलाइन एप्लिकेशन विकसित किया, ''क्रायोबेस'' को इन्फोग्राफिक्स और संरचित बैक–एंड अप–टू–डेट प्रबंधन के लिए विकसित किया। AKMU ने NHCP के साथ मिलकर एक ऑनलाइन एप्लिकेशन वर्चुअल हर्बेरियम विकसित किया है जिसमें टैक्सोनॉमिक जानकारी और 7,000 चित्र हैं। ICAR-NBPGR ने 2018 के दौरान विभिन्न हितधारकों के लिए 12 प्रशिक्षण आयोजित किए। इसके अलावा, 14 वैज्ञानिक और तीन तकनीकी कर्मचारियों ने विभिन्न संगठनों द्वारा प्रदान किए गए प्रशिक्षण कार्यक्रमों में प्रशिक्षण लिया। संस्थान के वैज्ञानिक और तकनीकी कर्मचारियों ने संबद्ध अनुसंधान क्षेत्रों में 127 सेमिनार/संगोष्ठी/सम्मेलन/कार्यशालाओं में भाग लिया। इसके अलावा, संस्थान के 22 वैज्ञानिक कर्मचारियों ने 2018 के दौरान विदेशी प्रतिनियुक्ति पर काम किया। 2018 के दौरान, अद्वितीय लक्षण वाले 46 विभिन्न कृषि–बागवानी फसलों जर्मप्लाज्म पंजीकृत किए गए। चार छात्रों को M.Sc. डिग्री और चार पीएच.डी. डिग्री प्राप्त की। वर्तमान में, पीजीआर में 27 छात्र (21 पीएचडी, 6 एमएससी) हैं। वर्ष के दौरान, सभी कर्मचारियों श्रेणियों में 13 पदोन्नति, 08 स्थानान्तरण, 17 सेवानिवृत्ति को प्रभावित किया गया। वैज्ञानिक स्टाफ को 19 युवा/सर्वश्रेष्ठ वैज्ञानिक पुरस्कार एवं छह वैज्ञानिकों को अन्य पहचान के साथ सम्मानित किया गया। सहकर्मी–समीक्षा किए गए शोध लेख (107), पुस्तकें (12), पुस्तक अध्याय (68), बुलेटिन (13), लोकप्रिय लेख (20), टीवी वार्ता (4), रिपोर्ट (3), शोध आउटपुट का प्रसार प्रशिक्षण मैनुअल (3), पादप जननद्रव्य रिपोर्टर (2) और ई–प्रकाशन (10) किया गया। आउटरीच गतिविधियों के रूप में संस्थान ने छह जननद्रव्य प्रक्षेत्र दिवस और तीन किसान दिवस, और 15 PGR जागरूकता–सह– जैव विविधता कार्यक्रम, TSP या MGMG के तहत आयोजित किए।

EXECUTIVE SUMMARY

Significant achievements during 2018-19 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 programmes and 39 externally funded projects are summarized hereunder:

Plant exploration and collection of germplasm

A total of 3,287 germplasm of various agri-horticultural crops, crop wild relatives (CWR) and other economic plants were collected from 109 districts of 24 states across the country through 34 explorations. Of these, 1,538 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through conducting 16 explorations. Besides, a total of 690 herbarium specimens (including 84 unrepresented taxa) was processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi.

The **Akola** station undertook two explorations and a total of 164 germplasm of different medicinal, field and vegetables crops were collected from Madhya Pradesh. Diverse crops and their CWR comprising 204 germplasm were collected from Assam and Odisha through two explorations undertaken by the **Cuttack** station. Additionally, 1300 herbarium specimens are being maintained in the herbarium of the centre. Significantly, flood tolerant rice and black kernel rice were collected. The **Jodhpur** station undertook two collaborative exploration and 175 germplasm of various agri-horticultural crops were collected. Two hundred and thirty nine accessions of various crops were collected from a collaborative exploration in Bihar by **Ranchi** station. **Shillong** station conducted two explorations in Meghalaya and a total of 92 germplasm were collected. Two explorations were conducted by **Shimla** station and 192 germplasm from Himachal Pradesh and Jammu & Kashmir were collected. Thhree multi-crop germplasm exploration covering Kishtwar and Lolab valley of Kashmir were undertaken by **Srinagar** station and 151 unique germplasm of cultivated crops and CWR were collected. Three exploration programmes covering Karnataka and Great Nicobar Biosphere Reserve were undertaken by Thrissur station and 419 germplasm were collected.

Germplasm exchange

An import of 56,183 accessions (1,58,117 samples) which included 37,515 accessions (38.229 samples) of germplasm and 18,668 entries (1,19,888 samples) of CGIAR nurseries for trials was effected during 2018. A total of 1558 samples were exported to various countrieson 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. In addition, 61544 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

National supply: 21,909 samples of different crops were supplied to national users for utilization in various crop improvement programmes based on requests received from research workers under a Material Transfer Agreement (MTA). In addition, 61544 samples were supplied for various research purposes to different institutions.

Prominent germplasm introduced

Wheat: Double haploid and Zip4-Ph mutant lines (UK), Heritage wheat varieties (Canada), and ditelocentric genetic stocks (Mexico).

Paddy: Nematode resistant and high Zn content lines (Phillipines).

Maize: Large kernel and wild species (Mexico).

Sesame: Phyllody resistant (Turkey).

Safflower: High Alpha tocopherol, Resistant to phytophthora rot, verticillium wilt and striped rust (USA).

Seabuckthorn: Superior quality and best tasting berries (Russia).

Monk fruit: 300 times sweeter than sugar (China).

Banana: Wild species (Belgium).

Plant germplasm quarantine

Quarantine processing for 1,08,525 imported germplasm (seeds and vegetative propagules) were performed at **HQ** and 2,925 samples of 998 infected samples were salvaged and the rest were rejected. The rejections were due to *Tilletia barclayana* in *Oryza sativa* (1648), *Peronospora manshurica* in *Glycine max* (21), *Dendryphion penicillatum* in *Papaver somniferum* (3), fungal pathogens, viruses, weeds and insect infestations. Post-entry quarantine (PEQ) for exotic legume germplasm (1,898) was performed in greenhouses and seeds from virus-free plants were harvested and released to the indenters. Thirty on-site PEQ inspections were performed during 2018. For export involving 1,748 samples, a total of 7 phytosanitary certificates was issued. Absence of terminator gene was ensured in 164 import transgenic samples, one exotic virus was found in maize and all were salvaged prior release. Seed health testing of 15,804 samples [pathogens (infected/rejected)]: fungi (745/12), nematodes (207/0), and insect pests (1159/93) resulted in long term conservation of rest of the samples. Of 82 cryo-preserved samples (or for cryo-preservation) received for seed health testing, 2 samples were found infected with different fungi and all were salvaged. A total 1721 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 147 samples were found infested while infestation of insect-pests was recorded visually in 1012 samples. Additionally, in **Hyderabad** station, 51,278 samples (44,159 imports; 7,119 exports) were processed for quarantine and 65 phytosanitary certificates were issued. 11,491 infected/infested import samples were salvaged and 115 export samples were detained due to heavy infestation. In total, 29,499 samples were released after quarantine. PEQI for 6,951 samples were conducted at RS-Hyderabad, NBPGR.

Germplasm characterization and evaluation

During 2018, an immense number of accessions (18,087) of agri-horticultural crops were characterized, evaluated, regenerated and multiplied. Preliminary screening for wheat (150+31), brinjal wild species *Solanum incanum* (12), okra (130), vegetable and pulse crops (430) were done for various biotic stresses. A total of 1,179 accessions comprising of wheat (959) and barley (220) were evaluated for abiotic stresses. Agri-horticultural crops (1,104) and medicinal & aromatic plants (160) were evaluated for quality and phyto-chemical parameters, respectively. Under CRP-AB-PGR Component-II, 2,701 accessions of various agri-horticultural crops were evaluated for agronomic traits, biotic and abiotic stresses. In **Akola**, 132 and 1819 acc. of various agri-horticultural crops were characterized / evaluated during *Rabi* 2016-17 and *Kharif* 2017 respectively. Besides, 2,164 accessions of various crops were multiplied and regenerated. A total of 1,375 accessions were characterized/evaluated for morpho-agronomic traits in **Bhowali**. **Cuttack**

station characterized **a** total of 3596 accessions comprising cultivated rice, wild rice, *Hibiscus sabdariffa*, *Ocimum* spp, *Cucumis* spp, *Abelmoschus* spp. Also, evaluation of rice (216) for salinity tolerance was done. Phytochemical evaluation of *Mucuna pruriens* for L-Dopa identified a black seeded accession (IC-599290) having L-Dopa content of 7.09 %. In **Hyderabad**, 1,020 accessions were characterized/evaluated/ multiplied. **106** exploration voucher samples were multiplied and sent for long-term conservation in NGB. In **Jodhpur**, during *Kharif* 2018, 360 accessions of different crops were evaluated. A total of 1427 accessions of agri-horticultural crop germplasm were multiplied at **Shillong** station. In **Shimla**, various crops were characterized and evaluated (1,765). Additionally, horticultural crops, a total of 124 germplasm accessions comprising of apple (24), apricot (15), plum (10), peach (26) and walnut (49) were characterized and evaluated for various pomological traits. In **Srinagar**, 316 accessions comprising of wheat (209) and barley (107) were characterized for their agro-morphological traits during *rabi* 2017-18 under rain fed conditions. In **Thrissur**, 624 collections of agri-horticultural crops were characterized for various economic traits.

Ex situ and *in situ* conservation of germplasm

Total germplasm holding in NGB as on 31st December 2018 is 4,39,717. During this year, 4,764 were augmented and 7,160 accessions were added after; comprising varieties to be notified, released cultivars and trait-specific registered germplasm of various crops. Other prioritized activities were: assessing seed viability (10,041) and distribution (62,556) for various research purposes. A free and open source software 'viabilitymetrics' was developed as an add-on package of the statistical programming language 'R' for the seed viability equation fitting and calculations. Number of germplasm being conserved at MTS / FGB facilities across the RS/ BC of NBPGR are provided in the table below.

Station	FGB	MTS
Akola	02	20838
Bhowali	1251	11266
Cuttack	591	
Hyderabad	776	37927
Jodhpur	752	36410
Ranchi	917	
Shillong	690	1207
Shimla	1023	12565
Srinagar	65	
Thrissur	1813	6493

In vitro- and cryo-conservation of germplasm

During 2018, *in vitro* cultures (1,861 acc.) of fruits, bulb, tuber spices, plantation and industrial crops, medicinal, aromatic and rare/endangered plants, and others were conserved under ambient (25±2°C; 16/8h) / low temperature (4-10°C) conditions. In cryogenebank, 13,363 accessions comprising fruits, industrial crops, legumes, millets, forages, vegetables and wild species were cryostored as seeds, embryonic axes, pollen and genomic resources, including 428 new accessions. Varying degree of pre- and post-freezing success was achieved in cryopreservation of *Allium* spp., *Bacopa*, *Colocasia*, *Dioscorea* spp., *Gentiana* and *Humulus lupulus. In vitro* cryobanking was done in *Allium* spp. (8), *B. monnieri* (2), *D. deltoidea* (4), *Musa* spp. (10) and *Vaccinium ovatum* (1) during the year. Genetic stability assessment revealed 70-80% similarity in profiles of cryopreserved and regenerated plantlets and their respective controls in *Musa* (using EST-SSR markers) and *Allium* spp. (using ISSR markers), respectively. Periodic testing for viability of 45 accessions of orthodox and non-orthodox seeds revealed retention of original

viability in most of the accessions after 15-26 years of cryostorage.

DNA fingerprinting, genomic resources' generation and GM detection

DNA fingerprinting for 195 samples (20 crops) from public and private sector organization for varietal confirmation, seed purity and hybrid testing was done. A total of 462 genomic resources (6 crops) were augmented in National Genomics Resources Repository during 2018, leading to a total of 5936 accessions (48 crops). Genetic diversity in various agri-horticultural crops (585 acc.) were studied. Seven candidate genes for root nitrogen uptake and transportation were identified in wheat, its chromosomal location synteny with other cereals was analyzed. A wheat association panel (96 from minicore) tested at Delhi for three years was used to associate 23 SNPs to grain size and shape. A total of 1,816 accessions of little millet was characterized. Calyx and locule number diversity were characterized in sesame. In *Luffa*, 280 bp marker was associated with solitary fruiting using F_2 population of an inter-specific cross. Karyotyping for *L. cylindrica* delineated 12 meta-centric and 1 sub-metacentric chromosomes. Wheat minicore set (224) was subjected to GWAS using 35K array for spot blotch resistance association. Pre-breeding derived F_4 lines (1459) of heat-stress tolerant and susceptible genotypes were characterized for 12 grain and plant traits. Additionally, a MAGIC population development for terminal heat-stress tolerance in wheat is under progress. Putative regulators of Kranz anatomy in *Poaceae* family exhibit differences at phosphorylation sites between C_3 and C_4 crop. LAMP assay targeting p35S and *cry1Ac* gene in cotton were developed. Nine imported consignments of transgenics (>100) of different crops were tested for embryogenesis deactivator gene. GM Detection Research Facility at ICAR-NBPGR has been NABL accredited (ISO/IEC 17025:2005).

Other Activities

The PGR Policy Planning unit provided inputs to the policy makers at various national and international levels on PGR management issues. Agricultural Knowledge Management Unit (AKMU) developed an online application, Cryobase was developed to replete with infographics and structured back-end for up-to-date management. AKMU collaborated with NHCP to develop an online application creating a virtual herbarium with taxonomic information and 7,000 images. ICAR-NBPGR organized 12 trainings for various stakeholders during 2018. Apart from this, 14 scientific and three technical staff underwent various training programmes imparted by various organizations. Scientific and technical staff of the institute had participated in 127 seminars / symposia / conferences / workshops during 2018 to share scientific updates through a common platform to gain an edge on current development in allied research areas. Besides, 22 scientific staff of the Institute underwent foreign deputation during 2018. During 2018, 46 germplasm with unique traits were registered belonging to 27 species of various agri-horticultural crops. Four students were awarded M.Sc. degree and four Ph.D. degree during 2017-18. Currently, the PGR discipline has on rolls 27 students (21 PhD, 6 MSc). During the year, 13 promotions, 08 transfers, 17 retirements were effected across all staff categories. The scientific staff were bestowed with 19 young/best scientist awards, six scientists with other recognitions. Dissemination of research outputs in the form of peer-reviewed research articles (107), books (12), book chapters (68), bulletins (13), popular articles (20), tv talks (4), reports (3), training manuals (3), plant germplasm reporter (2) and e- publications (10). As a part of outreach activities, the institute organized six field days and three farmers field days, and 15 PGR awareness-cum- biodiversity fair programmes under TSP or MGMG.

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.

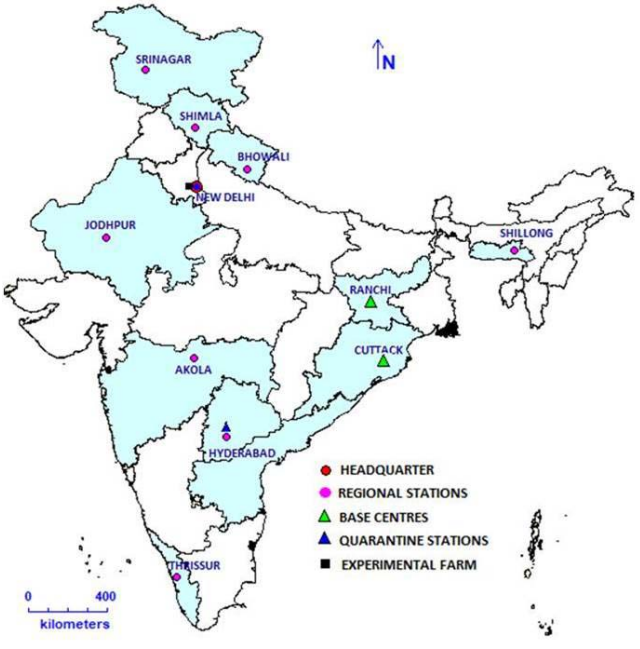


Fig. 1: NBPGR network of regional stations and base centres

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, 2017 was 314 comprising 123 scientific, 69 technical, 47 administrative and 61 supporting staff.

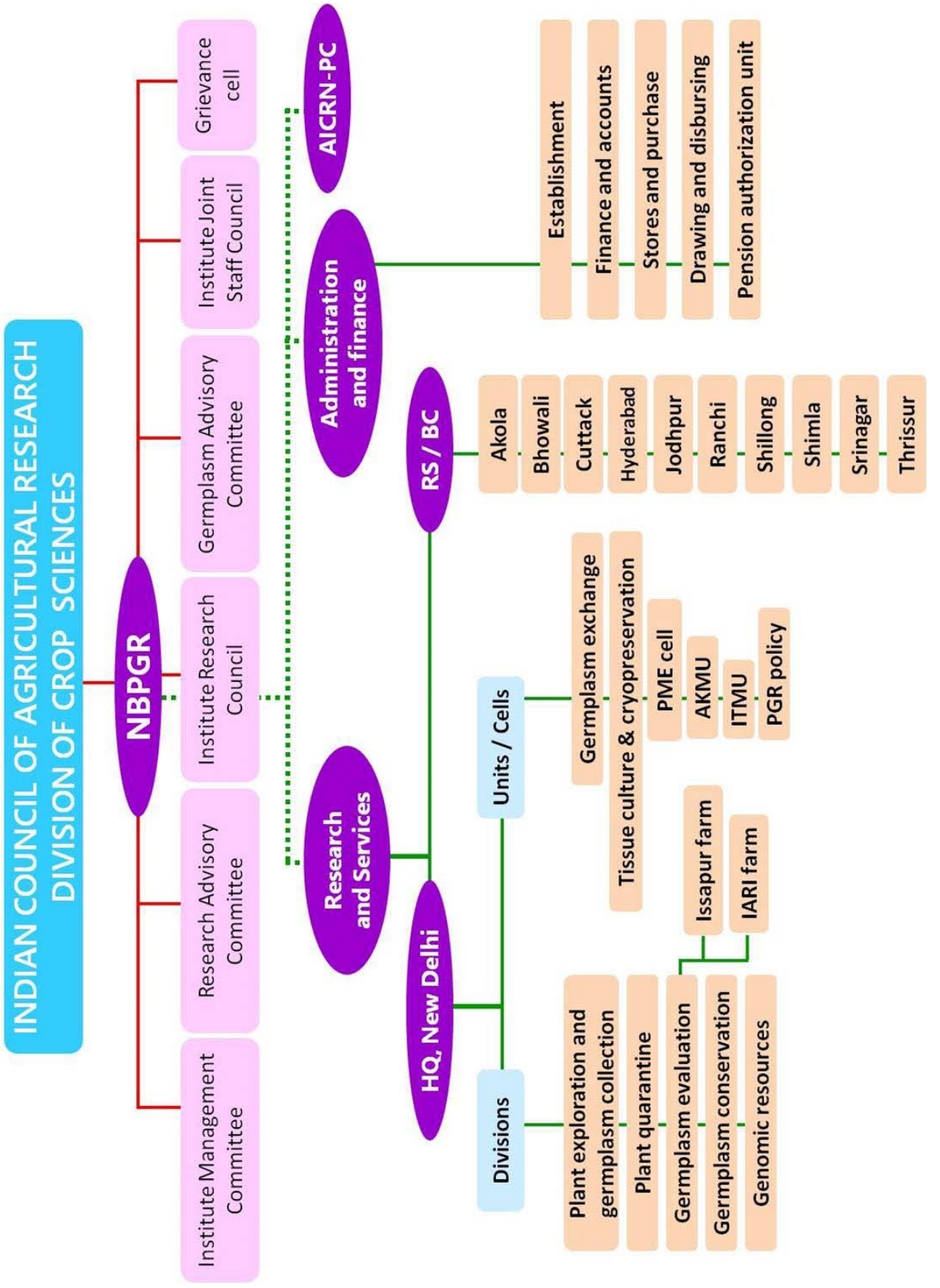


Fig. 2: Organogram of ICAR-NBPGR

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.

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. Also, seven new voluntary centres were 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 on-line 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, 152 books related to various aspects of PGR management and Hindi literature were added to the library collections through purchase and exchange basis. 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 575 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. During the year 2017-18, four students were awarded M.Sc. and Ph.D. degrees each. Currently, the PGR discipline has on rolls 27 students (21 PhD, 6 MSc).

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.

Funds allocated and expenditure incurred during the financial year 2018-19

Unified Budget 2018-19 (Rs. In Lakh)

A - Non-Recurring (Capital)	B.E. 2018-19	R. E. 2018-19	Expenditure
Works - Office Building	400.00	116.80	116.79
Equipments	1041.00	360.75	360.73
Information Technology	15.00	0.00	0.00
Library Books & Journals	25.00	23.00	22.94
Vehicles & Vessels	32.00	18.60	18.54
Furniture & Fixtures	10.00	3.85	3.81
Total (A)	***1523.00***	***523.00***	***522.82***
B - Recurring (Revenue)	**B.E. 2018-19**	**R. E. 2018-19**	**Expenditure**
Establishment Charges - Regular	4095.00	4937.25	4937.18
Wages - Regular	85.00	57.75	57.64
Pension & Other Retirement Benefits - Regular	3080.00	4116.36	4116.23
Domestic TA/Transfer TA	35.00	36.70	36.69
Research Expenses	265.00	202.30	202.29
Operational Expenses	550.00	269.15	269.14
Infrastructure	620.00	455.02	455.01
Communication	10.00	6.75	6.73
Equipments, vehicles & others	36.00	34.10	34.09
Office Building	255.00	146.65	146.63
Residential Building	50.00	27.00	26.99
Minor Works	10.00	2.46	2.45
Others (excluding TA,)	90.00	69.07	69.06
HRD	20.00	7.10	7.08
Publicity & Exhibitions	3.50	0.39	0.38
Guest House - Maintenance	1.00	0.10	0.09
Others Miscellaneous	26.5	20.95	20.94
Total (B)	***9232.00***	***10389.10***	***10388.62***
Total (A+B)	***10755.00***	***10912.10***	***10911.44***
Tribal Sub-Plan (TSP)	77.80	20.00	19.99
NEH Expenditure	191.00	76.00	75.91
SCSP Fund		471.00	470.73
G. Total (A+B+NEH+TSP+SCSP)	**11023.80**	**11479.10**	**11478.13**
AICRN - PC 2018-19	**B.E. 2018-19**	**R. E. 2018-19**	**Expenditure**
Grant-in-Salaries	231.00	256.00	256.00
Grant-in-General	88.40	78.00	77.70
TSP	35.36	30.00	30.00
Total	**354.76**	**364.00**	**363.70**
CRP on AB 2018-19	**B.E. 2018-19**	**R. E. 2018-19**	**Expenditure**
Grant-in-Capital	11.50	11.50	10.57
Grant-in-General	418.50	315.00	314.74
Total	**430.00**	**326.50**	**325.31**

Status of audit paras of ICAR-NBPGR	No. outstanding paras	Settled during 2018-19	Present position	%age
Internal audit (ICAR-HQ)	**38**	**28**	**10**	**73.68**
External audit (DGA-CE)	**12**	**5**	**7**	**41.66**

DIVISION OF PLANT EXPLORATION AND GERMPLASM COLLECTION

1

Summary: In 2018, a total of 34 exploration was undertaken across the country wherein 3,287 accessions of various agri-horticultural crops, their wild relatives and other economic species were collected from 109 districts lying in 24 states of India. Of these, 1,538 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through conducting 16 explorations in parts of Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Rajasthan, Telangana, Tirpura, Uttarakhand and Uttar Pradesh. A total of 690 herbarium specimens (including 84 unrepresented taxa) was processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi.

1.1 Plant Exploration and Germplasm Collection

In the year 2018, a total of 34 exploration (involving 23 collaborators) was undertaken and 3,287 accessions of different agri-horticultural crops comprising 2,542 accessions of cultivated and 745 of wild species (29.31%) were collected from 109 districts covering 24 states of India (Fig. 1.1). The states include Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Madhya Pradesh, Manipur, Maharashtra, Meghalaya, Mizoram, Odisha, Punjab, Rajasthan, Telangana, Tripura, Uttarakhand and Uttar Pradesh. Status of germplasm collected in explorations conducted by ICAR-NBPGR and its Regional Stations/Base Centres is given below (Table 1.1 & 1.2). The collections captured diversity in 527 species; cultivated (229 sp.) and crop wild relatives (CWR, 298 sp; 56.54%) in various crop- groups (Table. 1.2). Emphasis was mainly given on collecting germplasm from various diversity-rich, remote/ tribal inhabited and disturbed under-explored areas, namely Dhubri, Kokrajhar and Chirang (Assam), South West and West Garo Hills (Meghalaya), Churachandpur and Pherzawl (Manipur), Upper Siang (Arunachal Pradesh), Saiha, Lawngtlai and Lunglei (Mizoram), South Tripura

Table1.1: Explorations undertaken and germplasm collected in the year 2018

Headquarters /Station/Centre	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	2	136	30	166
Bhowali	3	78	133	211
Cuttack	2	136	68	204
Hyderabad	2	97	118	215
Jodhpur	2	128	47	175
New Delhi	16	1301	237	1538
Ranchi	1	238	-	238
Srinagar	3	121	30	151
Thrissur	3	307	82	389
Total	**34**	**2,542**	**745**	**3,287**

Table 1.2: Details of germplasm collected in different crop groups during the year 2018

Crop-group (accs.)	Crop/wild species (accs.)
Cereals (650)	*Aegilops tauschii* (14), *Coix lacryma-jobi* (8), *Elymus atratus* (1), *E. dahuricus* (4), *E. himalayanus* (3), *E. longearistatus* (4), *E. nutans* (17), *E. repens* (1), *E. schrenkianus* (5), *E. semicostatus* (10), *E. spurious* (1), *Hordeum vulgare* (55), *H. vulgare* var. *nudum* (7), *Leymus secalinus* (11), *Oryza nivara* (2), *O. rufipogon* (6), *O. sativa* (289), *O. sativa x O. rufipogon* (1), *Triticum aestivum* (56), *T. durum* (10), *Zea mays* (145)
Pseudo-cereals (67)	*Amaranthus cruentus* (2), *A. graecizans* (1), *A. graecizans* subsp. *thellungianus* (1), *A. hypochondriacus* (14), *A. spinosus* (3), *A. tricolor* (15), *A. viridis* (1), *Chenopodium album* (6), *C. karoi* (1), *Fagopyrum tataricum* (10), *F. tataricum* subsp. *potanini* (1), *F. dibotrys* (2), *F. esculentum* (9), *Secale cereale* (1)
Millets and minor millets (148)	*Avena sativa* (3), *Brachiaria ramosa* (1), *Echinochloa colona* (5), *E. crus-galli* (1), *E. frumentacea* (5), *Eleusine coracana* (20), *E. indica* (1), *Panicum miliaceum* (5), *P. sumatrens* (6), *Paspalum scrobiculatum* (3), *Pennisetum glaucum* (24), *Setaria italica* (35), *S. viridis* (3), *Sorghum bicolor* (36)
Pulses/grain legumes (445)	*Cajanus cajan* (29), *C. scarabaeoides* (2), *Cicer arietinum* (9), *Lathyrus sativus* (3), *Lens culinaris* (11), *Macrotyloma uniflorum* (21), *Phaseolus lunatus* (1), *Phaseolus vulgaris* (45), *Vigna aconitifolia* (14), *V. angularis* (2), *V. dalzelliana* (2), *V. marina* (1), *V. mungo* (88), *V. radiata* (73), *V. stipulacea* (1), *V. umbellata* (22), *V. unguiculata* (106), *V. unguiculata* subsp. *sesquipedalis* (8), *V. unguiculata* var. *cylindrica* (7)
Oilseeds (145)	*Brassica rapa* (2), *B. rapa* var. *brown sarson* (5), *B. rapa* var. *toria* (2), *B. juncea* (17), *B. napus* (5), *B. nigra* (9), *B. rapa* subsp. *oleifera* (1), *B. rapa* var. *yellow sarson* (7), *Carthamus tinctorius* (1), *Eruca sativa* (2), *Glycine max* (12), *Guizotia abyssinica* (1), *Lepidium apetalum* (3), *L. sativum* (2), *Linum perenne* (1), *L. usitatissimum* (4), *Perilla frutescens* (11), *Ricinus communis* (4), *Sesamum indicum* (63), *S. mulayanum* (2)
Fibres and allied species (149)	*Corchorus aestuans* (24), *C. capsularis* (4), *C. fascicularis* (8), *C. olitorius* (39), *C. trilocularis* (19), *Crotalaria juncea* (2), *C. pallida* (1), *C. verrucosa* (1), *Gossypium arboreum* (4), *G. barbadense* (3), *G. barbadense* var. *acuminatum* (1), *G. herbaceum* (1), *Hibiscus cannabinus* (12), *H. sabdariffa* (28), *Sesbania sesban* (2)
Fruits and nuts (183)	*Aglaonema simplex* (1), *Buchanania lanzan* (6), *Carica papaya* (4), *Carissa carandas* (9), *Celosia cristata* (1), *Cerbera manghas* (1), *Citrus aurantium* (1), *C. aurantifolia* (3), *C. hybrid* (2), *C. indica* (2), *C. jambhiri* (1), *C. latifolia* (1), *C. latipes* (1), *C. limon* (3), *C. maxima* (2), *C. medica* (6), *C. reticulata* (2), *Dimocarpus longan* (1), *Ficus subulata* (1), *Fragaria nubicola* (2), *Garcinia gummi-gutta* (1), *G. indica* (14), *G. nervosa* (3), *Grewia serrulata* (1), *Hippophae salicifolia* (1), *Jasminum elongatum* (1), *Juglans regia* (21), *Maclura cochinchinensis* (1), *Mangifera camptosperma* (3), *Muntingia calabura* (1), *Musa indandamanensis* (1), *Physalis peruviana* (1), *Pithecellobium dulce* (1), *Prinsepia utilis* (1), *Prunus amygdalus* (1), *P. armeniaca* (22), *P. cornuta* (6), *P. persica* (11), *P. venosa* (2), *Psidium guajava* (1), *Punica granatum* (1), *Pyracantha crenulata* (2), *Pyrus lanata* (1), *P. pashia* (3), *Rhopaloblaste augusta* (1), *Ribes alpestre* (2), *Rosa macrophylla* (1), *R. webbiana* (13), *Rubus rosifolius* (2), *Salvadora persica* (3), *Semecarpus prainii* (1), *Stixis sauveolens* (1), *Syzygium cumini* (1), *S. samarangense* (1), *Vangueria spinosa* (1), *Vanilla albida* (1), *Ziziphus horsfieldii* (1), *Z. mauritiana* (2), *Z. nummularia* (1)
Vegetables (1,176)	*Abelmoschus esculentus* (36), *A. manihot* var. *pungens* (21), *A. manihot* var. *tetraphyllus* (27), *A. ficulneus* (23), *A. tuberculatus* (9), *Acrostichum aureum* (1), *Allium ampeloprasum* (1), *A. cepa* (3), *A. chinense* (1), *A. consanguineum* (3), *A. hookeri* (1), *A. porrum* (1), *A. proliferum* (2), *A. przewalskianum* (5), *A. roylei* (3), *A. sativum* (4), *A. schoenoprasum* (1), *A. seminovii* (1), *A. stracheyi* (16), *Allium* sp. (8), *A. tuberosum* (3), *Alocasia indica* (1), *A.*

	macrorrhizos(1), *Amorphophallus hirsutus* (1), *A. paeonifolius* (1), *Atriplex hortensis* (1), *Basella alba* (3), *Benincasa fistulosa* (2), *B. hispida* (38), *Beta vulgaris* (1), *Brassica juncea* var. *rugosa* (9), *B. oleracea* (8), *B. rapa* (9), *Canavalia gladiata* (3), *Capsicum annuum* (90), *C. baccatum* (1), *C. chinense* (2), *C. frutescens* (3), *Celosia argentea* (1), *Citrullus lanatus* (4), *Coccinea grandis* (2), *C. cordifolia* (1), *C. indica* (1), *Colocasia esculenta* (13), *Cucumis callosus* (6), *Cucumis maderaspatanus* (1), *C. sativus* var. *hardwickii* (20), *C. melo* (41), *C. melo* var. *agrestis* (28), *C. melo* var. *conomon* (3), *C. melo* var. *momordica* (5), *C. melo* var. *utilissimus* (1), *C. sativus* (33), *Cucurbita maxima* (18), *C. moschata* (65), *C. pepo* (2), *Cyamopsis tetragonoloba* (26), *Cyphomandra betacea* (1), *Daucus carota* (2), *Dioscorea alata* (4), *D. bulbifera* (2), *D. glabra* (4), *D. pentaphylla* (1), *D. piscatorum* (1), *Dioscorea* sp. (1), *Diplocyclos palmatus* (4), *Lablab purpureus* (57), *Lagenaria siceraria* (75), *Luffa acutangula* (79), *L. aegyptiaca* (97), *L. hermaphrodita* (17), *Lycopersicon esculentum* (5), *L. pimpinellifolium* (3), *Malva sylvestris* (1), *Momordica balsamina* (2), *M. charantia* (51), *M. dioica* (1), *M. charantia* var. *muricata* (1), *M. subangulata* subsp. *renigera* (1), *Moringa oleifera* (11), *Pisum sativum* var. *arvense* (6), *P. sativum* (5), *Psophocarpus tetragonolobus* (2), *Raphanus sativus* (9), *Rumex acetosa* (3), *Solanum aethiopicum* (6), *S. khasianum* (1), *S. macrocarpon* (3), *S. melongena* (38), *S. pseudocapsicum* (1), *S. pubescens* (1), *S. spirale* (1), *S. surattense* (1), *S. torvum* (6), *S. viarum* (4), *S. violaceum* (5), *S. virginianum* (2), *Spinacia oleracea* (4), *Trichosanthes anguina* (2), *T. bracteata* (2), *T. cucumerina* (15), *T. majuscule* (1), *T. quinquangulata* (1), *T. tricuspidata* (1), *T. wallichiana* (1), *Tubocapsicum anomalum* (1), *Vicia faba* (11), *Xanthosoma sagittifolium* (2), *X. violaceum* (1)
Medicinal and aromatic plants, spices and condiments (311)	*Abrus precatorius* (1), *Aloe barbadensis* (8), *Alpinia conchigera* (1), *Amomum compactum* (1), *Andrographis paniculata* (2), *Anethum graveolens* (2), *Aristolochia tagala* (1), *Asparagus racemosus* (2), *Berberis aristata* (1), *Bunium persicum* (1), *Carum carvi* (8), *Chlorophytum borivilianum* (21), *C. comosum* (1), *C. tuberosum* (3), *Cinnamomum bejolghota* (3), *Clerodendron coolebrokianum* (2), *Citrullus colocynthis* (2), *Clitoria ternatea* (2), *Convolvulus pluricaulis* (1), *Coriandrum sativum* (47), *Corylus jacquemontii* (1), *Costus pictus* (1), *C. speciosus* (13), *Cuminum cyminum* (4), *Curcuma amada* (2), *C. angustifolia* (1), *C. aromatica* (1), *C. longa* (7), *C. rubescens* (2), *Curcuma* spp. (1), *Curcuma zedoaria* (2), *Cymbopogon flexuosus* (2), *Datura metel* (1), *Diplocyclos palmatus* (1), *Etlingera fenzlii* (1), *Foeniculum vulgare* (7), *Gymnema sylvestre* (20), *Hellenia lacera* (1), *Hemidesmus indicus* (3), *Horsfieldia glabra* (2), *Knema andamanica* (2), *Lawsonia inermis* (2), *Leucas aspera* (1), *Malva verticillata* (4), *Marsdenia macrophylla* (1), *Mentha longifolia* (1), *Mucuna monosperma* (1), *M. pruriens* (4), *M. prurita* (1), *Murraya koenigii* (12), *Myristica andamanica* (2), *Nicotiana tabacum* (1), *Nigella sativa* (2), *Ocimum basilicum* (1), *O. gratissimum* (4), *O. tenuiflorum* (7), *Oroxylum indicum* (1), *Papaver somniferum* (1), *Piper betle* (6), *P. longum* (1), *P. miniatum* (1), *P. pedicellatum* (1), *P. sarmentosum* (1), *Piper* spp.(3), *Plumbago zeylanica* (2), *Psoralea corylifolia* (1), *Rauvolfia serpentina* (1), *Rheum australe* (1), *Salacia chinensis* (1), *Solanum anguivi* (2), *S. nigrum* (6), *S. torvum* (2), *S. violaceum* (2), *Tabernaemontana divaricata* (1), *Terminalia bellerica* (1), *Tinospora cordifolia* (1), *Trachyspermum ammi* (3), *T. roxburghianum* (1), *Trigonella foenum-graecum* (12), *Thymus linearis* (1), *Vetiveria zizanioides* (1), *Viburnum cotinifolium* (1), *Withania somnifera* (6), *Zingiber officinale* (12), *Z. squarrosum* (1), *Z. zerumbet* (1)
Forages (8)	*Calopogonium mucunoides* (3), *Pennisetum pedicellatum* (1), *Pueraria phaseoloides* (3), *Vicia hirsuta* (1)
Other economic species (5)	*Canarium strictum* (1), *Dendrolobium umbellatum* (1), *Leucaena pulverulenta* (1), *Macaranga nicobarica* (1), *Urena lobata*

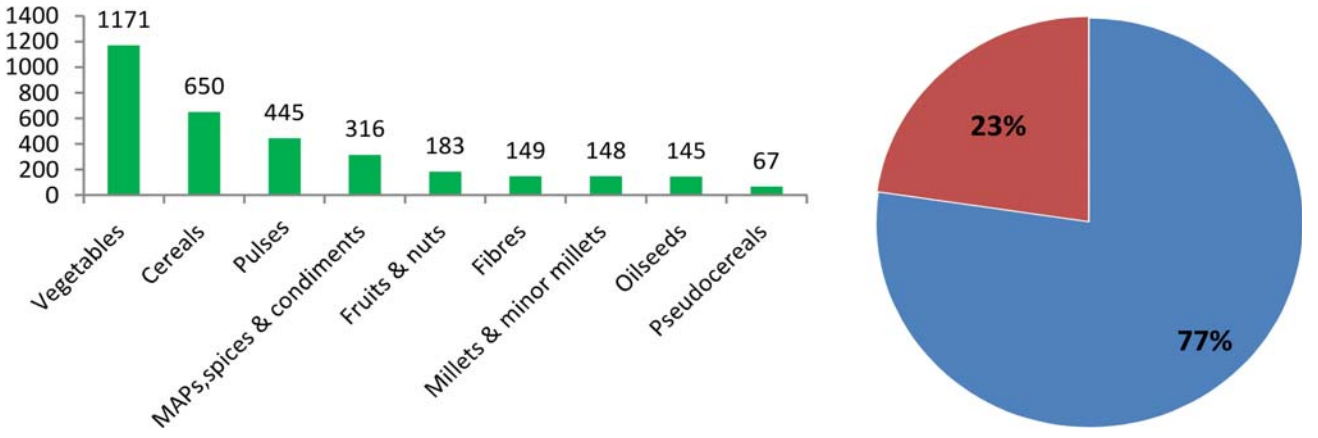


Fig. 1.1: Germplasm accessions collected across different crop-groups and % share of CWRs (23% CWR and 77% other crops) in 2018

and Dhalai (Tripura) and Lahul & Spiti (Himachal Pradesh). A total of 1,495 collected accession was sent to Germplasm Handling Unit (GHU) for conservation, while the remaining were sent for multiplication and maintenance in National Active Germplasm Site (NAGS).

1.2 Explorations undertaken and germplasm collected by the Headquarters

During the period under report, sixteen explorations were undertaken in parts of Assam, Arunachal Pradesh, Bihar, Goa, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Rajasthan, Tripura and Uttarakhand. A total of 1,538 accessions (cultivated: 1301 and wild: 237) of different agri-horticultural crops were collected (Table 1.3).

1.2.1 Agricultural crops

1.2.1.1 *Trait-specific germplasm collected*

Cold tolerant wheat from Uttarakhand: A total of 79 germplasm samples comprising of barley (21), wheat (15), buckwheat (7), *Brassica jucea* var. *toria* (12), *Allium* spp. (21), French bean (2) and coriander (1) were collected from Dharchula and Tawaghat areas (Byans & Darma valleys) of Pithoragarh district, Uttarakhand. Rich variability was collected in barley for grain shape, size, colour, awns, and number of grain per row (Fig. 1.2). Variability was also observed for leaf size, shape & colour, flower colour, plant height, aroma in *Allium* spp.

Fig. 1.2: Variability in ear heads of barley from Pithoragarh, Uttarakhand

Wild relatives of wheat & barley from cold desert of J&K & Himachal Pradesh: A total of 104 accessions in 17 taxa namely *Elymus nutans* (17), *Hordeum vulgare* (13), *Leymus secalinus* (11), *Triticum aestivum* (6), *Allium przewalskianum* (5), *Brassica napus* (5), *Carum carvi* (4), *Elymus schrenkianus* (5), *E. semicostatus* (4), *E. longearistatus* (4), *E. dahuricus* (4), *E. himalayanus* (3), *Avena sativa* (3), *Pisum sativum* var. *arvense* (3), *Setaria viridis* (2), *Elymus* spp.(3), *Fagopyrum*

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

Diversity collected (state and period)	No. of accessions			Lead & collaborating institute(s)
	Cultivated	Wild	Total	
Explorations undertaken				
Tropical underutilized fruits (Goa & Maharashtra)	11	28	39	NBPGR; CCARI, Goa
Cold tolerant wheat & vegetables (Uttarakhand)	78	1	79	NBPGR; VPKAS, Almora
Multi-crop including CWR (HP & J&K)	40	64	104	NBPGR; IARI, Wellington & PAU, Ludhiana
Multi-crops (Tripura)	37	14	51	NBPGR
Multi-crops (Manipur)	67	9	76	NBPGR
Multi-crop (Arunachal Pradesh)	76	6	82	NBPGR
Multi-crops (Mizoram)	49	3	52	NBPGR; KVK, Saiha
Multi-crops (Meghalaya)	77 91	- 2	77 93	NBPGR; NBPGR, Shillong NBPGR; KVK, Tura
Multi-crops (Assam)	227 69	16 8	243 77	NBPGR; AAU, Gossaigainstitute(s) on; KVK, Kokrajhar NBPGR; KVK, Udalguri & Mangaldai
Cucurbitaceous vegetables (Raj.)	9	5	14	NBPGR
Vegetables (wild okra & others) (Raj. & Haryana)	4	50	54	NBPGR; IIVR, Varanasi
Vegetables (cultivated & wild) (Tripura)	283	16	299	NBPGR; IIVR, Varanasi
Vegetables (Bihar)	74	1	75	NBPGR; IIVR, Varanasi
Explorations under NICRA project				
Cereals and vegetables (Madhya Pradesh)	109	14	123	NBPGR, New Delhi
TOTAL	**1301**	**237**	**1538**	

spp. (3), *Allium* spp. (2), and others (7) were collected from parts of Kullu, Lahaul & Spiti districts of Himachal Pradesh and Leh district of Jammu & Kashmir (Fig. 1.3). Occurrence of *Elymus nutans* was most common across the altitudes, especially in field boundaries, unattended fields, ungrazed disturbed sites, road sides and also in hill slopes. Variability in *E. nutans* was observed for plant stature, no. of spikelets/node, pigmentation, spike characterstics (length,thickness,colour), awn length and colour; *E. dahuricus* was observed with late spike maturity as compared to *Elymus* spp.; *E. longearistatus* subsp. *canaliculatus*, having disarticulate rachis, a habitat-species was confined to high altitudes (>3400m); *E. himalayanus* is specifically common in occurrence and is characterized by thin, easily breakable rachis and straight long lemma awn; *E. repens*, a synanthropic

Fig. 1.3: A: Variability in grain colour in barley from Leh (J&K); B: Tibetan purple barley with green awns from Leh (J&K); C: Collecting *Elymus* germplasm from Lahual & Spiti (HP)

species was observed with tall and dwarf forms; *E. schugnanicus* is early maturing species with very dwarf plants (about 30 cm high); *E. schrenkianus*, which is a habitat-specific species confined above 4700m. In Leh district, wild population of *Allium przewalskianum* (Vern. *kotse)* having purple-red flowers occured in rocky crevices (its dried leaf paste is added to traditional food *Thupka)*; Tibetan purple barley cultivated sparingly as admixture with regular (naked) barley in Nyoma block; a variant of purple barley with green awn from Rango village and 2-rowed barley from Sumdo and Rango villages; wild population of *Carum carvi* was seen in the East of Nyoma; were some interesting collections.

1.2.1.2 Multi-crop germplasm collection from Madhya Pradesh and adjoining Rajasthan: A total of 123 accessions of 50 taxa comprising of *Triticum aestivum* (18), *T. durum* (9), *Cicer arietinum* (8), *Hordeum vulgare* (7), *Vicia faba* (6), *Trigonella foenum-graecum* (5), *Zea mays* (4), *Pisum sativum* (4), *Brassica nigra* (4), *Sesamum indicum* (4), *Vigna mungo* (3), *Lens culinaris* (3), *Coriandrum sativum* (3), *Oryza sativa* (2), *Lablab purpureus* (2), *Pisum sativum* var. *arvense* (2), *Linum usitatissimum* (2), *Foeniculum vulgare* (2), *Moringa oleifera* (2), *Ziziphus mauritiana* (2), *Abelmoschus ficulneus* (2), *Amaranthus* spp. (3), *Solanum* spp. (3), *Echinochloa* spp. (2), *Abelmoschus* spp. (2), and others (19) were collected from parts of Shivpuri and Guna districts (Madhya Pradesh, Fig.1.4); Jhalawar and Baran districts (Rajasthan). It was observed that almost all the obsolete varieties of wheat have been replaced by high yielding varieties, however sporadically, few traditional/obsolete varieties (*Lok-1, Sharbati, Khattiya* and *Desi Lal gehun*) are under cultivation. Rainfed and drought tolerant sticky rice landrace '*Saali*', grown for kheer purpose being cultivated since ages was collected from

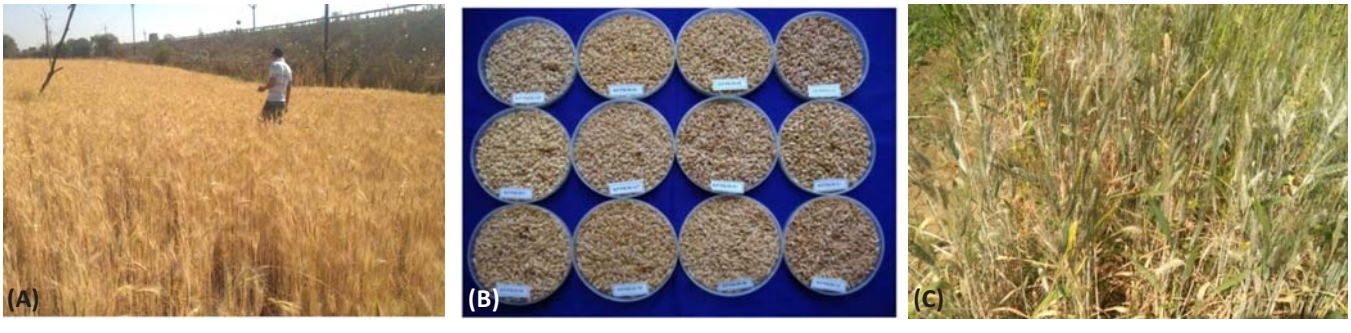


Fig. 1.4: A: Collecting local wheat germplasm from Guna, MP; B: Variability in wheat from MP; C: Black awned durum wheat from Guna, MP

Jhalawar district of Rajasthan; a local brinjal germplasm with spiny calyx is tastier than improved type; and faba bean with variability in seed size and shape (angular, compressed) and colour (black, yellowish brown); immature fruits of *Abelmoschus tuberculatus* are consumed by local tribal (Bheel, Shariya and Lodha) in Jhalawar and Baran districts of Rajasthan; *Senna tora* seeds used as pulse and young leaves cooked as vegetable in Shivpuri and Guna district; were interesting collections.

1.2.1.3 Region specific/multi-species collection in NEH region

***Explorations in underexplored areas of Assam*:** A total of 243 accessions comprising of *Oryza sativa* (49), *Colocasia esculenta* (10), *Capsicum annuum* (9), *Vigna unguiculata* (12), *V. mungo* (8), *Citrus* spp. (8), *Zingiber officinale* (6), *Brassica juncea* (5), *B. juncea* var. *rugosa* (2), *Triticum aestivum* (5), *Curcuma longa* (5), *Curcuma* spp. (4), *Zea mays* (4), *Corchorus* spp. (4), *Malva verticillata* (4), *Eleusine coracana* (4), *Lens culinaris* (4), *Sesamum indicum* (4), *Dioscorea alata* (4), *Ocimum tenuifolium* (3), *Cajanus cajan* (3), *Macrotyloma uniflorum* (3), *Setaria italica* (3), *Coriandrum sativum* (3), *Abelmoschus esculentus* (3), *A. pungens* (2), *Cucurbita moschata* (3), *Luffa aegyptiaca* (3), *Amaranthus tricolor* (2), *Linum usitatissimum* (2), *Ricinus communis* (2), *Fagopyrum esculentum* (2), *Gossypium barbadense* (2), *Nigella sativa* (2), *Phaseolus vulgaris* (2), *Hordeum vulgare* (2), *Capsicum frutescens* (2), *Solanum melongena* (2), *Xanthosoma sagittifolium* (2), *Celosia* spp. (2), *Hibiscus* spp. (2), *Oryza* spp. (2), *Curcuma* spp. (2), *Luffa* spp. (2), *Trachyspermum* spp. (2), *Vigna* spp. (2), and others (28) were collected from Kokrajhar and Dhubri districts of Assam (Fig. 1.5). Twenty-five rice landraces (*Aghun Sali, Ampaki, Asu Dhan (Ahu Dhan), Beto Bao, Bhog Dhan, Bhogmai, Borni, Damua, Dhepa, Gopal Bhog, Isong, Jwsa Daotu, Jwsagwswn, Kartik Sali, Lal Hincha, Mai Gosham, Maibra, Maima, Malsira, Nagari, Parimal, Sadu Dhan, Sal Bao, Salibawa and Sandojwsa. Bsara Puthiya, Dubraj, Kalagauriya* and *Lal Bhosi*) are newly added landraces to NGB. Among these, *Gopal Bhog* and *Maibra* are consumed during festive times; *Dhepa, Jaldepha, Bao* and *Hawai* are known for their submergence tolerance; *Kartik Sali* for early maturity. Variability in rice was observed for maturity, plant height, panicle colour, sterile glume colour, lemma awniness, husk color, grain size, shape, kernel skin colour, glutinous/non-glutinous scented/non-scented nature. Natural introgressed germplasm between rice and *Oryza rufipogon;* semi-aquatic rice *Beto Bao* with awns were interesting collections. In blackgram, a landrace *Matikala* with pinkish-brown skin colour was commonly grown landrace in Kokrajhar; while greenish ashy grained blackgram, which yields less sticky batter was collected from Dhubri district; a unique collection in green gram with high seeds/pod (13 seeds), also collected. In taro, variation was observed for tuber size, shape, apart from petiole pigmentation; 'Panchmuki' taro with 5-7 faces in tubers was collected from Saralpara forested village adjoining to Bhutan. *Malva verticillata*,

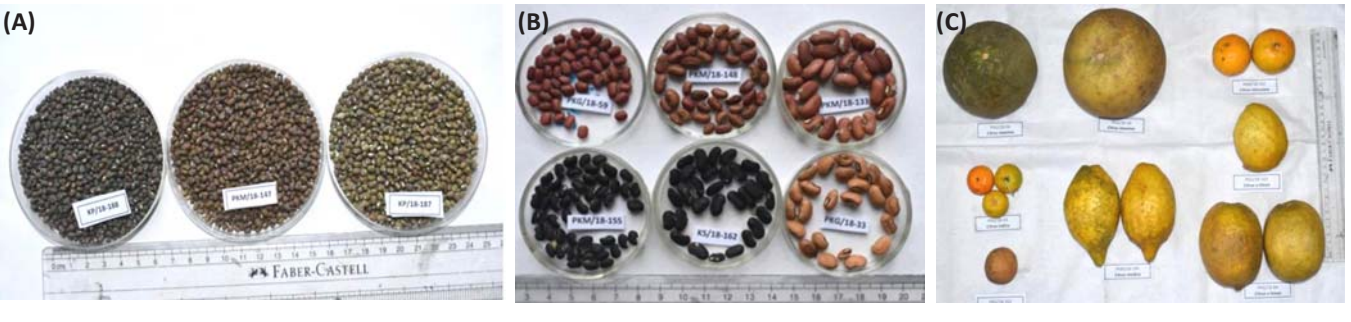


Fig. 1.5: Diversity from Kokrajhar, Assam. A: Urd; B: Cowpea; C: Citrus

locally known as *Lapha*, is popularly gown as a winter season leafy vegetable, irrespective of community. *Plectranthus ternifolius* and *Phlogacanthus thrysiformis* are cultivated in kitchen garden by Bodos for leafy vegetable purpose. Most of the households grow *Oroxylum indicum* for the flowers used as vegetable, besides overall medicinal value.

In another exploration, a total of 77 accessions comprising of *Oryza sativa* (44), *O. rufipogon* (4), *O. nivara* (2), *Vigna mungo* (4), *V. unguiculata* (2), *Sesamum indicum* (3), *Brassica juncea* (2), *Capsicum annuum* (2), *Luffa aegyptiaca* (2), *Lagenaria siceraria* (2), and others (10) were collected from parts of Udalguri and Darrang districts of Assam. The notable collections include 39 landraces of rice (*Badshah Bhog, Bahadur Boni, Bet Guti, Boga Joha, Boni Dhan, Bora Dhan, Borni, Borsali, Eyejung Buni, Garbasali, Gettu, Guru Pukhi, Haldharam, Jamuna Boni, Jawsa, Joha, Joha Boni, Kala Joha, Kala Musara, Kalamdani, Kali Bet Guti, Komal Dhan, Kunkuni Joha, Kunkuni Joha (Scented), Lata Hali, Maal Sua, Maigawsum, Malbhog Boka, Moi Leti, Old Upendra, Raj Dhan, Rukmani Buni, Sanga Dhan, Siyalgati, Suhagmoni, Suhagmoni (*small seed*), Tea Rice, Tingri and Tulsi Joha); Khilini* and *Suraj mukhi* landraces of *Capsicum annum, kalo dal* of *Vigna mungo. Oryza nivara* called as *Bao dhan*, is eaten in remote, tribal areas. Significant population of *O. rufipogon* were found in Sonitpur and Udalguri districts (Fig. 1.6). A large diversity in rice landraces was collected, and recorded their use in different items and suitability of cultivation for different conditions. Some of the farmers are still preserving the diverse landraces of rice and traditional cultivars of horticultural crops.

***Explorations in underexplored areas of Meghalaya*:** A total of 77 germplasm accessions including 28 rice landraces (*Purabini, Mal Bhog, Malschira, Sillgutti, Kalazeera, Minil, Lakhipur, Tulsimala, Champali, Minil Kakua, Minil Gitchak, Minil Agunia, Kuchia, Sarang, Jorong, Sarang, Chaging, Minil Danggap, Mirosi, Chaging, Mimachureng, Minil Gachcha, Minil Gambal, Mikatchu, Mi Phisa, Mima Misomal, Minil Gapok, Mima Boldak* and *Mima Mianjke)*; 9 maize landraces (*Meraku, Meraku Sobok, Meraku minil, Mikop, Meraku Berma, Meraku Agra* and *Meraku Badur)*; *Citrus* spp. (11); pseudo-cereals and minor millets (6); vegetables (9); pulse/grain legume (3); tuber & rhizomatous crops (6); other crops (5) were collected from South Garo Hill district of Meghalaya. Significant variability was observed for grain & kernel size, shape and colour in rice; grain colour (yellow, cream, white and reddish black), cob shape & size in maize; panicle shape & size, grain colour (black, yellowish, & blackish) in foxtail millet; fruit size & shape, rind clour & thickness, aroma, number of fruits in Citrus. An interesting collection in soybean with bushy plant type, grains small, greenish yellow, 2.5-3 cm long pods with 2-3 grains per pod was also collected (Fig. 1.7).

Fig. 1.6: Diversity from Assam, A: Rice collection from a farmer in Udalguri; B: *Oryza rufipogon* in Sonitpur & Udalgiri; C: Grains of *O. rufipogon*

Fig. 1.7: Variability from South Garo hills, Meghalaya, A: Paddy grains; B: *Citrus* spp.; C: *Coix* with red leaf

In another exploration, ninety-three germplasm samples comprising of rice (57), maize (8), foxtail millet (12), brinjal (3), *Amaranthus* spp. (3), sesame (2), and other crops (8) were collected from remote localities of South West and West Garo Hill districts of Meghalaya (Fig. 1.8). Variability was observed in 43 rice landraces (*Babu jaha, Ganji, Goriya, Halai, Jaha gapok, Jaha ghisim, Kala bini, Kala jira, Kishormi, Kotchu-ghisim, Malbhog, Mekudep, Memietim gitchak, Mi bissa, Mi chandak, Mi kotchu, Mi kudep, Mi ma, Mima buring, Mima gurum, Mima boldok, Mima ghisim, Mima-gitchak, Mi miraka, Minil dokdang, Minil midambak, Minil mikohgken, Minil Mikongsi, Minil nasket, Minil aringa, Minil ghipok, Minil gitchak, Minil guhati, Minil michmopok, Minil pappu, Mi wasit, Nal bini, Pura bini, Raha bini, Rangabhog, Rong-chram, Tairol, Thepra*) for grain husk colur (golden, yellow, blackish, red), kernel colour (white, creamy, red, black, greenish, off-white), sticky and non-sticky, scented types, awned & awnless; 8 maize landraces (*Minil gitchak, Miraku wabok, Gippok, Bini maku, Miraku jagiting, Miraku agatchi, Miraku ashok, Miraku bolmag*) for cob size, no. of cobs per plant, sticky, graincolour (white, reddish, yellow).

***Exploration in remote areas of Arunachal Pradesh*:** A total of 82 germplasm accessions include cereals, millets & pseudo-cereals (45) with 15 rice landraces (*Ambing, Taker, Gezang, Pelu, Moyina, Umpang, Panging, Datung, Amsher, Jajung, Jabar, Ammo, Takiyer, Aamkel* and *Amsing*), maize (8), finger millet (5), soybean (5), Coix (4), *Solanum* spp. (4), foxtail millet (3), perilla (3), chilli (3), chenopod (2), buckwheat (2), adzuki bean (2), ricebean (2), mustard (2), sesame (2), ginger (4), *Allium* spp. (3), and other crops (5) were collected from Upper Siang district of Arunachal Pradesh (Fig. 1.9). Significant variability was observed in upland and irrigated rices for grain and kernel size, shape and husk colour. In maize, variability was observed for grain colour (yellow, cream, white and reddish black), shape, size and cob size. Three types of soybean (creamy bold, greenish- white and whitish- brown flat small grain) were collected. Wild species (*Tubocapsicum anomalum*) allied to

Fig. 1.8: Variability in S.W.Garo hills in Meghalaya, A: Foxtail millet; B: Paddy; C: Maize

Fig. 1.9: A: Fruits of *Tubocapsicum anomalum:* newly reported taxa from Arunachal Pradesh; B: *Maclura cochinchinensis* 'Tayun': a wild edible fruit from Arunachal Pradesh

chilli was collected first time from India. Another wild edible fruit *Maclura cochinchinensis* was also collected. The *Coix* is cultivated in *jhums* under rainfed conditions on large area in Mariyang circle for food, animal feed and to brewed local wine from its grain and also used to its grains to trap the rats in the fields.

***Multi-crop exploration in underexplored districts of Manipur*:** A total of 76 germplasm samples include 32 rice landraces (*Sang Bu, Buman, Sang Buman, Edo, Bupui, Tielte, Buman Dum, Buman Hmui, Bupui Chawte, Thangjingphou, Uidow Tei Buman, Maivarsa Bu, Pawn Bu Malzawn San, Malsang Buman, Sunpawl Bu, Mante Hmui, Zongam Bu, Maltam Bu, Sunpawl, Satsuok Bu, Sangailo Bu, Pawn Bu, Pherzawl Tei, Tielpui, Man Sen Hmui, Kawnglaung Buman, Faisen Buman, Mantlep Buman* and *Mansun*) with variability in grain and kernel colour, shape and size, maize (7), rice bean (5), *Perilla frutescens* (4), cowpea and yard-long bean (3), sesame (3), chilli (3), *Phaseolus vulgaris* (2), *Abelmoschus tetraphyllus var. pungens* (2), *Brassica* spp. (2), brinjal (2), and others (11) were collected from Churachandpur and Pherzawl districts of Manipur (Fig. 1.10). The landraces of rice possess significant characteristics as variation in maturity, plant height, grain yield and rice quality (stickiness, softness, aroma); while in maize, variability was observed for grain colour (red, blackish, creamy, off-white, white and yellow) and shape.

***Germplasm collection in unexplored areas of Tripura*:** A total of 51 germplasm samples of 19 crops/species, which includes *Vigna mungo* (11), *Cajanus cajan* (10; Fig. 1.11), *Lablab purpureus* (4), *Solanum nigrum* (3), *S. anguivi* (2), *Brassica rapa*

Fig. 1.10: Variability in paddy and maize from Manipur

var. *yellow sarson* (3), *Calopogonium mucunoides* (3), *Pueraria phaseoloides* (2), *Sesamum indicum* (2), wild *Solanum* (3) and others (12) were collected from parts of Gomati, South Tripura and Dhalai districts of Tripura. Variability was observed for seed shape, size and colour in pigeonpea. *Vigna mungo* and *V. radiata* germplasm were collected with variability in seed shape and size. Local people were using *Solanum anguivi* and *S. torvum* as chatni or pickle.

Fig. 1.11: Variability in pigeonpea collected from Tripura

Exploration in remote districts of Mizoram: A total of 52 accessions comprising of cultivated (49) and wild (3) samples of 20 taxa, which include *Zea mays* (11), *Vigna umbellata* (5), *Oryza sativa* (4), *Perilla frutescens* (4), *Vigna unguiculata* (3), *V. unguiculata* subsp. *sesquipedalis* (3), *Capsicum annuum* (3), *Abelmoschus esculentus* (2), *Glycine max* (2), *Canavalia gladiata* (2), *Brassica rapa* var. *brown sarson* (2), *Sesamum indicum* (2), *Solanum violaceum* (2), and others (7) were collected from parts of Lunglei, Lawngtlai and Saiha districts of Mizoram (Fig. 1.12). Eleven distinct accessions of maize commonly known as *Mimban/Faisa/Viamim* with variability for number of cobs per plant, cob shape, size and grain colour were collected. Dent, flint, popcorn types maize with black, red, white, off white, yellow colour seeds, locally known as *Viamim* are used by tribal people for preparing soups and other cusines. The unique diversity/ variability of cowpea landraces locally known as *behlawi, bete* was observed for seed shape, size and colour. *V. unguiculata* var. *sesquipedalis* germplasm with variability in seed shape, size and colour was also collected.

1.2.2 Horticultural crops

***Collecting underutilized tropical fruits from Konkan region*:** A total of 39 germplasm samples in tropical underutilized minor fruits belonging to *Garcinia indica* (14), *Carissa caranda* (9), *Buchanania lanzan* (6), *Salvadora persica* (3), and others (7) were collected from remote localities of Goa (North and South) and Konkan region (Sindhudurg district) of Maharashtra (Fig. 1.13). Variability was observed for fruit shape (oval, rounded, pear shaped), size (small, medium and large), taste (sweet and sour), colour (red, brown, grayish), branching pattern (upright and pendulous), leaf size and colour in *Garcinia indica*;

Fig. 1.12: Variability from Mizoram, A: Maize; B: *Momordica subangulata* var. *renigera:* an underutilized vegetable; C: *Stixis sauveolens:* a wild edible fruit

Fig. 1.13: Variability from Konkan, A: *Garcinia indica*; B: Karonda fruits for sale

fruit size (rounded and oval), plant size and leaf size in *Carissa caranda*. Good population of *Buchanania lanzan* was observed in Mangaon-Shivapur forest (Kudal Taluk), with early maturity.

Collecting cucurbitaceous vegetables from parts of Rajasthan & Haryana: A total of fourteen accessions comprising of vegetable melon 'Arya'- *Cucumis melo* (6), *C. melo* var. *agrestis* (5), *C. melo var.momordica* (3) were collected from parts of Alwar district (Rajasthan) and Rewari district (Haryana), known for cultivation of these landraces in limited pockets. Variability in size and shape of vegetable melons particularly 'Arya' (green, striped and whitish yellow fruited) was recorded (Fig. 1.14).

Collecting wild okra from foothills Uttarakhand and U.P: A total of 55 accessions comprising of wild okra *Abelmoschus manihot* var. *tetraphyllus* (20), *A. manihot* var. *pungens* (13), *A. tuberculatus* (7), *A. ficulneus* (3) and other crops like *Solanum nigrum* (2), *Sesamum mulayanum* (2), and others (7) were collected from parts of Haridwar, Rishikesh, Dehradun districts of Uttarakhand; and adjoining Sirmour districts of Himachal Pradesh and Sonipat district of Haryana (new record on distribution for *A. tuberculatus*). Significant collections included: the closest wild relatives of cultivated okra, *A. tuberculatus*, *A. ficulneus* and a more common species *Abelmoschus manihot* var. *teraphyllus* and var. *pungens* from wild, semi-domesticated/protected habitats (Fig. 1.15).

Fig. 1.14: Variability in melons from Alwar, Rajasthan, A: Fruit variability; B: 'Arya' *C. melo*- a newly collected melon

Fig. 1.15: A: Cultivation of wild *Abelmoschus manihot* ssp. *tetraphyllus* (Shuklai); (B) Harvested stems for sale from Saharanpur, Uttar Pradesh

Among the other collected accessions wild *Corchorus capsularis, C. trilocularis, Trichosanthes cucumerina*, *Solanum nigrum, Sesamum mulayanum, Ziziphus nummularia, Physalis peruviana* and *Diplocyclos palmatus* were important wild useful species. Gradual reduction in traditional farming practices leading to loss of local/traditional cultivars under cultivation was observed in parts of Somali, Saharanpur in Uttar Pradesh and Roorkee, Rishikesh in Uttarakahand.

Collecting vegetables from remote districts of Tripura: A total of 299 accessions comprising of *Capsicum annuum* (28), *Cucurbita moschata* (26), *Solanum melongena* (22), *Cucumis sativus* (22), *Benincasa hispida* (20), *Lablab purpureus* (20), *Luffa acutangula* (15), *Vigna unguiculata* (15), *Coriandrum sativum* (11), *Lagenaria siceraria* (10), *Zea mays* (9), *Trichosanthes cucumerina* (7), *Momordica charantia* (6), *Abelmoschus esculentus* (6), *Solanum torvum* (6), *Sesamum indicum* (6), *Brassica juncea* (5), *Vigna umbellata* (4), *Luffa cylindrica* (7), *Solanum aethiopicum* (4), *Amaranthus tricolor* (4), *Setaria italica* (4), *Solanum violaceum* (4), *Solanum viarum* (3), *Phaseolus vulgaris* (3), *Cajanus cajan* (3), *Basella alba* (3), *Oryza sativa* (2), *Mucuna pruriens* (2), *Brassica juncea* var. *rugosa* (2), *B. rapa* var. *yellow sarson* (2), *Citrullus lanatus* (2), *Moringa oleifera* (2), *Vigna unguiculata* subsp. *sesquipedalis* (2), *Raphanus sativus* (2) and other crops (10) were collected from Khowai, Dhalai, Gomati and South Tripura. Variability was observed for fruit colour (light green to green), shape and size (long, round, pear shaped) in bottle gourd; green,purple,purple black coloured fruits having with long, oblong, round shaped fruits in brinjal; small round, small thin,long thin shaped fruits in chillies; brown and black seeded types in cowpea; white and purple flowered having brown, brownish black, black, light green, light brown, dark purple, white seeded types in dolichos bean; cylindrical long flatish round fruit shape in pumpkin.

Collecting vegetables from tribal dominated districts of Bihar: A total of 75 accessions comprising of *Luffa acutangula* (11), *L. cylindrica* (11), *Momordica charantia* (11), *Lagenaria siceraria* (10), *Cucurbita moschata* (7), *Luffa hermaphrodita* (6), *Trichosanthes cucumerina* (4), *Cucumis melo (3), Benincasa hispida* (2), and others (10) were collected from parts of Arwal, Aurangabad, Rohtas, Bhojpur, Buxar, Kaimur districts of Bihar. Variability for fruit size and shape in sponge gourd, ridge gourd and bottle gourd was observed.

1.3 On-farm crop diversity survey and conservation

Seeds of identified crops landraces of rice (*Chwari dhan*), buckwheat, foxtail millet, cheena and rajma (*Chakarata rajma* and *Panchgain rajma*) were distributed among the selected farmers in

identified 18 villages in three districts (Dehradun, Tehri and Uttarkashi) of Uttarakhand for *on-farm* conservation and multiplication during *Kharif* 2018 (Fig. 1.16). An obsolete landrace of wheat (*Menshre*) was also identified and procured from Jaunpur area of Tehri and distributed among the 23 selected farmers of 10 villages (six villages in Jaunsar-Bawar area and four villages of Ranwain area for *on-farm* conservation and multiplication during *Rabi* 2018-19). The information on farmer's economic status, cropping systems, crop rotations, crop status of erosion, uses of fertilizers/chemicals, seed source & seed storage systems, role of local crop landraces in their daily needs and uses of wild & medicinal and aromatic plants in routine use was also completed from the informants.

1.4 National Herbarium of Cultivated Plants

A total of 690 herbarium specimens, seed samples and economic products were added to the National Herbarium of Cultivated Plants (NHCP), making to a total collection of 23,665 herbarium specimens (representative of 4,271 species belonging to 1,521 genera and 267 families), 3094 seed samples and 720 economic products. Eighty-four taxa, not represented earlier, were added as specimens and digital images to the NHCP (Table 1.4). Herbarium specimen (326) of *Coix lacryma-jobi* var. *stenocarpa, Paspalum scrobiculatum, P. sumatrense, Momordica dioica, Amaranthus tristis, Alternanthera philoxeroides, Solanum virginianum, Abelmoschus manihot* subsp. *tetraphyllus, Cajanus scarabaeoides, Musa indandamanensis* and *Trichosanthes anaimalaiensis* were added from explorations to Andaman & Nicobar Island, Andhra Pradesh, Chhattisgarh, Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Rajasthan and parts of Uttarakhand. Other collections included as herbarium specimens of *Allium* species, *Chenopodium ambrosioides, Rubus fruticosus, Solanum nigrum, Sorbus lanata, Spiraea chamaedryfolia* and *Potentilla argyrophylla* (214; regional station Bhowali, Shimla and base centre Cuttack, Odisha); experimental vouchers of species under *Allium*, *Hordeum*, *Luffa*, *Cucumis*, *Vigna stipulacea* and *V. trilobata* and *Phoenix* sp., (*Agave, Abelmoschus, Hibiscus* and *Crotalaria* Barrakpore, Kolkata); seeds of *Hyptis suaveolens* and *Phaseolus coccineus* from Uttarakhand, *Perilla frutescens* from Sikkim and *Ocimum basilicum* from Mumbai, Maharashtra; dried fruits of *Prosopis cineraria, Canavalia gladiata, Myristica fragrans, Semecarpus anacardium, Garcinia gummi-gutta, Theobroma cacao, Cyclanthera pedata, Smila x zeylanica* from Rajasthan and Thrissur, Kerala, Meghalaya and Uttarakhand. Identification services were provided (20) and authentication certificates (18) issued to students and researchers for material taken up for experimental study.

Digitization of NHCP: A total of 886 specimens/ taxa belonging to crop genepools were authenticated and digitised including 84 taxa unrepresented in NHCP resulting into a total of 8,409 digitised images. Among them significant ones were *Abelmoschus mizonagensis*, *Corchorus pseudo-olitorius*, *Trichosanthes smilacifolia*, *T. truncata*, *Solanum macrocarpum*, *Rosa longicuspis*

Fig. 1.16: Seed distribution of crops, A: Performance of Panchgain rajma distributed in Pokhari village for seed chain; B: Obsolete wheat landrace *Menshre* to the farmers in Pokhari and Mehravana villages

and *Xanthosoma sagittifolium.* The digital images of reference herbarium specimen(s) were placed in respective database.

1.5 Biosystematics studies

Biosystematics studies were undertaken during explorations in natural habitats (in Sikkim, West Bengal and Meghalaya, surveyed Garalgacha, Barlgachia, Kalipor, Chapadanga, Tarkeswar and Barasat areas, Dauki (Bangladesh border), Mawsyram (South-East side) and Diengposah (South-West side) for *Trichosanthes* and Niti valley, Uttarakhand and Kishtwad in Jammu and Kashmir for *Allium*. Studies of herbarium (70) specimens in Gangtok (BHSC) and experimental work (50 accessions; in pots) resulted in micro-morphological observations on leafy amaranth. About 150 herbarium specimens belonging to about 10 taxa were collected as vouchers. Based on study of field collected specimens, data from various herbaria and the observations made are presented below:

Trichosanthes: Consolidation of work on systematics showed the occurrence of 13 species (16 taxa) of *Trichosanthes* (excluding *Gymnopetalum*). Infrageneric classification indicated these species belonged to those two subgenera and five sections. Diagnostic key for identification of all the Indian taxa was completed. New distribution of *T. tricuspidata* and *T. pilosa* in Great & Little Nicobar; new occurrence of *T. kerri* in Manipur; extended distribution of *T. anaimalaiensis* in Manipur and Nagaland; *T. cordata* in Bihar and Uttar Pradesh; *T. cucumerina* subsp. *suiblobata* in Gujarat, Madhya Pradesh and Odisha; *T. dicaelosperma* in Nagaland; *T. Kerrii* in Arunachal Pradesh and Manipur. *T. majuscule* in Arunachal Pradesh, Assam and Sikkim; and *T. truncata* in Nagaland were noted. Two taxa, namely, *Trichosanthes dicaelosperma* and *T. majuscule*, earlier combined with *T. ovigera/ T. cucumeroides* and *T. dunniana*, respectively were described. A new taxon namely *T. dunniana* subgsp. *clarkei* from Sikkim and hills of West Bangal in northeastern India; and the first confirmed records of four southeast Asian taxa, *viz., T. dunniana* subsp. *dunniana, T. inthanonensis* and *T. wallichiana* subsp. *subrosea* from north-eastern India and *T. tricuspidata* from Andaman & Nicobar Island. While south Chinese *T. subrosea* was transferred at reduced rank *as T. wallichiana* subsp. *subrosea* and *T. tridentata* has been synonymed to this subspecies. A total of 104 accessions involving snake gourd and related species were collected.

***Amaranthus*:** Experimental study in *Amaranthus* spp. (10) available at ICAR-IIVR, Varanasi and NBPGR-Regional Station, Shimla was carried out for consolidation of work on systematics; occurrence of six species (15 taxa) under leafy amaranth group was recorded. An updated diagnostic key for identification of all these 15 taxa was prepared, especially of PGR workers and traditional botanists.

***Luffa*:** In *L. hermaphrodita* diverse accessions were compared with related *L. acutangula* using molecular analysis. Analysis of data/information and report on *Luffa* genetic resources in India with future gaps in North Eastern region (Chhattisgarh, Bihar) for satputia (the hotspots in tribal tracks) was identified for collection.

Allium: Phylogenetic and molecular evolutionary analyses have confirmed the relationships amongst the members of subg. *Cepa* and *Polyprason, A. roylei* based on sequence analyses of the ITS region. Field identification key was developed for Indian *alliums* for sect. *Cepa* and subg. *Polyprason.* Field study undertaken in Niti valley, Uttarakhand and grow out test in RS Bhowali of *A. stracheyi* and earlier collections of *Allium* from Kashmir and *A. roylei* in Kishtwad region of Jammu and Kashmir showed variation among the taxa mainly for flower colour.

1.6 Diversity mapping in agri-horticultural crops

Geo-referencing and mapping of 2,532 accessions of kodo millet (*Paspalum scrobiculatum*), 1,745 accessions of little millet (*Panicum sumatrense*) and 1,485 accessions of proso millet (*P. miliaceum*) collected from various parts of the country was done (Fig. 1.17). Mapping of assembled diversity has shown that Karnataka (1,041) followed by Madhya Pradesh (468), Maharashtra (350), Chhattisgarh (147), Uttar Pradesh (125), Andhra Pradesh (83), Tamil Nadu (76), Gujarat (55) and Telangana (51) in Kodomillet; Karnataka (454) followed by Andhra Pradesh (339), Maharashtra (229), Madhya Pradesh (200), Tamil Nadu (125), Odisha (104), Chhattisgarh (83) and Bihar (59) in little millet; and Karnataka (579) followed by Himachal Pradesh (179), Maharashtra (129), Madhya Pradesh (124), Chhattisgarh (88) and Andhra Pradesh (62) in proso millet were extensively explored states. Whereas areas have been identified for future collection in prosomillet are: Arunachal Pradesh (Anjaw, Changlang, Lower Dibang valley, Upper Dibang valley, Upper Siang, West Siang, Tawang, East and West Kameng); Gujarat (Chhota Udaipur, Surat, Tapi, The Dangs); Jammu & Kashmir (Kishtwar, Kargil and Leh); Odisha (Kandhamal, Rayagada and Kalahandi) and Sikkim (East, South, West and North) as gaps.

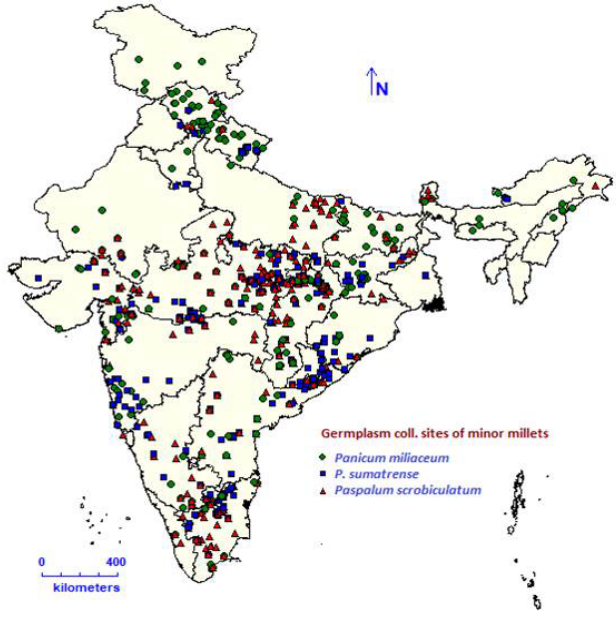


Fig. 1.17: Germplasm collection sites of *Paspalum scrobiculatum, Panicum miliaceum* & *P. sumatrense*

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

PGR/PGC-BUR-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/PGC-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, PK Malav [till 30th June, 2018]and *NS Panwar*)

PGR/PGC-BUR-DEL-01.02: Exploration for collection of genetic resources of horticultural crop species and their wild relatives (**KC Bhatt**, K Pradheep, RS Rathi, DP Semwal, S Nivedhitha and Soyimchiten)

PGR/PGC-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 & *Rita Gupta*)

PGR/PGC-BUR-DEL-01.04: Systematic studies of native crop taxa (**K Pradheep**, Anjula Pandey, KC Bhatt, S Nivedhitha and *Rita Gupta*).

PGR/PGC-BUR-DEL-01.05: Geo-informatics for assessment of diversity distribution in agri-horticultural crops (**DP Semwal**, KC Bhatt, Anjula Pandey, N Sivaraj, Soyimchiten, PK Malav (till 30th June, 2018) and *NS Panwar*)

PGR/PGC-BUR-DEL-01.06: Survey, collection and assessment of *in-situ* /on-farm crop diversity in the Indian Himalayan Region (RS Rathi, KC Bhatt, SK Malik, **DP Semwal**, PK Malav (till 30th June, 2018) *NS Panwar, PS Mehta*)

GERMPLASM EXCHANGE UNIT 2

Summary: During the period under report 56,183 accessions (1,58,117 samples) were imported which included 37,515 accessions (38,229 samples) of germplasm and 18,668 entries (1,19,888 samples) of CGIAR nurseries for trials. 21,909 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, 61544 samples were supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

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 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. Additionally 692 accessions imported were of Indian origin and assigned IC numbers. Introductions of seed/planting material made during the year were as follows:

Germplasm accessions procured and processed	:	37,515 accessions (38,229 samples)
CGIAR nurseries for trials	:	18,668 entries (1,19,888 samples)
No. of countries involved	:	36
No. of Import Permits issued	:	600
Resource generated	:	₹ 75,42,675/-

Cereals: *Agropyron* sp. (1) from USA; *Elymus angulatus* (3), *E. aristiglumis* (1), *E. canadensis* (1), *E. caninus* (1), *E. czimganicus* (1), *E.dentatus* (3), *E. dahuricus* (3), *E. fibrosus* (1), *E. glaucus* (2), *E. gmelinii* (1), *E. lanceolatus* (2), *E. magellanicus* (1), *E. mutabilis* (2), *E. nutans* (2), *E. patagonicus* (1), *E. pendlinus* (2), *E. repens* (21), *E. schrenkianus* (2), *E. semicostatus* (4), *E. siiricus* (3), *E. trachycaulus* (2), *E. tsukushiensis* (2) all from USA; *Hordeum vulgare* (407) from Australia, (218) from Netherlands, (288) from USA; *Oryza alta* (1), *O. australiensis* (1), *O. barthii* (1), *O. brachyantha* (1), *O. glaberrima* (3), *O. glumaepatula* (4), *O. grandiglumis* (4), *O. granulata* (1), *O. longiglumis* (1), *O. longistaminata* (2), *O. meridionalis* (1), *O. minuta* (4), *O. nivara* (4), *O. officinalis* (1), *O. punctata* (1), *O. ridleyi* (1), *O. rufipogon* (4) all from Philippines, *O. sativa* (86) from Belgium, (4) from Brazil, (7) from China, (36) from Nepal, (4324) from Philippines, (1) from Thailand, (5) from UK, (498) from USA, (6) from Vietnam; *Triticale* (x *Triticosecale*) (2) from USA; *Triticum aestivum* (1146) from Australia, (4) from Canada, (1) from Germany, (574) from Mexico, (30) from South Africa, (742) fromUK, (39) *T. aestivum* subsp. *aestivum* (1) from USA, *T. dicoccum* (45) from Morocco, *Triticum* sp. (36) from Mexico, *T. spelta* (25) from USA; *Zea diploperennis* (2) from CIMMYT, Mexico, (1) from USA, *Zea mays* (42) from Argentina, (426) from Brazil, (3614) from Chile, (1) from Czech Republic, (166) from France, (3) from Germany, (85) from Indonesia, (4) from Italy, (25) from Kenya, (2585) from Mexico, (20) from Nigeria, (2896) from Philippines, (592) from South Africa, (6943) from Thailand, (3519) from USA, (25) from Zimbabwe, *Zea nicaraguensis* (2) from USA.

Millets: *Eleusine coracana* (383) from Kenya, *Eleusine indica* (8) from UK, *Pennisetum glaucum* (90) from Kenya,(30) from UK, *P. hohenackeri* (1), *P. mezianum* (1), *P. orientale* (2), *P. purpureum* (6), *Pennisetum* sp. (12) all from UK; *Sorghum bicolor*

(691) from Kenya, (31) from Japan, (1) from UK, (6) from USA.

Oilseeds: *Brassica carinata* (2) from Tanzania; *Brassica juncea* (391) from Canada, (1) from Germany; *Carthamus tinctorius* (210) from USA; *Glycine max* (40) from USA, (1) from Taiwan, *G. soja* (2) from USA; *Helianthus annuus* (395) from USA; *Ricinus communis* (98) from USA; *Sesamum indicum* (2) from Turkey.

Grain legumes: *Cajanus scarabaeoides* (14) from UK; *Cicer arietinum* (38) from ICARDA, Morocco, (11) from USA; *Pisum sativum* (17) from USA; *Vigna radiata* (9) from Afghanistan, (2) from (USA); *Vigna unguiculata* (4) from USA.

Vegetables: *Abelmoschus esculentus* (274), *A. manihot* (17), *A. moschatus* (38) from USA; *Allium cepa* (2) from Netherlands; *Brassica oleracea var. botrytis* (157) from Kenya, (4) from Netherlands; *Brassica oleracea var. capitata* (168) from Netherlands; *Capsicum annuum* (1) from Bangladesh, (19) from China, (4) from Guatemala, (20) from Korea, (3) from MEXICO, (775) from Netherlands, (218) from Taiwan, (6) from Tanzania, (4) from Thailand, (48) from USA; *Citrullus lanatus* (7) from China,(2) from Netherlands, (229) from USA, (13) from Vietnam, *Citrullus* sp. (1) from USA; *Cucumis melo* var. *utilissimus* (10) from France, *Cucumis sativus* (2) from Bangladesh, (755) from Netherlands, (13) from Taiwan; *Cucurbita moschata* (13) from Vietnam; *Daucus carota* (13) from USA; *Lactuca sativa* (1) from Netherlands; *Lagenaria siceraria* (2) from Bangladesh; *Lens culinaris* (7) from Bangladesh, (7) from Nepal; *Luffa acutangula* (20), *L. aegyptiaca* (23), *L. graveolens* (1), *L. operculata* (1) all from USA; *Momordica charantia* (17) from Bangladesh, (2) from Tanzania, (514) from Thailand, (1) from USA; *Solanum aethiopicum* (3) from Tanzania, *S. chilense* (26), *S. corneliomulleri* (15), *S. galapagense* (10), *S. huaylasense* (4) all from USA, *S. lycopersicum* (9) from Australia, (1) from Czech Republic, (59) from Guatemala, (167) from Israel, (96) from Netherlands, (130) from Taiwan, (7) from Tanzania, (37) from Thailand, (311) from USA, *S. lycopersicum* var. *cerasiforme* (1) from USA; *Solanum melongena* (4) from Taiwan; *S. pennellii* (11), *S. peruvianum* (8) both from USA; *S. scabrum* (1) from Tanzania, *Solanum* sp. (2) from USA; *Trigonella caerulea* (1), *Trigonella* sp. (1), from Germany.

Fruits: *Artocarpus heterophyllus* (7) from Kenya, (3) from Nepal; *Hippophae rhamnoides* (2) from Russia; *Malus domestica* (2), Malus sp. (3) both from USA; *Mangifera indica* (1) from Vietnam; *Musa jackkeyi* (1), *M. paradisiaca* (2), *Musa* spp. (9), *M. textilis* (1) all from INIBAP, Belgium; *Punica granatum* (45) from France, (2) from USA; *Siraitia grosvenorii* (1) from China.

Forages: *Setaria viridis* (1) from USA.

Fibres: *Gossypium arboreum* (121), *G. barbadense* (209) both from USA, *G. hirsutum* (1) from Belgium, (353) *Gossypium* sp. (70) from USA.

Medicinal and Aromatic plants: *Cannabis sativa* (7) from Czech Republic, (3) from Hungary, (1) from Serbia.

Spices: *Ferula asafoetida* (6) from Iran.

Potential Crops: *Amaranthus cruentus* (3), *A. dubius* (1), *A. hypocondriacus* (1), *A. tricolor* (2) all from Tanzania; *Jatropha curcas* (72) from Germany.

Tubers: *Solanum tuberosum* (2) from Australia, (7) from Chile, (7) from Holland, (20) from Netherlands, (97) from Peru, (15) from UK, (28) from USA.

Narcotics: *Papaver somniferum* (7) from Australia.

Beverages: *Coffea canephora* (3) from France.

Table 2.1: Trait specific seed/planting material imported in 2018.

Crop/EC No./Country	Specific Traits	Distribution
Paddy		
EC955800 / IRRI, Philippines	Nematode resistant	Indian Statistical Institute, Giridih
EC955801-828/ IRRI, Philippines	Wild species	ICAR-NIBSM, Raipur
EC956439-956453/ Nepal	Submergence and bacterial blight tolerance	ICAR-NRRI, Cuttack
EC966570-966583/ IRRI, Philippines	High Zn content rice lines	ICAR-NRRI, Cuttack
Wheat		
EC968471-969176/ UK	Double haploid lines from UK	PAU, Ludhiana
EC946384-946387/ Canada (Fig. 2.1A)	Heritage wheat varieties with excellent grain quality namely Ladoga, Bishop, Marquis and Red fife	ICAR-NBPGR, New Delhi
EC949682-949712/ CIMMYT, Mexico	Ditelocentric genetic stocks	ICAR-NRCPB, New Delhi
EC955298-955309/ UK	*Zip4-Ph* mutant lines	ICAR-IARI, New Delhi
EC958797/ USA	Cultivar USA-Apogee (NSSL Registration no. 331390, PI592742), very short life cycle cultivar, unique material used to accelerate cycling breeding lines, dwarf hard red, resistance to calcium induced leaf tip necrosis in controlled conditions	SKUAST, J & K
EC967632-967724/ Australia	Leaf rust, yellow rust, stem rust differential set	ICAR-IIWBR, Karnal
Elymus		
EC938713-938773/ USA (Fig. 2.1B)	Wild species *: Elymus angulatus*, E. aristiglumis *, E. canadensis* , E. caninus* , E. czimganicus* , E.dentatus *, E. dahuricus , E. fibrosus *, E. glaucus* , E. gmelinii* , E. lanceolatus* , E. magellanicus* , E. mutabilis* , E. nutans , E. patagonicus , E. pendlinus , E. repens , E. schrenkianus , E. semicostatus, E. siiricus , E. trachycaulus , E. tsukushiensis* (*first time introduction)	ICAR-NBPGR, New Delhi
Barley		
EC967726-967724/ Australia	Rust resistance genes	ICAR-IIWBR, Karnal
Maize		
EC967289-967291/ CIMMYT, Mexico	Large kernels (Cuzco type)	PAU, Ludhiana
EC937995- EC938021 /USA	Short season inbreds , US Protected varieties. Source of useful germplasm in line improvement programs / breeding source to increase grain yield significantly higher extractable starch	ICAR-NBPGR, New Delhi ICAR-IARI, New Delhi
EC941076-77/CIMMYT, MexicoEC938023/USA	Wild species *Zea diploperennis* and *Z. nicaraguensis* (first time introductions)	ICAR-NBPGR, New Delhi

Crop/EC No./Country	Specific Traits	Distribution
Pigeonpea		
EC944119-132/ UK	Wild species (*Cajanus scarabaeoides*)	ICRISAT, Patancheru
Fingermillet		
EC944111-118/UK	Wild species (*Eleusine indica*)	ICRISAT, Patancheru
Sesame		
EC961169-70/ Turkey	New source for phyllody resistance	ICAR-NBPGR, New Delhi
Safflower		
EC938657-938675/ EC938708-938710/ USA	Salinity tolerant	ICAR-NBPGR, New Delhi
EC938676-938683/ USA	High yielding lines	ICAR-NBPGR, New Delhi
EC938684-938691, EC938705, 938706, EC938711/ USA	High Alpha tocopherol	ICAR-NBPGR, New Delhi
EC938695-938704/ USA	Resistant to Phytophthora rot	ICAR-NBPGR, New Delhi
EC938707/ USA	Resistant to verticillium wilt and striped rust	ICAR-NBPGR, New Delhi
Soybean		
EC937291/ USA	High temperature tolerant	TNAU, Coimbatore
Seabuckthorn		
EC935319-935320/ Russia	Superior quality and best tasting berries	
Siratia (Monk fruit)		
EC938819/ China (Fig. 2.2)	Fruit extract is nearly 300 times sweeter than sugar and has been used as a natural sweetener in China for nearly a millennium due to its flavor and lack of food energy, used in traditional Chinese medicine	CSIR-Institute of Himalayan Bioresource Technology, Palampur
Banana		
EC949665/ INIBAP, Belgium	Wild species *Musa textilis* (first time introduction)	NRCB, Thiruchirapalli
EC949666/INIBAP, Belgium	Wild species *Musa jackeyi* (first time introduction)	NRCB, Thiruchirapalli
Apple		
EC971990-971991/USA (Fig. 2.3)	Resistant to fire blight and phytophthora, resistant to collar rot, woolly aphid and drought tolerant	SKUAST J & K
Potato		
EC959700-959703/ Holland	Varieties Camel, El Mundo, Everest and AFP08-59 having good eating quality, high yielding, drought tolerant	Technico Agri Sciences Limited, Chandigarh
EC965736-965792/ CIP, Peru	Resistant and susceptible lines to Poty virus Y	CPRI, Shimla
Hemp		
EC956242 / Serbia	Seed oil content between 28 to 32% and high level protein content (25%)	CSIR-NBRI, Lucknow

Fig. 2.1 A: Heritage wheat varieties (EC946384-387) from Canada; B: Elymus accessions (EC938713-73) from USA growing at Greenhouse

Fig. 2.2: Monk fruit (EC938819), a new introduction from China (Photo Courtesy: IHBT, Palampur)

Fig. 2.3: A: Apple germplasm from USA; B: Pomegranate acc. from France (EC937299-343) C: Hing seeds from Iran (EC968466)

Table 2.2: Details of Transgenic seed material imported during 2018.

Accession No./ Country	Gene/event/trait	Indentor
Arabidopsis		
EC944060-944053/ USA	Harbouring promoters ARR 6: GUS (CS25263) and pCYCLINBI: GUS (CS68142)	Sea 6 Energy Pvt Ltd, Bengaluru
EC961171- EC961179/ USA	Columbia/ Landsberg erecta -T-DNA with insertional mutagenesis	ICAR-National Institute on Plant Biotechnology, New Delhi
Cotton		
EC938774/USA	Lyophilized tissue powder expressing Bt protein	Monsanto Holdings Pvt. Ltd., Bengaluru
EC939630/ Belgium	GHB 614, GHB 119, MON88913 (for proficiency testing)	Bayer Bio Science Private Limited, Hyderabad
EC955798- EC955799/ USA	Lyophilized Leaf Bits containing Event MON757 & MON1445	Monsanto Holdings Private Limited, Bengaluru
EC957250 -EC957252/ USA	MON531 X MON 16985 X MON88913 X COT102	Monsanto Holdings Private Limited, Bengaluru
Maize		
EC937887- 888/ Philippines	TC507 event DAS -01507-1	Pioneer Hi-Bred Private Limited, Medak
EC968353/USA	Lyophilized leaf powder expressing Cry2Ab protein	Monsanto Holdings Pvt. Ltd., Bengaluru
Rice		
EC939631/ Belgium	Devitalized seeds WITH Construct pT1B235 (Hh), LLRICE 62 (HH), LLRICE 604 (HH)	Bayer BioScience Private Limited, Hyderabad

Others: *Arabidopsis thaliana* (13) from USA.

2.2 Export of plant genetic resources

The seed and plant material of agricultural and horticultural crops were exported to other countries on the basis of requests received by NBPGR/ICAR headquarters or from Scientists working in ICAR institutes/SAUs/other universities in India as per approved International Collaborative Research Projects. The plant material intended for export were forwarded to foreign collaborators along with phytosanitary certificates issued by 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 2018 are indicated below.

Under Collaborative Research Projects : A total of 1558 samples sent to Bangladesh (353), Bolivia (353), Philippines (825) and Taiwan (27).

Crop wise export:

Cereals: Wheat (353) Bangladesh, (353) Bolivia ; Paddy (825) Philippines

Grain legumes: Mungbean (27) Taiwan

30 samples of wheat were exported to UK from Central University of HP on approval of National Biodiversity Authority. Also, facilitated supply of FAO designated accessions (1540) of ICRISAT mandate crops to different countries and 16,875 samples of CIMMYT Maize trials/nurseries through RS, Hyderabad. Further facilitated issuance of Phytosanitary certificated for three consignments.

National supply of plant genetic resources

The seed and planting material of diverse agri-horticultural crops were supplied to ICAR institutes/coordinated projects, agricultural universities and other users in India. Based on specific requests received 21,909 samples were supplied under the Material Transfer Agreement (MTA). The crop wise samples and the recipient institutes are listed in table 2.3. In addition a total of 61, 544 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

Table 2.3: National supply of seed/planting material to recipients during 2018.

Crop group/crop	No. of samples	Recipient Institute
Cereals (4275)		
Barley	461	NIN, Hyderabad; IIWBR, Karnal; VPKAS, Almora SKUAST (K), SDAU, Vijapur; CENTRAL Scientific Instrument Organization, Chandigarh; BSI, Kolkata
Maize	232	PAU; IIMR; IARI; RVSKVV, Gwalior; bau, Ranch; Bundelkhand University, Jhansi; Kuvempu University, Shimogga; Maize Improvement Project, Kolhapur; BSI, Kolkata
Rice	1798	VPKAS, Almora; SVBPUAT, Meerut; CSIR-IHBT, Palampur; NRCPB; TNAU; Killikulam; Amity University; IARI, New Delhi; BSI, Kolkata;
Triticale	2	SKUAST (K)
Teosinte	19	IIMR, Ludhiana
Wheat	1763	IARI; CSAUAT, Kanpur; CCSUAT, Meerut; SKUAST (K); CSKHPKV, Kangra; CSUAT, Kanpur; UBKV, Cooch Behar; SDAU, Vijapur; VPKAS, Almora; Rasi Seeds Pvt Ltd; IARI, RS Indore; BSI, Kolkata
Millets (5012)		
Barnyard millet	1002	PAU, Ludhiana
Fingermillet	1505	PAU, Ludhiana
Foxtail millet	1002	PAU, Ludhiana
Little millet	500	PAU, Ludhiana
Pearlmillet	3	BSI, Kolkata;NIABSM, Raipur
Proso millet	1000	PAU, Ludhiana
Grain legumes (2957)		
Chickpea	33	Amity University, Noida; SVBPUAT, Meerut
Cowpea	476	College of Hort., Mandsaur; BSI, Kolkata;, Viswa Bharti, Shantiniketan; IIPR, Kanpur; IIPR RS Dharwad
Dolichos bean	27	SKLTS Hort. Univ., Adilabad
Frenchbean	317	PAU, Ludhiana; IIFSR, Modipuram;, IIPR, Kanpur; SKUAST (K); VCSG Uttarakhand Univ. of Hort. & Forestry, Pauri Garhwal
Horsegram	571	IIAB, Ranchi;HPU, Shimla; KAU, Thriruvananthapuram
Guar	98	Dr YSR Hort. University, AP;ICAR-CAZRI, Jodhpur

Crop group/crop	No. of samples	Recipient Institute
Lentil	40	Kisan PG College, Simbhaoli
Mungbean	469	IARI, New Delhi; IIPR, Kanpur; Viswa Bharti, Shantiniketan; ILS, Bhubaneswar; CARI, Port Blair, LPU, Phagwara; SDAU, Sardar Krushinagar; Annamalai University, Chidambaram; PJTSAU, Madira
Pea	11	IARI, New Delhi; Regional Centre for Biotechnology, Biotech Science Cluster, Faridabad
Pigeonpea	179	IIPR RS Bhopal; Annamalai University, TN; NBPGR
Rice bean	2092	BSI, Kolkata; NIPGR, Delhi; NBPGR; Jiwaji University, Gwalior; University of Delhi; SKUAST (K)
Urdbean	681	CARI, Port Blair; HPU, Shimla; PAU, Ludhiana; Viswa Bharti, Shantiniketan; Osmania University, Hyderabad; SDAU, Sardar Krushinagar; PJTSAU, Madira
Vigna sp.	55	IARI, New Delhi; NBPGR
Oilseeds (3334)		
Crambe	4	NBAIR, Bangalore
Eruca sativa	4	NBAIR, Bangalore
Eruca vesicaria	4	NBAIR, Bangalore
Lepidium	4	NBAIR, Bangalore
Mustard	353	IIT, Guwahati; CCSHAU, Bawal; RB (PG) College, Agra; BSI, Kolkata; Daftari Agro-Biotech, Nagpur; Nuziveedu Seeds; BCKV, Nadia; Tierra Seesd, Hyderabad
Rapeseed	30	Mata Gurjri College, Punjab
Sesame	1978	ANGRAU, Yelamanchi; PJTSAU, Hyderabad; PAU, Ludhiana
Sinapsis alba	1	AAU, Jorhat
Soybean	935	Basant Agrotech, Akola; DSR, Indore; NRC PB; SKUAST (K)
Sunflower	21	UAS, Dharwad; IARI, New Delhi
Vegetables (2193)		
Bitter gourd	90	SKUAST (K); Navsari Agri. University; Annamalai University, Chidambaram
Bottle gourd	185	CCSHAU, Hisar; LPU, Phagwara; IARI, New Delhi
Brinjal	445	TNAU, Coimbatore, Plur; UHS, GKVK, Bangalore; LPU, Phagwara; UAS, Dharwad; Gautam Budh University, Gr Noida; Annamalai University, TN; Dr YSPUAT, Solan; IARI, New Delhi;SKUAST (K)
Carrot	38	UAS, Raichur; SKUAST (K)
Chilli	487	TNAU, Palur; College of Hort. Sci., GKVK, Bangalore; Guru Jambeshwar University of S & T, Hisar; SKLTSHU, Hyderabad; IARI, New Delhi; KM Univ. of Hort Sci., Bagalkot; SKUAST (K); SKLTS Hort Univ., Hyderabad
Cucumber	91	IARI, New Delhi; CISH, Lucknow; IIHR, Bangalore; TNAU, Coimbatore; CSUAT, Kanpur

Crop group/crop	No. of samples	Recipient Institute
Methi	135	Bharti Vidyapeeth, Pune
Musk melon	16	CAU, Mandore
Okra	90	TNAU , Coimbatore; Noble Seeds Pvt. Ltd, Delhi
Ridge gourd	31	College of Hort. Sci., GKVK, Bangalore; Navsari Agri. University
Squash	10	SKUAST (K)
Sponge gourd	1	Navsari Agri. University
Tomato	574	College of Hort. Sci., GKVK, Bangalore ;IARI, New Delhi; UAS, Dharwad; LPU, Phagwara; PJTSAU, Hyderabad; AAU, Assam; Sir Chhotu Ram PG College, Muzaffarnagar, NABI, Mohali; KRC College of Horticulture, Arbhavi; SKUAST (K); KAU, Thrissur; SVPUAT, Meerut
Medicinal and Aromatic plants (141)		
Abrus	2	Ausadhi Foundation, Lucknow
Artemisia annua	4	University of Allahabad
Ashwagandha	1	University of Delhi
Asparagus	2	Ausadhi Foundation, Lucknow
Andrographis	5	University of Delhi; Ausadhi Foundation, Lucknow; CSIR North East Institute of Technology, Jorhat
Catharanthus	2	University of Delhi
Centella	2	University of Delhi
Chamomile	1	IIHR, Bangalore
Costus	2	IIHR, Bangalore
Galangal	10	CSIR North East Inst. Of Science & Technology, Jorhat
Gloriosa	1	IIHR, Bangalore
Eclipta	19	IIHR, Bangalore
Mucuna	2	Ausadhi Foundation, Lucknow
Ocimum	69	Dr YSRHort. Univ, AP; University of Delhi; KAU, Thrissur; UAHS, Shimoga; Ausadhi Foundation, Lucknow
Psoralea	4	BHU, Varanasi; Ausadhi Foundation, Lucknow
Vetiver	15	TNAU, Coimbatore
Potential Crops (2333)		
Adzuki bean	28	Inst. of Bio resources & Sustainable Development, Imphal; IARI, New Delhi; Annamalai University, Chidamabarm; Dr Rajendra Prasad CAU, Pusa, Samastipur
Amaranth	78	BSI, Kolkata; College of Agriculture, Badnapur; Rajmata Vijayraje Sciindia Krishi Vishwavidyalaya, Indore; UBKV, WB; NBRI, Lucknow
Buckwheat	90	SHIATS, Allahabad; SKUAST (K)

Crop group/crop	No. of samples	Recipient Institute
Chenopodium	43	Directorate of Weed Research, Jabalpur; Rajmata Vijayraje Sciindia Krishi Vishwavidyalaya, Indore
Fababean	2	BHU, Varanasi
Fruit crops (93)		
Apple	2	Dr YSPUHF, Solan
Feijoa sellowiana	2	IARI, New Delhi
Grapes	32	IARI, New Delhi
Kiwi fruit	1	Faith Academy
Musa	56	NRC Trichy; SVBPUAT, Meerut; Panjabi University, Patiala
Fibres (734)		
Cotton	719	PAU, Ludhiana; TNAU, Madurai
Roselle	15	UAS Krishinagar, Dharwad
Forages (837)		
Melilotus	837	Bharti Vidyapeeth, Pune

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

PGR/GEX-BUR-DEL-01.00: Exchange of plant genetic resources with foreign countries (import/ export) their national supplies to the scientists/users in the country along with related information and documentation of these activities in the form of plant genetic reporter on line publication (**Pratibha Brahmi**)

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

PGR/GEX-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, *SP Singh, Surender Singh, PC Binda*)

PGR/GEX-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 (**SK Yadav**, Pragya, *SP Singh, Surender Singh, PC Binda*)

PGR/GEX-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**, SK Yadav, *SP Singh, Surender Singh, PC Binda*)

DIVISION OF PLANT QUARANTINE 3

Summary: A total of 1,08,525 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 (2925) - comprised insects (219), nematodes (233), fungi (2,224), viruses (57), viroids (50) and weeds (142) including several exotic pests. Of the 2,925 infested/ infected/ contaminated samples, 988 were salvaged through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test. The remaining 1,937 samples could not be salvaged and hence rejected. A total of 1,898 samples of exotic germplasm of different legume crops imported from different countries/ sources were grown in post-entry quarantine (PEQ) greenhouses and virus free harvest of the plants was released to the indenters. Thirty post-entry quarantine inspections were carried out at various indenter's sites during this period. A total of 1,748 samples of various crops were processed for export of which two infected samples were salvaged and seven Phytosanitary Certificates were issued. Quarantine processing of 164 samples of imported transgenic planting material revealed exotic virus in maize; absence of terminator gene was ensured; all samples were salvaged prior to release and PEQ inspection undertaken. Under seed health testing, 15,804 samples were received from Division of Germplasm Conservation of which 745 samples were found infected with different fungal pathogens and rice (3) infected with *T. barclayana,* wheat (5) infected with *T. indica* and sorghum (4) infected with *Sphacelotheca sorghi* were rejected as they could not be salvaged. A total 1721 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 147 samples were found infested while infestation of insect-pests was recorded visually in 1,012 samples. A total 1,159 samples were found infested by various insect-pests of which 93 samples could not be salvaged and hence rejected. A total of 207 samples was found infected with nematodes. Out of total 1,159 infested samples, 1,066 were salvaged by X-ray radiography (124), cold treatment (897) and mechanically (45). In addition, 82 cryo-preserved samples were received from TCCU for seed health testing of which two samples were found infected with different fungi and all were salvaged.

3.1 Import quarantine

3.1.1 Quarantine examination: A total of 1,08,525 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, 2,623 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids.

Of these, 219 samples were found infested with insects/ mites, including 173 with hidden infestation; 233 samples infected with nematodes, 2224 infected with fungi, 57 with viruses, 50 with viroids and 142 with weeds (Fig. 3.1). A total of

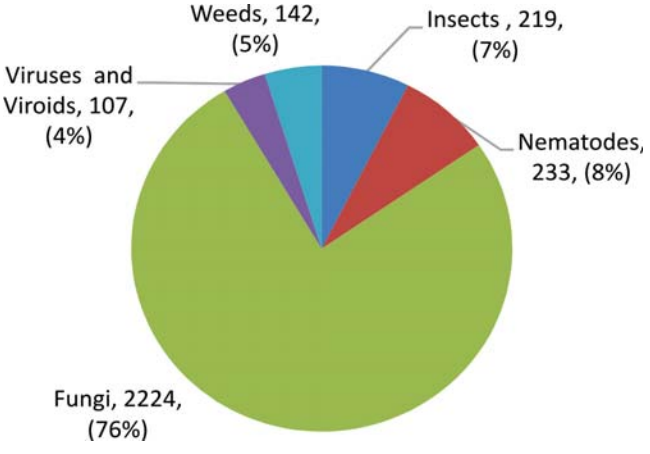


Fig. 3.1: Infected / infested / contaminated samples detected through quarantine examination

142 samples comprising germplasm accessions, nurseries/ trial breeding material of various crops were found contaminated with 15 types of weed seeds out of which, three are quarantine weed and five are not reported from India (Fig. 3.2).

Centaurea melitensis | *Bromus secalinus* | *Polygonum cuspidatum* | *Echinochloa crus-pavonis*

Sinapsis arvensis | *Lolium rigidum* | *Galium tricornutum* | *Phalaris paradoxa*

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

3.1.2 Salvaging of infested/ infected/ contaminated germplasm: Of the total 2925 infested/ infected/contaminated samples, 988 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 @ 2 g/cu/m 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 219 insect infested samples, 210 were salvaged by X-ray radiography (173), aluminium phosphide fumigation /Ethylene dichloride Carbon tetrachloride funigation (28) and mechanical cleaning (9) while 9 samples were rejected due to heavy insect infestation. In order to prevent the introduction of new strains of the associated fungal pathogen intercepted, 2,224 infected samples were salvaged by fungicidal seed treatment and ethyl alcohol wash and a total of 1730 samples were rejected. The rice samples infected with nematodes (174) were salvaged by hot water treatment. The rooted samples of *Hippophae rhamnoides* (11), *Artocarpus heterophyllus* (25) and *Malus domestica* (12) infected with nematodes were salvaged by root-dip treatment of 0.25 percent formalin for 10 min. The nematode infected samples of *Hordeum vulgare* and *Lens culinaris* were salvaged by mechanical removal of soil clods. A total of 37 samples contaminated with weed seeds was salvaged by mechanical cleaning.

A total of 1937 samples could not be salvaged and were rejected. These rejected samples included 21 samples of *Glycine max* from USA due to *Peronospora manshurica;* three samples of *Papaver somniferum* from Australia due to *Dendryphion penicillatum;* 1648 of *Oryza sativa* from China (1609), USA (25) and Brazil (14) due to *Tilletia barclayana*, 16 samples from Thailand and 18 from Vietnam due to multiple infection of fungal pathogens; one of *Triticum aestivum* from Lebanon due to *T. indica*, 20 of *Hordeum vulgare* from Morocco due to *Ustilago hordei*; two samples of maize from Thailand due to *Bipolaris maydis* and one sample of chilli from Netherlands due to *Fusarium solani*. In addition, 26 samples treated with pesticides were also rejected. Rejected

samples also included 67 samples of *G. max* (17) from USA due to *Arabis mosaic virus* (ArMV), *Cherry leaf roll virus* (CLRV), *Cowpea severe mosaic virus* (CPSMV), *Grapevine fanleaf virus* (GFLV), *Raspberry ringspot virus* (RpRSV) and *Tomato black ring virus* (TBRV) and 50 samples comprising chili (16) and tomato (34) due to *Potato spindle tuber virus.* Samples of *Hordeum vulgare* (105) imported from Morocco were rejected due to contamination of weed species of quarantine importance. In addition, nine samples were rejected due to heavy insect infestation.

3.1.3 Prophylactic treatments: A total 13,237 seed samples were subjected to fumigation with aluminium phosphide/Ethylene dichloride Carbon tetrachloride and 537 vegetative propagules were given pesticidal dip/spray treatment against pests. A total of 4710 samples of paddy was 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 (438) and tomato (732) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate (Fig 3.3).

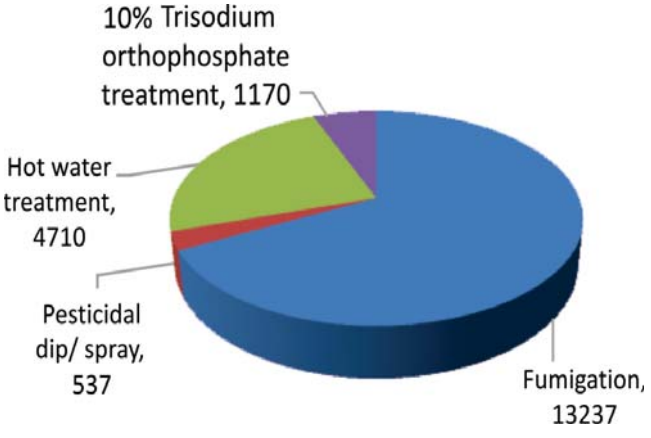


Fig. 3.3: Prophylactic treatments of introduced germplasm samples

3.1.4 Growing out test for detection of viruses: A total of 1,198 samples of exotic germplasm comprising *Glycine max* (320), *Phaseolus vulgaris* (585), *Pisum sativum* (21), *Vigna radiata* (119), *V. umbellata* (102) and wild *Vigna* spp. (51) were grown in PEQ greenhouses. Also, a total of 700 samples of exotic *G. max* germplasm grown in PEQ greenhouses at NBPGR RS, Hyderabad (200), greenhouses at Indian Institute of Soybean Research, Indore (300) and Punjab Agricultural University, Ludhiana (200) were also inspected for seed-transmitted viruses. 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 17 samples of *G. max* from USA due to *Arabis mosaic virus* (ArMV), *Cherry leaf roll virus* (CLRV), *Cowpea severe mosaic virus* (CPSMV), *Grapevine fanleaf virus* (GFLV), *Raspberry ringspot virus* (RpRSV) and *Tomato black ring virus* (TBRV) were rejected. The harvest from only healthy plants of different accessions was released to the indenters. Several viruses were intercepted (Table 3.1). A total of 50 samples comprising chilli (16) and tomato (34) were rejected due to *Potato spindle tuber viroid*.

A total of 86 accessions of *Vicia faba* imported from ICARDA, Lebanon and grown at ICAR-NBPGR Experimental farm, Issapur were inspected. The leaf samples showing virus-like symptoms and without symptoms were indexed for different viruses. Two viruses, *Broad bean stain virus* and *Red clover vein moisic virus*, both of quarantine significance were intercepted (Table 3.1).

3.1.5 PEQ inspection at indenter's site: A total of 30 post-entry quarantine inspections (PEQI) were carried out at various indenters' sites during this period for a total of 29,002 imported germplasm (Table 3.2). During PEQI, two samples of wheat under IQ 464/2017 infected with *Ustilago segetum* causing loose smut at M/s Bioseeds Pvt. Ltd., Ludhiana, Punjab, eleven samples of maize under IQ 107 & 132/2018 suspected to be infected with *Maize chlorotic dwarf virus* at M/s Syngenta India

Table 3.1: Pests intercepted in the exotic germplasm during 2018

Pests	Host	Country
Insects		
*Bruchus tristis**	*Lathyrus sativus*	Lebanon
*B. ervi**	*Lens culinaris*	Lebanon
*B. dentipes**	*Vicia faba*	Lebanon
B. lentis	*Lens culinaris*	Bangladesh
Rhizopertha dominica	*Hordeum vulgare* *Oryza sativa*	Morocco Philippines, Brazil
Sitophilus oryzae	*Hordeum vulgare* *Oryza sativa*	Morocco Philippines
Sitophilus zeamais	*Zea mays*	Thailand
Immature stages of bruchid	*Vigna radiata* *Lens culinaris*	Afganistan Lebanon
Pathogens		
Alternaria alternata	*Hordeum vulagare*	Australia
Alternaria brassicicola	*Brassica oleracea* var. *capitata*	The Netherlands
Alternaria padwiki	*H. vulagare*	Australia
Bipolaris cynodontis	*Capsicum annuum* *Zea mays*	Guetamala, Mexico Thailand
B. hawaiensis	*Oryza sativa*	Vietnam
B. maydis	*Z. mays*	Philippines, Thailand
B. micropus	*Triticum aestivum*	Australia
B. oryzae	*O. sativa* *T. aestivum* *Z. mays*	Nepal, Philippines, Thailand Australia Thailand
B. rostrata	*H. vulagare* *T. aestivum* *Z. mays*	USA Australia, Mexico Thailand
B. sorokiniana	*H. vulagare* *O. sativa* *T. aestivum*	USA USA Mexico
Bipolaris sp	*B. oleracea*	The Netherlands
Cephalosporium maydis	*B. oleracea*	The Netherland
Cercospora kikuchi	*Glycine max*	USA
Colletotrichum capsici	*C. annuum* *G. max*	Bangladesh USA
Curvularia eragrostidis	*Z. mays*	Thailand
Dendryphion penicillatum	*Papaver somniferum*	Australia

Pests	Host	Country
Fusarium dimerum	*O. sativa*	USA
F. graminarum	*O. sativa* *Z. mays*	USA Thailand
F. oxysporum	*C. annuum* *G. max* *O. sativa* *Z. mays*	The Netherlands USA Nepal, Philippines, Vietnam Philippines, USA
F. poae	*Z. mays*	Thailand
F. semitectum	*B. oleracea* var. *botrytis*	Kenya
F. solani	*B. oleracea* var. *botrytis* *C. annuum* *Siraitia grosvenorii*	Kenya The Netherlands China
F. verticillioides	*Abelmoschus esculentus* *Aegilopes* sp. *B. oleracea* var. *botrytis* *C. annuum* *Citrullus lanatus* *G. max* *Lathyrus sativus* *Momordica charantia* *O. sativa* *Solanum tuberosum* *T. aestivum* *Vigna radiata* *Z. mays*	USA UK Kenya, The Netherlands The Netherlands USA USA Lebanon Thailand China, Philippines, Vietnam USA Australia, Germany, UK Afghanistan Brazil, Chile, Mexico, Philippines, Thailand, USA
Lasiodiplodia theobromae	*M. charantia*	Thailand
Myrothecium roridum	*G. max* *Lagenaria siceraria* *M. charantia*	USA Bangladesh Thailand
Nigrospora oryzae	*O. sativa*	Vietnam
Peronospora manshurica	*G. max*	USA
Phoma sorghina	*G. max* *M. charantia* *O. sativa* *Z. mays*	USA Thailand Philippines Mexico, USA
Phoma sp.	*C. lanatus*	USA
Phomopsis phaseoli	*G. max*	USA
Pyrenochaeta oryzae	*O. sativa*	Philippines, Vietnam
Pyricularia oryzae	*O. sativa*	Thailand, Vietnam
Tilletia barclayana	*O. sativa*	Brazil, China, USA
T. indica	*T. aestivum*	Lebanon

Ustilaginoidea virens	*O. sativa*	China, Nepal
Ustilago hordei	*H. vulagare*	Morocco
Verticillium alboatrum	*B. oleracea* var. *capitata*	The Netherlands
Viruses		
#*Arabis mosaic virus*	c&*Glycine. max*	USA
Bean common mosaic virus	*G. max*	USA
Bean common mosaic necrosis virus	*Phaseolus vulgaris*	Colombia
**Broad bean stain virus*	*P. vulgaris* *Vicia faba*	Colombia, South Africa ICARDA, Lebanon
**Broad bean true mosaic virus*	*P. vulgaris*	Colombia
**Cherry leaf roll virus*	*G. max* *P. vulgaris*	USA Colombia
**Cowpea severe mosaic virus*	*G. max*	USA
Grapevine fan leaf virus	c&*G. max*	USA
**Raspberry ringspot virus*	*G. max*	USA
#*Red clover vein mosaic virus*	c&*V. faba*	ICARDA, Lebanon
Southern bean mosaic virus	c&*G. max*	USA
Soybean mosaic virus	*G. max*	USA
Tomato black ring virus	c&*G. max* *P. vulgaris*	USA Colombia
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Brazil, China, Japan, Nepal, Philippines, USA Vietnam
Pratylenchus sp., *Meloidogyne* sp., *Tylenchorhynchus* sp.	*Hippophae rhamnoides*	Russia
Meloidogyne incognita, Pratylenchus sp., *Tylenchorhynchus* sp.	*Artocarpus heterophyllus*	Nepal
Meloidogyne spp., *Aphelenchus avenae*	*Malus domestica*	USA
Weeds		
Brassica tournefortii	*Solanum lycopersicum*	USA
***Bromus secalinus*	*H. vulgare*	Morocco
**Centaurea melitensis*	*H. vulgare*	Morocco
Echinochloa crusgalli	*Oryza sativa*	China
***E. crus-pavonis*	*O. sativa*	China
**Galium tricornutum*	*H. vulgare, Lens culinaris*	Lebanon, Morocco

Pests	Host	Country
Lathyrus aphaca	*L. culinaris*	Bangladesh
Lolium perenne	*H. vulgare*	Morocco
L. rigidum	*H. vulgare*	Morocco
**Phalaris paradoxa*	*H. vulgare*	Morocco
Polygonum aviculare	*H. vulgare*	Morocco
***Polygonum cuspidatum*	*S. lycopersicum*	USA
**Sinapsis arvensis*	*H. vulgare*	Morocco

**Quarantine weed
* Pest not yet reported from India
c& Pest present in India but not recorded on the host on which intercepted
pest regulated under PQ Order 2003

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

IQ No.	Crop	No. of Samples	Indentor's site	Date
348/2017	*Triticum aestivum*	129	Syngenta India Ltd., Aurangabad	Mar. 3, 2018
337/2017	*T. aestivum*	2450	Nizuveedu Seed Pvt. Ltd., Karna	Mar. 14, 2018
339 & 423 /2017	*T. aestivum*	660	Metaheix Pvt. Ltd., Alwar	Mar. 15, 2018
138, 329 & 330/2017	*T. aestivum*	836	ITC, Indore, MP	Mar. 16, 2018
334 & 430 /2017	*T. aestivum*	1495	Syngenta India Ltd., Karnal	Mar. 19, 2018
407 & 420 /2017	*T. aestivum*	1860	Ajeet Seeds Pvt. Ltd., Aurangabad	Mar. 21, 2018
247, 375 & 422/2017	*T. aestivum*	1548	Nirmal Seeds Pvt. Ltd., Jalgaon	Mar. 22, 2018
380 & 417 /2017	*T. aestivum*	1585	Ankur Seeds, Nagpur	Mar. 22, 2018
408/2017	*T. aestivum*	3126	Rasi Seeds Pvt. Ltd. Delhi	Mar. 24, 2018
186, 340, 410, 421	*T. aestivum*	3266	MAHYCO, Jalna	Mar. 26, 2018
336, 372 & 464/2017	*T. aestivum*	1177	Bioseeds Pvt. Ltd., Ludhiana	Mar. 26, 2018
419/2017	*T. aestivum*	164	JK Seeds Pvt. Ltd. Jaipur	Apr. 3, 2018
61 & 74/2017	*Cucurbita moschata*	21	H.M. Clause India Pvt. Ltd. Panipat	Apr. 5, 2018

IQ No.	Crop	No. of Samples	Indentor's site	Date
182, 183 & 184/2015, 275 & 378/ 2016,50, 67, 104 & 129/2017	*Zea mays*	2346	Syngenta India Ltd., Hyderabad	Apr. 6, 2018
	Z. mays	2	Pioneer Hi-Bred Pvt Ltd, Hyderabad	May 18, 2018
464/2017	*Cucumis pepo*	2	VNR Seeds, Ambikapur	May 23, 2018
447/2017	*Solanum lycopersicum*	261	Syngenta India Ltd., Aurangabad	June 4, 2018
19/2018	*Capsicum annuum*	510	Syngenta India Ltd., Aurangabad	Jun. 5, 2018
104/2018	*Momordica charantia*	88	Ankur Seeds Pvt Ltd., Nagpur	Aug. 14, 2018
54, 107, 132 & 162/2018	*Z. mays*	4600	Syngenta India Ltd., Hyderabad	Sep. 14, 2018
124/2018	*Glycine max*	200	PAU, Ludhiana	Sep. 14, 2018
124/2018	*G. max*	200	RS, ICAR-NBPGR, Hyderabad	Sep. 15, 2018
124/2018	*G. max*	300	ICAR-IISR, Indore	Sep. 17, 2018
180 & 458/ 2015, 162/ 2016, 31/2017	*Eucalyptus camadulensis*	956	ITC, Bengaluru	Sep. 20, 2018
467/2017	*T. aestivum*	1	Bench Bio Pvt Ltd, Vapi	Sep. 22, 2018
256/2018	*Daucus carota*	13	Somani Seeds, New Delhi	December 1, 2018
155/2018	*Z. mays*	2	Acsen Hyveg (P) Ltd. Gurgaon, Haryana	December, 5, 2018
58, 106 & 189/2018	*S. lycopersicum*	104	Syngenta India Ltd, Auranagabad	December 7, 2018
19/2018	*C. annuum*	206		
348/2018	*Brassica juncea*	873	Pioneer Hi-bred, Hyderabad	December 18, 2018
30/20015 & 290/2017	*Manihot esculenta*	21	CTCRI, Thiruvananthapuram	December 20, 2018

Ltd., Hyderabad, Telanga, one sample of summer squash under IQ 175/2017 suspected to be infected with *Didymella bryoniae* causing Gummy stem blight at M/s VNR Seeds Pvt. Ltd., Ambikapur, Chhattisgarh and 34 samples of bittergourd under IQ 104/2018 suspected to be infected with *Zucchini yellow mosaic virus* at M/s Ankur Seeds Pvt. Ltd., Nagpur, Maharashtra were destroyed.

3.2 Export quarantine

A total 1,748 samples of crops comprising, wheat, hybrid paddy, polished rice and green gram, were exported to UK, Singapore, Phillippines, USA, Bangladesh and Bolivia. Ten samples of polished rice were found infested with dead adult of *Tribolium castaneum* insect and salvaged

mechanically. Twenty-seven green gram samples were exposed to X-ray radiography. Prophylactic treatment with aluminium phosphide fumigation Ethylene dichloride Carbon tetrachloride funigation was given to all 1,748 exported samples. One sample each of wheat and rice was found infected with fungal pathogens, *Bipolaris sorokiniana* in *Triticum aestivum* and *Ustilaginoidea virens* in rice was salvaged by fungicidal seed treatment. Seven Phytosanitary Certificates were issued.

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

A total of 15,804 accessions of indigenously collected seed material and various multiplied material were received and processed for pest-free conservation. Seed health testing could detect and identify infection of various fungi in 867 germplasm samples (Table 3.3).

Visual/ stereoscopic examination resulted in detection of symptoms of fungal (259) and viral (120) pathogens in germplasm samples which included purple stain (*Cercospora kikuchii*) in 235 soybean samples from Madhya Pradesh (201), Uttarakhand (31 samples), New Delhi (02), Karnataka (01). In sorghum, smut (*Sphacelotheca sorghi*) was detected in four samples from Telangana (02) and Delhi (02), In rice, kernel smut (*Tilletia barclayana*) detected in two samples of rice from Andhra Pradesh (02) and false smut (*Ustilagenoidea virens*) in eight samples from Andhra Pradesh (02), Chhattisgarh (01), Kerala (01), West Bengal (01) and Telangana (03). Seed gall (*Protomyces macrosporus*) detected in one sample of coriander from Delhi, Karnal bunt (*Tilletia indica*) in five samples of wheat from Haryana (01) and Delhi (04). Viral symptoms included mottled seeds in soybean (38) from Madhya Pradesh, split seed coat in pea from Delhi (23), HP (54) and tennis ball samples from Delhi (04) and HP (01).

Blotter test revealed detection and identification of seed-borne fungi in 608 accessions of various crop germplasm. The important fungi detected include *Bipolaris sorokiniana, B. maydis, B. oryzae*, *Colletotrichum capsici*, *Fusarium oxysporum*, *F. solani*, *Phomopsis phaseoli*, *Phoma exigua*, *Verticilium abo-atrum*. Out of 867 samples infected with fungal pathogens, 11 samples were rejected including rice (2) infected with *T. barclayana*, wheat (5) due to *T. indica* and sorghum (4) due to *S. sorghi*. The pathogens detected are given in Table 3.3.

A total 1,159 samples were found infested by various insect-pests. Of the total 1,159 infested samples, 1,066 were salvaged by X-ray radiography (124), cold treatment (897) and mechanically (45) while 93 samples that could not be salvaged were rejected. The insect pests detected are given in Table 3.3. A total 1,721 samples were exposed to X-ray radiography and hidden infestation of bruchids and chalcids was recorded in 147 samples while infestation was detected in 1012 samples through visual/ stereo-binocular examination.

In addition, 191 cryo-preserved samples or for cryo-preservation were received from TCCU for seed health testing of which 9 samples were found infected with different fungi and all were salvaged. Out of them, 17 oil palm sample were exposed to X-ray radiography. All the samples were found free of insect-pests infestation.

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

A total of 52 *in vitro* accessions of *Rubus* were virus-indexed for associated viruses viz., *Arabis mosaic virus*, *Raspberry bushy dwarf virus*, *Raspberry ringspot virus*, *Strawberry latent ringspot virus*, *Strawberry mild yellow edge virus*, and *Tobacco streak virus* by electron microscopy and

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

Pests	Host	Source/ Collection site
Insects		
Acanthosceledis obtectus	*Phaseolus vulgaris* *Vigna umbellata*	Himachal Pradesh New Delhi
Bruchus pisorum	*Pisum sativum*	Himachal Pradesh, New Delhi
Callosobruchus analis	*Glycine max* *V. umbellata*	Himachal Pradesh Jharkhand
Callosobruchus chinensis	*Cajanus cajan* *Cassia accidentalis* *Cicer arietinum* *Hibiscus sabdariffa* *Lablab purpureus* *Macrotyloma uniflorum* *P. sativum* *Vicia faba* *V. mungo* *V. radiata* *V. unguiculata* *V. unguiculata* ssp *sesquipedalis*	New Delhi Telengana New Delhi New Delhi New Delhi Chattisgarh New Delhi New Delhi New Delhi, Uttar Pradesh New Delhi, Telengana, Jammu and Kashmir New Delhi New Delhi
Callosobruchus maculatus	*Glycine max* *Hibiscus cannabinus* *V. radiata*	Maharashtra West Bengal Karnataka
Callosobruchus phaseoli	*V. angularis*	Himachal Pradesh
Callosobruchus theobromae	*V. mungo*	Kerala
Cryptolestes ferrugenius	*Leymus sealinus* *Oryza sativa* *Sorghum bicolor*	New Delhi Odisha, West Bengal Telengana
Immature stages of bruchid	*Abelmoschus esculentus* *A. ficulneus* *C. cajan* *Cicer arietinum* *G. max* *Hibiscus sabdariffa* *Lathyrus sativus* *Lens culinaris* *Macrotyloma uniflorum* *Mallotus philippensis* *Phaseolus vulgaris* *V. aconitifolia* *V. mungo* *V. radiata* *V. umbellata* *V. unguiculata* *V. unguiculata ssp sesquipedalis*	Gujrat Odisha New Delhi, Telengana, West Bengal New Delhi, Maharashtra Uttrakhand, New Delhi New Delhi Bihar Uttrakhand, Madhya Pradesh, Jammu and Kashmir New Delhi, Kerala, Karnataka Odisha New Delhi, Jammu and Kashmir New Delhi New Delhi, Jammu and Kashmir, Tamilnadu New Delhi, Telengana, Gujrat New Delhi New Delhi, Telengana, Rajasthan, Tamilnadu New Delhi

Pests	Host	Source/ Collection site
Lasioderma serricorne	*Anethum graveolens* *Coriandrum sativum* *Ricinus communis* *Trachyspermum ammi*	Kerala Jammu and Kashmir Telengana Andhra Pradesh
Oryzaephilus surinemensis	*Triticum durum*	New Delhi
Pectinophora gossypiella	*Gossypium hirsutum*	Gujrat, Punjab
Rhizopertha dominica	*Hordeum vulgare* *Oryza sativa* *Pennisetum glaucum* *Sorghum bicolor* *T. aestivum* *Zea mays*	New Delhi, Jammu and Kashmir Odisha, Telengana, Kerala, Andhra Pradesh, Gujrat, Uttar Pradesh, Chattisgarh, New Delhi, Jharkhand Telengana Telengana New Delhi, Jammu and Kashmir, Punjab New Delhi
Sitophilus oryzae	*Hordeum vulgare* *O. sativa* *S. bicolor* *T. aestivum* *Z. mays*	New Delhi, Jammu and Kashmir Kerala Telengana New Delhi New Delhi
Sitophilus zeamais	*Z. mays*	Jammu and Kashmir, New Delhi
Sitotroga cerealella	*O. sativa* *S. bicolor* *Z. mays*	West Bengal, New Delhi, Odisha, Gujrat, Punjab, Haryana, Kerala, Telengana, Maharashtra, Jharkhand, Andhra Pradesh New Delhi, Telengana, Karnataka New Delhi, Madhya Pradesh, Karnataka
Tribolium castanium	*Brassica juncra* *Carthamus tinctorius* *Foeniculum vulgare* *Lagenaria siceraria* *O. sativa* *Panicum sumatrense* *Pennisetum glaucum* *Sesamum indicum* *S. bicolor* *T. aestivum* *Z. mays*	Rajasthan Telengana New Delhi Uttar Pradesh Odisha, West Bengal New Delhi Haryana Telengana, Kerala, New Delhi Telengana, New Delhi, Uttra Pradesh New Delhi
Pathogens		
Acremonium strictum	*Leucaena leucocephala*	Thrissur
Alternaria brassicicola	*Brassica oleracea var. capitata*	Shimla
Bipolaris cynodontis	*Eleusine coracana*	Vizianagaram
B. hawaiiensis	*E. coracana*	Hyderabad
B. maydis	*Zea mays*	Delhi
B. micropus	*Pennisetum glaucum*	Hyderabad

Pests	Host	Source/ Collection site
B. oryzae	*Oryza sativa*	Hyderabad, Pilicode
B. rostrata	*Cicer arietinum* *E. coracana* *O. sativa* *P. glaucum* *Sorghum bicolor*	Akola Hyderabad Ahmedabad Anand Hyderabad
B. sorghicola	*P. glaucum* *S. bicolor*	Hyderabad Hyderabad
B. sorokiniana	*Aegilops* *Solanum lycopersicum* *S. bicolor* *Triticum aestivum*	Srinagar Parbhani Hyderabad, Delhi Delhi
B. tetramera	*Hordeum vulgare* *S. bicolor*	Delhi Hyderabad
Lasiodiplodia theobromae	*Glycine max*	Indore
Cercospora kikuchii	*G. max*	Indore, Pantnagar
Colletotrichum capsici	*G. max* *Capsicum annuum*	Indore, Pantnagar Ranchi
C. gloeosporioides	*O. sativa* *C. annuum* *Phaseolus vulgaris*	Hyderabad Ranchi Srinagar
C. truncatum	*G. max*	Indore
Dinemasporium americana	*Aegilops* sp.	Srinagar
Fusarium dimerium	*Vigna ungiculata*	Bikaner
F. oxysporum	*G. max* *Momordica charantia* *Solanum melongena*	Delhi, Indore Delhi Varanasi
F. solani	*C. annuum* *Cicer arietinum* *Corchorus capsularis* *G. max*	Delhi Akola Kolkata Indore
F. verticillioides	*Capsicum annuum* *C. arietinum* *Citrullus lanatus* *C. capsularis* *E. colona* *G. max* *Helianthus annuus* *Hibiscus cannabinus* *L. leucocephala* *Momordica charantia* *O. sativa* *Pennisetum glaucum* *Pisum sativum*	Ranchi Akola Bangalore Delhi, Kolkata Bengaluru, Delhi Coimbatore, Delhi, Indore Delhi Akola, Thrissur Thrissur Delhi Hyderabad, Pilicode Hyderabad Delhi

Pests	Host	Source/ Collection site
	Solanum melongena *Sorghum bicolor* *Teosinte* *Vigna aconitifolia* *Vigna mungo* *Zea mays*	Varanasi Akola, Delhi, Hyderabad Raipur Thrissur Thrissur Delhi, Hyderabad.
Myrothecium leucotrichum	*Capsicum annuum*	Ranchi
M. roridum	*G. max*	Indore
Pestalotiopsis guepini	*Chenopodium* sp.	Shimla
Phoma exigua	*Aegilops* *Cucumis* sp.	Srinagar Thrissur
P. sorghina	*C. annuum* *Pennisetum pedicellatum* *S. melongena*	Srinagar Jhansi Varanasi
Phoma sp.	*L. leucocephala*	Thrissur
Phomopsis phaseoli	*G. max*	Indore
Phomophis sp.	*P. glaucum* *Ricinus communis* *S. bicolor*	Hyderabad Delhi Hyderabad
Protomyces macrosporus	*Coriandrum sativum*	Bihar
Pyrenochaeta oryzae	*O. sativa*	Hyderabad
Sphacelotheca sorghi	*S. bicolor*	Delhi
Tilletia barclayana	*O. sativa*	Karnal, West Godavari
T. indica	*T. aestivum*	Delhi, Karnal
Ulocladium consortiale	*Chenopodium karoi*	Delhi
Ustilaginoidea virens	*O. sativa*	Cooch Behar, Hyderabad, Raipur, Thrissur, West Godavari
Verticillium albo-atrum	*E. coracana* *S. melongena*	Vizianagaram Varanasi
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Kerala, Maharashtra, Odisha, Tamil Nadu, Telangana, Tripura, Uttar Pradesh, West Bengal
Weeds		
Asphodelus tenuifolius	*Brassica juncea*	New Delhi
Brassica tournefortii	*Lepidium sativum*	New Delhi
Bromus sp.	*Avena sativa*	New Delhi
Cichorium intybus	*Trifolium alexandrinum*	Punjab

Pests	Host	Source/ Collection site
Echinichloa colona	*Amaranthus,, O. sativa,*	J&K, New Delhi
E. crus-galli	*Amaranthus, Fagopyrum esculentum, O. sativa, Paspalam scrobiculatum, Sesamum indicum*	J&K, New Delhi, Telangana
Galium aparine	*Lathyrus sativus, Trigonella foenum-graecum*	Bihar, J&K
Hibiscus canabinus	*Hibiscus sp.*	MS
Ipomoea purpurea	*O. sativa*	Odisha
Lolium temulentum	*Amaranthus*	J&K
Lathyrus sativus	*Cicer arietinum*	New Delhi
Malva parviflora	T. aestivum	New Delhi
Melilotus alba	*H. vulgare, Brassica juncea*	Haryana, New Delhi
M. indica	*H. vulgare Brassica juncea*	Haryana, New Delhi, J&K,
Phalaris minor	*T. aestivum*	New Delhi,
Polygonium aviculare	*T. aestivum*	New Delhi
P. lapathifolium	*Amaranthus ,O. sativa*	J&K, Telangana
Rumex crispus	*H. vulgare*	New Delhi
Setaria viridis	*Eleusine coracana*	Telangana
Sorghum halepense	*Abelmoschus manihot, A. esculentus, Fagopyrum esculentum, Sorghum bicolor*	J&K, New Delhi, Telangana
Tribulus terrestris	*H. vulgare*	New Delhi
Vicia hirsuta	*Glycine max, Lens culinaris*	J&K, MP
V. sativa	*G. max, L. culinaris T. aestivum, Trigonella foenum-graecum*	J&K,MP, New Delhi

DAS-ELISA and were found to be free from six viruses tested.

3.5 Supportive research

3.5.1 Detection of *Dinemasporium americana* on goat grass: During seed health testing using blotter test, some fungal growth was observed on seeds of one accession (i.e. Sheikh-792) of goat grass (*Aegilops* sp.). The stromatic conidiomata was observed with thick brown to black setae and conidial mass under stereo microscope (Fig. 3.4a) and hyaline, aseptate, gently curved or straight shaped conidia with tubular appendage at both the terminal ends (Fig. 3.4b) were observed under compound microscope and ITS sequencing resulted in identification of the fungus as *Dinemasporium americana* (MK434150). This pest has been detected for the first time in the country.

3.5.2 Multiplex PCR based detection of *Alternaria brassicicola* and *Xanthomonas campestris* pv. *campestris*: A set of primers namely Aba28sF and Aba28sR based on SSR marker were developed for *A. brassicicola* causing dark leaf spot disease, whereas rpf region based primers namely rpfH_F

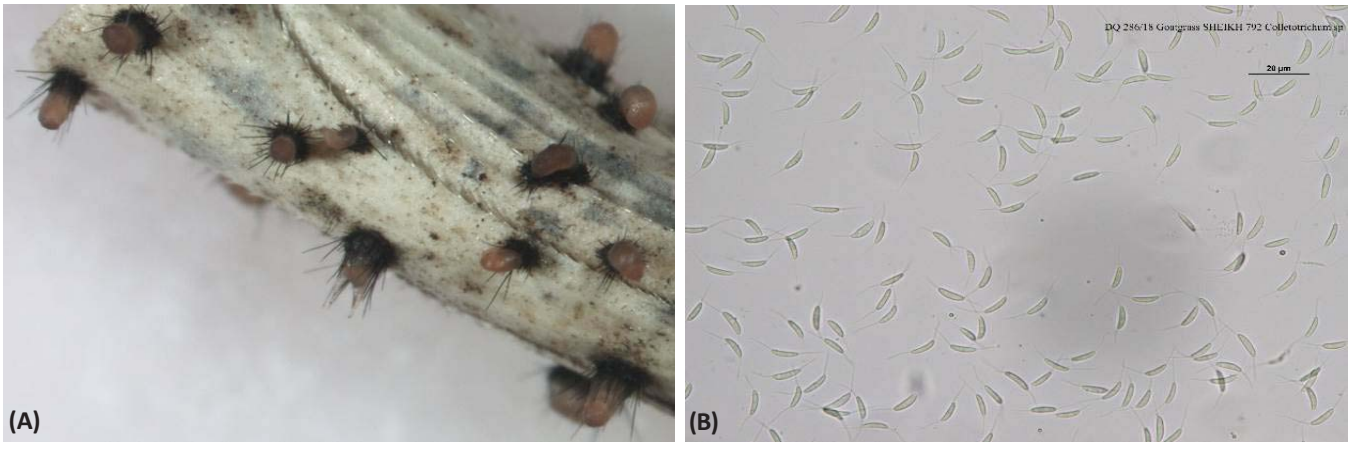


Fig. 3.4: (A) Stromatic conidiomata under stereo microscope; (B) conidial morphology of *Dinemasporium americana*

and rpfH_R were developed for *Xanthomonas campestris* pv. *campestris* causing black rot disease of crucifers. The annealing temperature for primers were optimized at 60°C and specific bands of 201 bp for *A. brassicicola* and 304 bp for *X. campestris* pv. *campestris* were obtained in multiplex PCR (Fig. 3.5). The detection sensitivity of the primer pairs was performed by dilution of genomic DNA and results revealed that it could detect up to 0.1 ng μl^{-1} of template DNA of both the pathogens. These primers are specific to *A. brassicicola* and *X. c.* pv. *campestris* and there is no cross amplification with other related fungal and bacterial pathogens.

3.5.3 Development of species-specific PCR for detection of *Alternaria padwickii* causing stack burn disease of rice: Eight isolates of *Alternaria padwickii* were isolated from infected seeds processed for seed health testing from different part of India. The pathogen was confirmed to be *A. padwickii* based of spore morphology and ITS based gene sequencing. Species-specific primers set (ApE1-F and ApE1-R) were designed from *translation elongation factor 1-alpha* (*tef 1-*α) gene regions and the primer set was able to amplify bands of ~174 bp in all isolates (Fig. 3.6) of *A. padwickii* but failed to amplify other related fungal

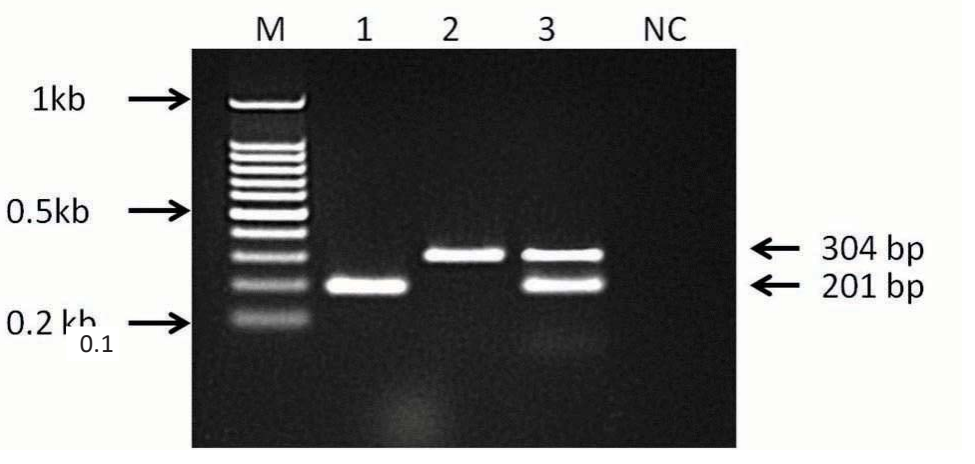


Fig. 3.5: Detection of *A. brassicicola* and *X. campestris* pv. *campestris* using multiplex PCR with two sets of specific primers. Lane M- 100 bp plus DNA ladder; Lanes 1– *A. brassicicola* (201bp), Lane 2- *X. campestris* pv. *campestris* (304 bp), lane 3- *A. brassicicola* and *X. campestris* pv. *campestris* Lane NC- Negative control.

pathogens. The primer set was highly specific and sensitive as it is able to detect 25 pg μl^{-1} fungal DNA.

3.5.4 PCR based detection of *Bipolaris oryzae* causing brown spot disease of rice: Infected seeds of rice were incubated for seven days in incubator and *Bipolaris oryzae* were isolated from infected seeds processed for seed health testing from different part of India. The pathogen was confirmed to be *B. oryzae* causing brown spot disease of rice based of spore morphology and ITS gene sequencing. Species-specific primers (BoP1-F and BoP1-R) were designed from the ATCC 44560 unplaced genomic scaffold scaffold_136. The DNA was extracted from pure cultures of *B. oryzae* and expected product size of 325 bp was observed in all the *B. oryzae* isolates (Fig. 3.7) but fail to amplify in other related fungal pathogens. The primer set is highly specific and sensitive as it could detect up to 0.1 ng of fungal DNA.

3.5.6 Potential quarantine pests for India in tropical and sub-tropical fruits: Information on insects, mites, fungi, bacteria, viruses, viroids phytoplasma and weeds of tropical and sub-tropical fruits was edited 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. The book was published in April 2018.

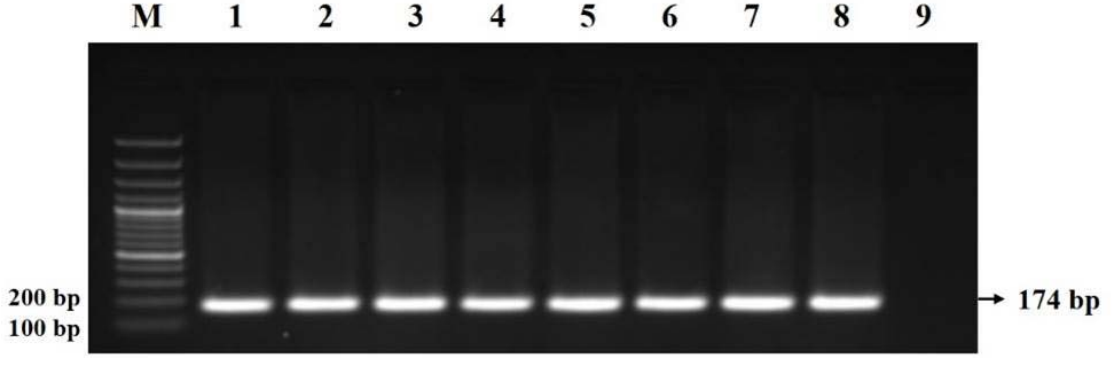


Fig. 3.6: PCR amplification of *Alternaria padwickii* using *tef 1-α* gene specific primers. M: 100 bp plus DNA ladder, 1-8: *A. padwickii* isolates, 9: Negative control

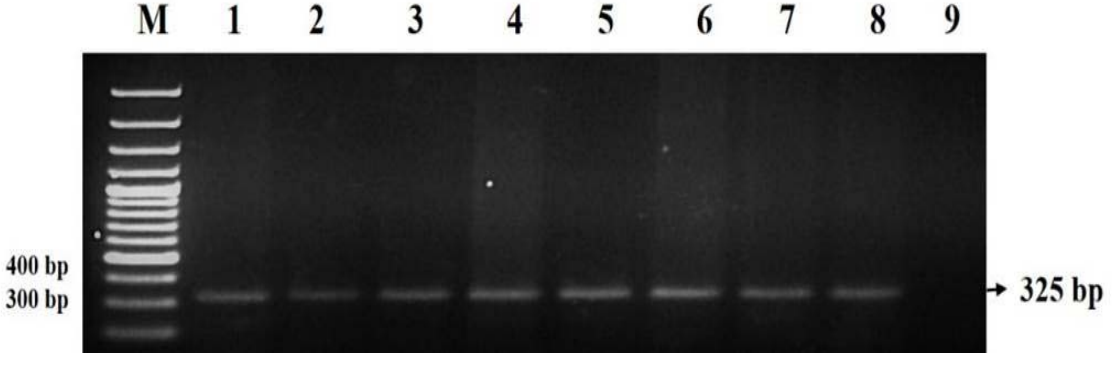


Fig. 3.7: PCR amplification of *Bipolaris oryzae* gene specific primers. M: 100 bp plus DNA ladder, 1-8: *Boryzae* isolates, 9: Negative control

3.5.7 Effect of wheat genotypes on weed species: In field studies conducted during 2016-17 and 2017-18 to determine the influence of wheat genotypes of different stature i.e. tall, medium and dwarf on the growth and development of *Phalaris minor*, *Chenopodium album* and *Melilotus indica* , tall wheat genotype (plant height about 115 cm) exerted a strong suppressing effect on the weed intensity (population & dry matter) and height of these weeds. The dwarf wheat genotype~ proved very favourable for the growth and development of these weed species.

3.5.8 National containment/ quarantine facility for transgenic planting material (DBT): Imported transgenic planting material (164) were received for quarantine clearance comprising of *Arabidopsis thaliana* (14) from USA for Sea6 Energy Pvt Ltd., Bangalore and ICAR-NRCPB, New Delhi; *Brassica napus* (10) and *Gossypium hirsutum* (66) from Belgium for Bayer Bioscience Pvt Ltd., Hyderabad; *Oryza sativa* (62) from Belgium for Bayer Bioscience Pvt Ltd., Hyderabad and Canada for Guru Govind Singh Indraprastha University, New Delhi, *Zea mays* (12) from the Philippines for Pioneer Overseas Corp. Hyderabad and Syngenta India Ltd., Pune. Only 92 samples (excluding *B. napus* (10), *G. hirsutnum* (10), and *O. sativa* (52)) were processed for quarantine clearance and released to the indenter; while those 72 samples were not processed due to non-availability of Phytosanitary Certificate.

A total of 27 samples of *Zea mays* from the Philippines for Monsanto India Pvt Ltd., Hyderabad and Pioneer Overseas Corp., Hyderabad were grown in the greenhouse/ containment facility for detection of seed-transmitted pathogens not detectable in the laboratory tests. Maize leaves showing virus-like symptoms during growing in containment facility and PEQ inspection were tested against five viruses using ELISA. The results revealed the presence of *Barley stripe mosaic virus* (BSMV), in samples from the Philippines. BSMV is not known to occur in India, hence, these are quarantine pests for India. In addition, three post-entry quarantine inspections were undertaken for *Z. mays* (2), *Eucalyptus* (1585) and *Manihot esculenta* (21) Suspected infected leaf and soil samples were tested at ICAR-NBPGR. *Fusarium verticillioides* was intercepted in maize from the Philippines.

3.5.9 Strengthening capacities of enforcement agencies (plant quarantine and customs officials) for transboundary movement of LMOs under UNEP-GEF supported Phase II Project on Capacity Building on Biosafety (UNEP-GEF being implemented by MoEF & CC): Two Training Workshops on *Strengthening Capacities of Enforcement Agencies (Plant Quarantine and Customs Officials) for Transboundary Movement of LMOs* were organized from April 12-13, 2018 at Customs House, Marmagoa, Goa and from April 19-20, 2018 at National Academy of Customs, Indirect Taxes & Narcotics (NACIN), Visakhapatnam, Andhra Pradesh. A total of 68 officials (Plant quarantine and Customs) from different parts of the country participated in these workshops.

3.5.10 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 (BT/PR18939/PFN/20/1211/2016) (DBT): Different gene specific markers were used for amplification of gene specific regions of the major fungal pathogens of pulse crops. Using ITS markers ~ 500-600bp, LSU and SSU markers ~1200bp, TEF á markers ~1000bp, COX, calmodulin and beta tubulin ~600bp amplicons were obtained in these pathogens. The amplified products were sequenced and aligned. Confirmed the identity of the pathogens/sequences through BLAST analysis. Barcode were developed from the sequences and submitted to the Barcode of Life Data System (BOLD) for the pathogen namely, *Alternaria alternata* (DBTPQ001-18; BAA2) and *Alternaria tenuissima* (DBTPQ002-18; BAT3)

both causing leaf spots, *Ascochyta rabiei* (DBTPQ003-18; BAR5) causing Ascochyta blight, *Fusarium oxysporum* f. sp. *ciceris* (DBTPQ004-18; BFC7 causing wilt, *Macrophomina phaseolina* (DBTPQ005-18; BMP14) causing dry root rot, *Rhizoctonia solani* (DBTPQ006-18; BRS17) causing web blight and wet root rot, *Sclerotium* (*Athelia) rolfsii* (DBTPQ007-18;BSR19) causing collar rot, *Sclerotinia sclerotiorum* (DBTPQ008-18; BSS21) causing stem rot and *Cercospora canescens* (DBTPQ009-18; BCC23) causing leaf spot diseases of pulse crops.

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

PGR/PQR-BUR-DEL-01: Quarantine processing of plant germplasm under exchange and supportive research (**SC Dubey)**

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

PGR/PQR- BUR-DEL-01.01: Detection and identification of fungi and bacteria in quarantine and supportive research (**SC Dubey** (w.e.f Oct. 1 2018) **Baleshwar Singh** (till Sep. 30 2018), Meena Shekhar (w.e.f Sep. 3, 2018), Jameel Akhtar, Pardeep Kumar, Raj Kiran and *Ashok Kumar Maurya*).

PGR/PQR-BUR-DEL-01.02: Detection and identification of viruses in quarantine and supportive research. (**V Celia Chalam**, DB Parakh (till June 31, 2018), Pooja Kumari (on study leave wef July 6, 2018) and *Ashok Kumar Maurya*)

PGR/PQR- BUR-DEL-01.03: Detection and identification of insect and mite pests in quarantine and supportive research (**Kavita Gupta**, Shashi Bhalla (till January 31, 2018), SP Singh, T Boopathi (w.e.f July 2018) and *DS Meena*)

PGR/PQR- BUR-DEL-01.04: Detection and identification of nematode pests in quarantine and supportive research (**Z Khan** and Bharat H Gawade)

PGR/PQR-BUR-DEL-01.05: Detection and identification of weeds intercepted in quarantine and supportive research (**MC Singh,** Madhubala Priyadarshi (on study leave) and *DS Meena*)

PGR/PQR-BUR-DEL-01.06: Quarantine treatments for disinfestation/ disinfection of germplasm under exchange against different pests and supportive research **(SP Singh**, Baleshwar Singh (till Sep. 30, 2018), Shashi Bhalla (till)Meena Shekhar (w.e.f Sep. 3, 2018), Kavita Gupta, Z Khan, Jameel Akhtar, T Boopathi (w.e.f July 2018), Bharat H Gawade, Pardeep Kumar (w.e.f Aug. 10, 2018), Raj Kiran (w.e.f Aug. 10, 2018), *Ashok Kumar Maurya and DS Meena*).

PGR/PQR-BUR-DEL-01.07: Quarantine processing of imported transgenic germplasm and supportive (**Shashi Bhalla (till January 31, 2018)**, **Baleshwar Singh (from February 1- September 30, 2018)**, **V Celia Chalam (w.e.f October 1, 2018),** Kavita Gupta (w.e.f February 1, 2018), Z Khan, Ashok Kumar Maurya and *DS Meena*)

PGR/PQR-BUR-DEL-01.08: Seed-health testing for conservation of indigenous germplasm free from pests (**J Akhtar**, SC Dubey, Baleshwar Singh, Shashi Bhalla (till) DB Parakh (till Jun. 30 2018), Meena Shekhar (w.e.f. Sep. 3, 2018), V Celia Chalam, Kavita Gupta, MC Singh, SP Singh, Z Khan, T Boopathi (w.e.f July 2018), Bharat H Gawade, Pardeep Kumar, Raj Kiran, Pooja Kumari (till Aug. 8 2018), Veena Gupta, Sushil Pandey, Sandhya Gupta (w.e.f. August 11, 2018), *Ashok Kumar Maurya, DS Meena and Smita Lenka Jain*).

PGR/PQR-BUR-DEL-01.09: Detection of viruses in *in vitro* cultures of germplasm meant for conservation (**DB Parakh** (till Jun. 30 2018) V Celia Chalam, Sandhya Gupta, Pooja Kumari (till July, 2018) and Ashok Kumar Maurya) (project closed and merged with PGR/PQR-BUR-DEL-01.08 in July, 2018)

PGR/PQR-BUR-DEL-01.10: Molecular based detection, identification and characterization of fungi and bacteria infecting plant genetic resources in quarantine (**Pardeep Kumar**, SC Dubey, Jameel Akhtar, Bharat H Gawade, and Raj Kiran). (project closed and merged with PGR/PQR-BUR-DEL-01.01 in July, 2018).

Externally funded projects

- National containment/ quarantine facility for transgenic planting material **(DBT) Component A** (**Shashi Bhalla (till January 31, 2018)**, **Baleshwar Singh (from February 1- September 30, 2018)**, **V Celia Chalam (w.e.f October 1, 2018),** Kavita Gupta, Z Khan and Jameel Akhtar (w.e.f July 2018)

- 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 (BT/PR18939/ PFN/20/1211/2016) (**DBT**). **(SC Dubey**, Jameel Akhtar and Pardeep Kumar)

DIVISION OF GERMPLASM EVALUATION 4

Summary: During 2018, a total of 18,087 accessions of various agri-horticultural crops were characterized / evaluated/ regenerated / multiplied. For evaluation against biotic stresses, 150 wheat germplasm were raised for preliminary screening for Karnal bunt disease and 31 wheat accessions were screened for Karnal bunt and Spot blotch disease under controlled conditon.In okra, 130 accessions of *Abelmoschus moschatus* were screened against okra yellow vein mosaic (OYVMD) and okra enation leaf curl (OELCD) diseases while 12 promising accessions of *Solanum incanum* were validated for fruit and shoot borer. In addition, 430 accessions comprising vegetables and pulses were evaluated for root-knot nematode resistance. Under abiotic stresses, 1179 accessions comprising wheat (959 acc.) and barley (220 acc.) were evaluated against drought. Quality parameters for 1,104 accessions comprising different crops *viz*., rice (178), wheat (100), maize (56), rapeseed-mustard (350), linseed (110), and potential crops (150) were studied. In medicinal and aromatic plants, 160 accessions were evaluated for various phyto-chemical constituents. Under CRP on Agro-biodiversity-PGR Component- 11,2,701 accessions comprising of rice (1,000), wheat (1,000), chickpea (290) and okra (411), were evaluated at AICRP centres/hotspots for biotic and abiotic traits. Five germplasm field days on major crops were organized to facilitate germplasm utilization and 6,991 accessions of various crops were supplied to 89 indenters for their use in crop improvement.

4.1 Germplasm evaluation

4.1.1 Characterization and preliminary evaluation for agro-morphological traits: A total of 18,087 accessions comprising wheat (2,820), barley (2,312), maize (684), lentil (2,314), mungbean (1,050), cowpea (2,308), ricebean (1,350), *Brassica* (791), sesame (2,900), pea (320), carrot (50), okra (531), brinjal (15), chilli (150), amaranth (80), fababean (50), *Chenopodium* (171) and *Ocimum* (117) were characterized for agro-morphological traits (Fig. 4.1) and promising accessions have been identified (Table 4.1). Entire set of lentil accessions (2,314) conserved in NGB were characterized for 28 descriptor traits with an aim to develop core set (Fig. 4.2). 127 accessions of lentil (trait specific & black lentils) also being evaluated at regional stations under multi-location trials. While in cowpea, 2308 accessions of cowpea comprising core set from IITA, Nigeria were characterized for pod and seed associated descriptors (Fig. 4.3). The superior barley accessions identified in the previous years were planted at two locations for further validation (Fig. 4.4 & Fig. 4.5). Hulled barley, IC445542 and EC578370 showed early maturity (< 105 days), whereas hull-less accessions IC542197 and IC470019 showed earliness (<107 days) and hooded barley accession EC0667420 matured in 117 days. IC113045 showed dwarf plant habit (42.51 cm) while EC578707 was validated for tall plant height (142 cm) with high biomass and without lodging. In ricebean, variability was observed for days to maturity, pod colour, pod length, pod, thickness, seed size and colour (Fig 4.6). Similarly maize germplasm recorded good variability for ear shape, ear size, kernel colour and kernel type (Fig. 4.7).

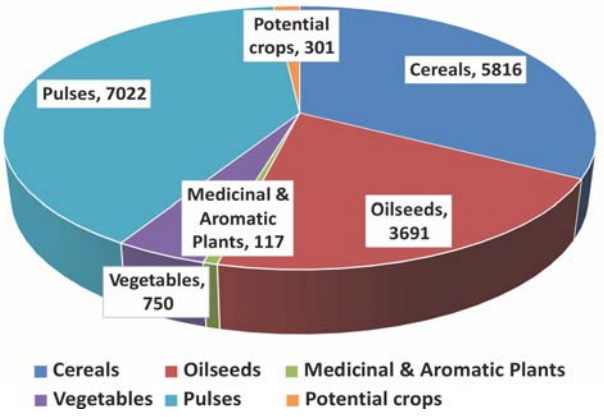


Fig.4.1: Accessions characterized / evaluated in various crop groups during 2018

Table 4.1: Promising accessions in different crops for various important traits

Crop	Characters	Promising accessions
Triticum aestivum	Days to heading (<80) Grains per spike (> 100) 1000 grain weight (>55g)	IC138883A, IC118758 IC530147,IC529494,IC529106,IC528914,IC144919 IC265331,IC145950,IC532452,IC534123,IC532139IC82453
T. durum	Days to heading (< 83) Grains per spike (> 70) 1000 grain weight (>55g)	IC532915, IC532434, IC532236, IC78707 IC144912, IC532914 IC78888, IC532124, IC73205, IC532915, IC534864
T. sphaerococcum	Grains per spike (> 40) 1000 grain weight (>40g)	EC187172, EC187181 EC576654 EC187182
Hordeum vulgare ssp.*hexastichum*	Days to spike emergence (<60 days) Days to maturity (<115 days) 100 grain weight(>6 g) Plant height (>160 cm)	IC138110, IC1381116, IC138118, EC578946 IC138109, IC138114, IC138110, IC138115, IC138116, IC138016 IC138017, IC138019, IC138026 IC138114, IC57532 IC137895, EC328983, IC446232
Hordeum vulgare ssp. *distichum*	Days to spike emergence (<60 days) Days to maturity (<115 days) 100 grain weight (>6 g)	IC137999 IC138119, IC138120, IC138121, IC445928 IC138120, IC446030, IC446204
Hordeum vulgare var. *nudum*	Days to maturity (<110 days) Spike length (>11 cm) 100 grain weight (>5 g)	IC384636, IC542197 IC411580 IC430092, IC393962
Maize	Days to tassel (< 40) 100 seed weight (> 29 g) Ear length (>20 cm) No. of ears/plant (>2) Waxy type/high amylopectin	IC97875, IC338625, IC280332, IC280347, IC280384 IC273365, IC296026, IC262803, IC427129, IC317315 IC427135, IC296026 EC894811, EC894812, IC130764 IC623954, IC624066, IC624018, IC624033, IC625138, IC625131
Brassica juncea	Dwarf habit (<95 cm) Main shoot length (>95cm) Early maturing (<98days) No. of silique on main branch (>81) Seeds/siliqua (>30)	IC422028, IC343199, EC766127 , IC347947 (72.5), IC491641, IC491251, IC422948, IC398763, IC570302, EC766133, EC766349 IC266810, IC491068, IC491196, EC765810, IC426385 IC20167, IC343199, IC589691, EC766320, IC426386, IC266266, IC426394 EC367885, IC491077, IC266810, EC765810 IC426322, EC634284, EC634281, IC20167
B rapa var. Yellow sarson	Dwarf habit (<97 cm) Early maturity (<100 days) Seed/siliqua (>40)	IC561347, IC399684, IC470977 IC561347, IC264824 IC267716, EC355319, EC355339
Lentil	Early flowering (<50 days) Number of secondary branches (>52) & Pods/plant (>300) 100 seed weight (> 6 g)	IC241532, IC241533, EC223238, EC223237A, EC78528, EC78477C, IC620659, EC955431 IC118930, IC201716, IC199461, IC282828 EC927418

	Mechanical harvesting (Pod setting above 15cm from ground)	IC240885, IC240886, IC241144, EC267615, EC267697 IC201557, IC201580, IC366159, IC240885, IC240886,
	Erect type	IC620659
	Number of pods/ cluster (5)	EC795516, EC836128
Ocimum basilicum	Plant height (>95cm)	EC338785, EC341845, EC385446, EC388846, EC338781, EC388894, EC176934
	Leaf length (>7.5 cm)	EC385449, EC338782, EC388846, EC385546, EC330274, EC385445EC388885
	Leaf width (>4.0cm)	EC385445, EC388846, EC388885, EC384555
	Herbage yield (>425 g/plant)	EC385448, EC385542, EC385542, EC282725, EC388846
Ocimum species	Plant height (>90cm)	IC618534, IC618358, IC623180, IC623176, IC618531, IC622543
	Leaf length (>6.0cm)	IC618534, IC619778, IC619787, IC623180, IC618531
	Leaf width (>4.0cm)	IC618534, IC623179
	Herbage yield (>400 g/plant)	IC618534, IC622543, IC622185, IC619777, IC622539, IC622541
Maize (winter-cold tolerance)	Germination (>70 %)	IC526537, IC526588, IC419530EC811232, IC568282, IC470459,IC568274, IC556413
	Dry matter accumulation at seedling stage (>6.0 g/plant)	IC436982, IC568298, IC556416, IC278614, IC447196, IC526430
	Test weight (>30.0 g/100 grain)	IC568282, IC326557, IC556415, IC568245, IC545306, IC568256
Pea	Earliness	IC356187, IC317547, EC598608
Carrot	Small core	IC144375, IC312928, IC325193
Cowpea	Nematode resistant (< 10 galls)	EC724523,EC723686, EC725122
	Early flowering (<40 days)	EC366776, EC701965, EC724439, EC724452
	Multiple pods (>4)/cluster	EC724658, EC724697, EC724700, EC769229, EC724054, EC725111, EC725120, EC242428-2
	Erect type	EC724365, EC12059, EC101997, EC240765, EC244396
	100 seed weight (< 4 g)	EC724824, EC724826
	100 seed weight (>22 g)	EC244164, EC99573,EC244080,
	Segmented leaves	EC723682, EC723867, IC402099
	Fodder type	EC724744, EC724746, EC724374, EC240890
	Hairyness	EC762384
Sesame	Dwarf type (<75 cm)	EC346212, IC132456, IC208670
	Early maturity (<85 days)	IC500866, EC346212, IC131651
	No. of Capsule/plant (>150):	IC500789, IC232271, IC23309, IC500847
	Seeds/ capsule (>65)	IC41945, IC500996, IC500944
	Capsule/nod (>5)	IC205312, IC500968-1
	Locule no./ capsule (>15)	IC132182, IC204639, IC43144-1
	Yield/plant (>36 g)	IC501018, IC501027, IC501010
	Non shattering type: Capsule	EC334978
	Hairyness	IC279373
Ricebean	Seeds/pod (e 11)	IC426795, IC373158, IC426788, IC426794, IC426796, IC426773, IC426773, IC426789
	Pod length (> 13 cm)	IC137130, IC545618, IC137180, IC422931, IC422822, IC423323, IC573536
	Early maturity (<80)	IC112379, IC589128, IC137161, IC341995, IC341992

Amaranth	Days to 50% flowering (≤65) Inflorescence length (> 61.30cm)	IC35546, IC35545, IC095558, IC095597, IC035624, IC035554, IC093941, IC355541
Fababean	No. of pods per plant (>43) No. of seeds per pod (≥4.00) Pod length (mm) (>60)	EC361485, EC351587, EC287710, EC343891 EC628940 EC293820, EC32923
Chenopodium	Days to 50% flowering (≤53) Inflorescence length (> 39 cm)	EC896062, EC896061, EC896279, EC896305 EC896244, EC896213, EC896068

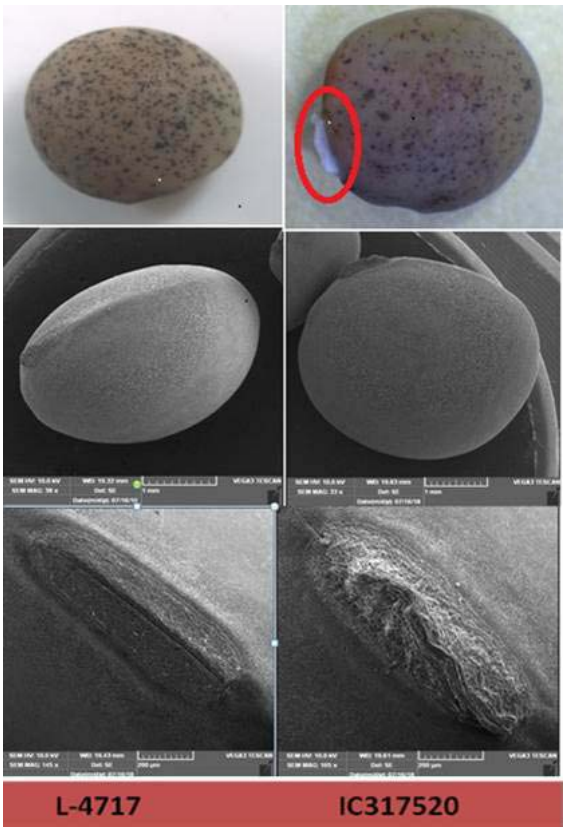


Fig. 4.2: Atypical morphotype of lentil with extended funiculus

Atypical morphotype with extended funiculus identified in lentil

An atypical morphotype (IC317520 from Rajasthan) of lentil was identified during mega characterization of entire set of lentil conserved in NGB at ICAR-National Bureau of Plant Genetic Resources. Based on comparative study with selected accessions for seed morphology, quality traits and physiology, this accession was identified with very distinct and prominent funiculus on the seed coat. It has higher rate of water uptake and superior nutritional traits (rich in sugar, starch, protein and minerals). This accession is also being evaluated under multi-location trial at NBPGR New Delhi, R.S. Ranchi & Bhowali to validate the stability of unique trait.

Evaluation of ber germplasm

Twelve ber (*Ziziphus mauritiana* L.) germplasm planted at Issapur farm, NBPGR, New Delhi were studied during 2017-18 for morphological and biochemical characterization. Minimum stone/ kernel size (7%) was recorded in accession IC0625596. It has oblong fruit shape, golden colour fruit at the time of maturity and TSS ~ 17° Brix. However, maximum yield (80.5kg) per plant was recorded in Umran germplasm with higher fruit weight compared to others.

Fig. 4.3: Pod, leaf and seed variability in cowpea germplasm

Fig. 4.4: Field view of characterisation of barley germplasm (2,312 accessions)

Establishment of field gene bank of neglected fruits and important perennial species of semi arid region at NBPGR Issapur, New Delhi

To strengthen plant genetic resources of neglected fruit and perennial plant species of semi arid region, the NBPGR has initiated to establish the field gene bank at experimental farm, Issapur, Delhi. The Soil and climatic condition of Issapur is favorably suitable for conservation of fruit, ornamental and medicinal plants species of semi-arid origin. Ex-situ conservation of perennial plant species of

(a) IC138115

(b) IC138119

Fig. 4.5: Barley accessions showing early maturity

Fig 4.6: Ricebean pod variability for length, thickness and colour in near maturity stage

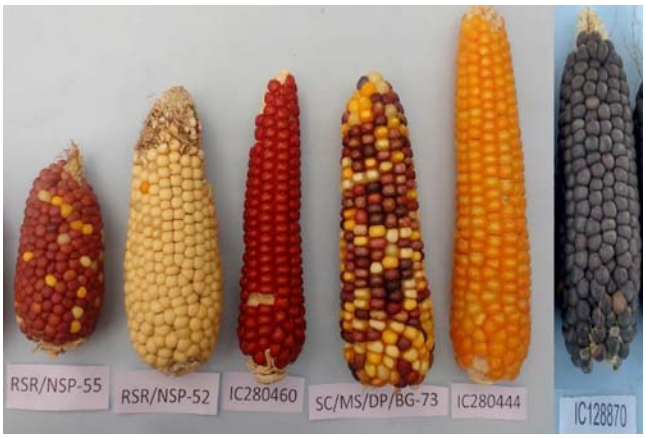


Fig. 4.7: Variability in maize germplasm for ear shape, ear length, kernel colour and kernel type

economic importance has been prioritized and landrace, cultivated types and their wild relatives have been collected from adjoining area of Delhi, SAU(RS, HAU, Bawal) and ICAR(CIAH-Bikaner) institutions. Presently, 165 perennial plants belonging to 34 species of 18 families have been established during rainy season, 2018.

4.1.2 Screening of germplasm for biotic stress resistance: In wheat, 150 accessions of minicore were screened against karnal bunt under artificial inoculation in collaboration with ICAR-Indian Agricultural Research Institute, New Delhi. In addition 31 promising accessions were validated under glasshouse condition for Karnal Bunt and Spot blotch diseases. Six accessions namely, EC 575772, IC443669, EC575729, EC577710, EC299009, IC611476, IC252431, IC443652, IC529962, IC548325 (< 5% of KB disease incidence and spot blotch resistance double digit score <13) were found tolerant to both diseases. In addition, a total of 430 accessions, comprising of various pulse crops, cowpea (230), lentil (100) and pea (100) were evaluated for their host status to root-knot nematode, *Meloidogyne incognita* in pots with artificial inoculation. Based on number of root galls induced by nematodes, four accessions of cowpea (EC723776, EC723796, EC528391, EC517140), two of lentil (EC078526, IC560045) and one accession of pea (NBP-147-R) were found resistant to *M. incognita*. Besides, three accessions of cowpea (EC0723686, EC0724523, EC0725122) and two accessions of lentil (IC559673, IC559890), which were previously evaluated as resistant were also evaluated to test their resistance consistency. All these five accessions were confirmed as resistant to *M. incognita*. A collaborative trial was also initiated to screen diverse lentil germplasm for rust, *Uromyces viciae-fabae* (250 acc.) and *Stemphylium* blight (500) at PAU, Gurdaspur and BCKV, Kalyani respectively.

4.1.3. Evaluation for abiotic stresses: During the period under report, evaluation for wheat, barley and urdbean was undertaken for various abiotic stresses viz., drought and water logging. The details are provided below.

Under NICRA project, a set of diverse wheat panel of 343 accessions were grown for evaluation against moisture stress at farm of ICAR-NRCPB, New Delhi 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: KP1874,

IC57472, IC445595, IC290192, HGP1-403, CRP-165/18, CRP-165/14, KP1860, IC445498, KP1876 (>417.50); thousand grain weight: EC664276, KKM/YKY11, KKM/YKY10, EC425336, KP1872, IC252960, KP2097, HGP1-359, EC635570, IC78822, IC82350, IC111840(>50.17); Mean NDVI: KP1875, IC290196, KP1863, IC445498, KP1874, IC549449, KP1867, KP1865, KP1862, IC547561, J31-101 (>0.47).

A set of 569 wheat accessions comprising of FIGS set and previous selection based on phenotypic data and was evaluated at NBPGR Experimental farm Issapur in Augmented Block Design using checks HD-2967, C-306, Raj-3765, WR-544, HD3086. These accessions were grown under rainfed and terminal heat stress conditions. and data were recorded for 16 morpho-physiological traits. Accessions KKM/YKY8,IC534047, IC415672, IC536113, IC535702, IC543290, IC539543, KP1858 performed better than best check WR-544 under both stress conditions based on grain yield and Normalized Difference Vegetation Index.

In addition, a reference set of 47 wheat lines (pre-screened at New Delhi and Hisar) was screened in alpha lattice design with three replications. Different morpho-physiological and yield traits were recorded in rainfed and irrigated plants. Under rainfed conditions, average yield reduced 37.27% and thousand grain weight reduced 17.4% compared to irrigated conditions. Study led to identification of wheat lines (IC443738, IC28669, IC416320, IC252376, IC539531, IC542494, IC445332, IC252792, IC401976, IC539316, IC539315, IC539317, IC498438) performing better for yield, while, IC31614, IC31525, IC443738, IC416164, IC252376, IC539531, IC445332, IC539316, IC498438 registered higher thousand grain weight compared to C306 under rainfed conditions.

Further, A set of ten wheat lines (screened earlier at New Delhi and Hisar) was evaluated for drought tolerance under Nanaji Deshmukh Plant Phenomics Centre at Indian Agricultural Research Institute, New Delhi. Experiment was conducted in randomized block design with three replications and two treatments i.e. irrigated and drought. Depending upon the water use, different genotypes responded differentially. Average yield reduced 40.1% under controlled conditions. Accession IC401979 was found to be drought susceptible, while accessions; IC443738 (19.6 g plant^{-1}) and IC28669 (18.9 g plant^{-1}) showed higher yield compared to C306 (17.1 g plant^{-1}). Similar set of genotypes was also evaluated in field under rainfed conditions. In field too, IC26889 and IC443738 performed better for thousand grain weight compared to C306 (36.5 g) Fig. 4.8.

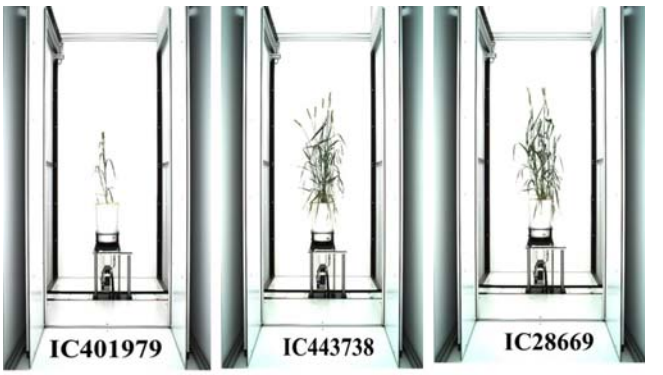


fig. 4.8: Response of different wheat lines to drought stress at phenomics centre, IARI

Evaluation of barley germplasm for drought tolerance: A set of 220 diverse barley germplasm was evaluated for root system architecture (RSA) under polyethylene-glycol simulated drought stress [15% PEG-6000 (-0.295 Øs at 25°C)] at seedling stage under long-day photoperiod (16 h light/8 h dark) at 22°C and a relative humidity of 65-75%. The evaluation of root images using WinRhizo root scanner indicated that PEG resulted in a decline of 47.18-54.53% in root length, root surface area and root volume. Under optimum conditions, the maximum value for total root length (RL) per seedling was 97.25 cm in IC533320 compared to check variety BH902 (48.69 cm), while under stress conditions, RL was highest (52.96 cm) in IC393980

compared to rain-fed varieties RD2660 (31.55 cm) and RD2624 (27.98 cm) used as check. For better RSA under drought stress, genotypes IC393980, IC082719, IC329556, EC492318, EC578789, EC578790, IC335811 and wild barley *H. marinum* ssp. *gussoneanum* proved to be the most tolerant based on high PC scores. The whole set of 220 accessions was also evaluated under field conditions for drought stress using agro-morphological and physiological parameters. Based on stress susceptibility index, 10 barley genotypes (six most tolerant; IC582699, EC578279, EC578711, IC113045, EC578521, EC492318 and four most susceptible; EC578829, EC578822, IC079456, IC542206) were selected for candidate gene association work and study of allelic variation.

Evaluation of black gram accessions against waterlogging stress

During *kharif* 2018, black gram accessions (IC530491 and IC519330) were validated for their response to waterlogging stress under controlled conditions. The experimental lines were selected from a set of 290 lines, screened earlier during *kharif* 2016 and 2017 for waterlogging tolerance. A pot experiment was conducted to study physiological and biochemical basis of waterlogging tolerance in identified accessions. Study was carried out in completely randomized design in three replications and was conducted twice during the season. Stress was imposed for 10 days at vegetative stage (30 days after sowing) and thereafter, excess water was drained to allow recovery. We studied the effect of waterlogging stress on membrane stability index (MSI), lipid peroxidation, superoxide dismutase (SOD) activity, chlorophyll content and chlorophyll fluorescence. Waterlogging tolerance in black gram accessions; IC530491 and IC519330 was associated with high SOD activity, membrane stability and chlorophyll content during the stress.

4.1.4 Biochemical evaluation: Biochemical evaluation for quality traits in cereal crops (rice, wheat and maize); oilseeds; organoleptic tests of vegetable amaranth species; phytochemical traits and fatty acid composition in medicinal and aromatic plants; non-destructive (NIRS based) prediction model in rice and ricebean-adzukibean for quality traits; were performed.

Quality analysis of cereal crops

Quality evaluation in wheat: 76 accessions of wheat were analysed for protein content. Superior accessions having >16% protein content were EC576930, IC325938, IC534892, IC144903,

Table 4.2: Evaluation of rice germplasm (178 Acc.) for proximate and minerals.

Trait	Range	Mean	Superior Acc
Ash %	0.73-2.11	1.58±0.41	IC622611, AD 84 >2
Protein %	6.56-15.8	11.1±1.91	AD16/101, IC622660 >**13.5**
Fat %	4.17-8.35	6.96±0.77	IC622651, IC623258, IC623260, IC622651 **>8**
Starch %	37.7-81.5	58.4±9.8	IC622634 **>80**; IC622608, AD16/101 **<40**
Sugar %	1.64-7.06	5.24±1.25	IC622656, IC622634 <2, IC622629, IC622638 **>7**
Phenol %	0.086-1.27	0.32±0.19	IC622624 >1.0
Cuprac %	0.302-4.8	1.91±1.1	IC623265, IC623260, IC622624 >4
Cu mg/100g	0.069-2.32	0.65±0.44	IC622636, IC623257, IC622623, IC622630 >2
Zn mg/100g	1.49-4.66	3.25±0.67	IC622629, IC622630, IC622623, IC622634, IC623258 >4
Fe mg/100g	0.869-6.83	3.16±1.23	IC623257, RSR12, IC622635, IC622646 **>6**
K mg/100g	71.5-127	99.7±11.7	IC622628 >120
Ca mg/100g	7.99-16.8	12.2±1.79	IC622641, IC622629, IC623253 **>14.5**

IC406521 and IC531183, EC592592, IC535236, IC406688 in comparison to check WH1021 (12.8%), C306 (12.22%), WR544 (12.20%), whereas low protein accession was IC35715 (6.22%) and IC252668 (9.4%). Further, 24 wheat accessions were also analysed for protein content for validation purpose and high protein accessions include EC217843 (18.35%), EC217659 (17.71%), EC217883 (16.91%), IC547637 (16.59%), EC473090 (16.43%), EC405359 (16.75%), IC296727 (16.43%) and EC217715 (16.27%) whereas low protein accessions were IC111979 (9.4%) and IC402010 (9.57%).

Quality evaluation in maize: 43 maize accessions were also analysed for protein content which ranged from 4.8 to 11.9%. Superior accessions include IC624146 (11.9%), IC624151 (11.81%), IC624181 (11.72%), IC624161 (11.28%), IC624165 (11.11%), IC624167 (10.41%), IC624145 (10.32%), IC624162 (10.15%) in comparison to check HQPM 4 (8.4%).

Validation of promising accessions in maize: Promising maize accessions (13 accs) for various fatty acids were further grown in field during *kharif* 2016 and *kharif* 2017 and analysed for fatty acid profile for validation purpose. Based on these two years data, accessions IC411287 (51.39%), IC251303 (50.77%), IC411285 (47.52%) and EC444523 (46.98%) for linoleic acid; and accessions IC405283 (42.05 and 41.62%), EC477374 (43.62 and 38.05%), EC477357 (38.53 and 44.39%) for both oleic and linoleic acids in comparison to check HQPM5 (oleic acid 31.23% and linoleic acid 40.15%) were validated. Promising accessions of maize for protein content were grown in field during 2016 (third year) and 2017 (Fourth year) and analysed for protein content and based on two years value, accessions EC638005 (11.81%) and IC563963 (10.15%) had higher protein content in comparison to check HQPM 4 (8.4%).

Quality analysis of oilseed crops

350 accessions of *B. juncea* were analysed for oil content which ranged from 31.22 to 44% with a mean value of 36.33%. Promising accessions include IC422156 (44.0%), IC422172 (43.87%), IC422161 (43.42%), IC491485 (43.32%), IC491455 (43.29%), IC426388 (42.79%), IC491641 (42.47%), IC491476 (42.44%). Similarly, 110 accessions of sesame were analysed for oil content which ranged from 32.29-62.01% and superior accession include IC131634 (62.01%).

In addition to this, two accessions (IC208326 and IC208329) of lentil validated for high protein content (28-29%).

Quality analysis of potential crops

100 accessions including five different vegetable amaranth species namely *A. tricolor* (69 accs.), *A. dubius* (14 accs.), *A. hybridus* (3 accs.), *A. lividus* (3 accs.) and *A. retroflexus* (one accs.) and 10 checks were analysed for various organoleptic tests based on appearance, smell, taste etc. Sampling of fresh leaves was done from field and cooked after washing. Ten persons who are regular consumers of vegetable amaranth were selected for organoleptic evaluation of the vegetables. Based up on the evaluation, some accessions of *A. dubius* namely IC551503, IC551504, IC551458, IC553738 were found highly bitter whereas IC551464, IC551501, IC553750 were found bitter in taste. Some other accessions of the *A. dubius* were normal in taste. So, biochemical evaluation is going on for various parameters including anti-nutritional factors.

In addition to this, 50 accessions of different vegetable amaranth species were also analysed for oxalate content in cooked leaves along with five checks. Oxalates are anti-nutritional and their higher intake leads to stone formation. The oxalate

content ranged from 5757.58 to 14393.94 mg/100g of leaves. The details are given in table 4.3.

Method development

NIR Prediction models

Amylose prediction model for rice flour was developed in collaboration with division of genetics, ICAR-IARI where samples used in calibration and validation had amylose range from 5-30%. This model was used for predicting 100 acc of rice. Results in brief are mentioned in table 4.4.

Ricebean-adzukibean prediction model

Ricebean-adzukibean prediction model was developed and validated for multiple traits where in model qualified for screening criteria (SD/SEP(c) $\geq$ 2.0) for most of the traits except for protein, ash and sugar, results in brief are mentioned in table 4.5.

Phytochemical evaluation of medicinal and aromatic plants: Medicinal and aromatic plants (160 acc.) were evaluated for various quality traits and the range values along with superior accessions are provided in table 4.6.Superior accessions of *M. pruriens* var. *pruriens* were validated for L-dopa content in dry seeds by HPTLC. IC599290 was confirmed with high L-dopa (7.29 %) over four years of evaluation.

Essential oil composition of six species of *Ocimum* germplasm

Essential oil profiling of 34 accessions of *Ocimum* germplasm comprising six *Ocimum* species was done

Table 4.3: Oxalate content of cooked leaves of different vegetable amaranth species.

Species	No. of accs.	Range (mg/100g)	Mean (mg/100g)	Check value	Value rich accs.
A. tricolor	29	5757.58-14393.94	13561.24	Pusa Kiran (14289.45 mg/100g)	IC469620 (5757.58 mg/100g), IC536561 (9414.84 mg/100g)
A. dubius	14	13777.43-14414.84	14.67.4	A Samraksha (13949.84 mg/100g)	
A. hybridus	3	12978.06-13965.52	13625.91	A Varna (14012.54 mg/100g)	
A. lividus	3	13939.39-14038.66	13991.64	Arun (13766.98)	
A. retroflexus	1	13928.94	13928.94	Pusa Lalchaulai (13777.43 mg/100g)	

Table 4.4: NIR Prediction model for rice.

	Calibration validation (N=100)	External (prediction) validation (N=49)	Prediction stat for 100 rice accessions
Mean	23.8±3.5	23.7±3.2	30.1±2.63
Est. Range	13.2-34.3	14.3-33.5	22.9-35.5
Std. dev. (SD)	3.62	3.32	Very high amylose >30 %
Std. Err. (SE)	2.01	1.69	IC623256, IC623253, IC622613,
SD/SE	1.80	1.96	IC622621, IC623254,IC622638,
R^2	0.815	0.777	IC623260

Table 4.5: NIR Prediction model for Ricebean-adzukibean

Trait	Range	R^2 (external)	SD/ SEP(c)
Protein %	19-24	0.684	1.72
D. Fiber %	11-25.5	0.695	1.92
Ash %	1.7-8.8	0.724	1.19
Sugar %	2.85-6.72	0.647	0.907
Starch %	31.5-47.7	0.714	1.99
Phytate %	0.394-1.9	0.889	3.01
Anthocyanin mg/g	0.103-3.85	0.939	3.86
FRAP mg/g GAE	0.62-5.06	0.818	2.14
CUPRAC mg/g GAE	3.15-9.38	0.698	2.05
Red	54-253	0.912	2.50
Green	41-236	0.913	2.99
Blue	54-201	0.823	2.17

by GC/FID and GC/MS. Each species was characterized by presence of distinct chemotypes based on chemical composition and major compounds. The five chemotypes identified in *Ocimum* species were: (1) Camphor rich chemotype in *O. americanum* and *O. kilmand-scharicum*; (2) Eugenol rich chemotype in *O. gratissimum* and O. *tenuiflorum*; (3) Methyl eugenol rich chemotype in O. *tenuiflorum* (4) Methyl cinnamate rich chemotype in *O.basilicum*; (5) Geranial and Neral rich chemotype in *O. citriodorum* (Table 4.7).

4.2 Evaluation under CRP on agro-biodiversity

Under CRP on Agro-biodiversity, a total of 2,701 accessions comprising rice (1,000), wheat (1),

Table 4.6: Phytochemical analysis of Medicinal and Aromatic Plants for active chemical compound.

Plant Name (Common name)	No. of Acc.	Plant partused	Active compound	Range(%)	Superior Accessions
Ocimum species (Basil)	5249 (2nd year)	Fresh Herb content	Essential oil	0.06 - 0.75% (FWB)0.07 - 0.32%	IC622523 IC622536 EC388887
Costus speciosus (Crepe ginger)	04	DryRhizomes	Diosgenin content	1.05-1.47% (DWB)	-
Dioscorea species (7) (Yam)	12	Dry Tubers	Diosgenin content	0.001- 0.003 % (DWB)	-
Mucuna pruriens var. *pruriens* (Kewanch)	06	Dry Seeds	L - 3,4-dihydroxy phenylalanine (L-dopa)	6.21 – 7.29 % (DWB)	IC599290
Hedychium coronarium *Hedychium flavecens* *Hedychium coccineum*	03	DryRhizomes	Essential oil content (DWB)	0.39%0.41%0.58%	-

Table 4.7: Chemical constituents of essential oil from *Ocimum* species.

Ocimum Species (Accessions)	Major Aromatic Compounds Identified
Ocimum tenuiflorum (8)	**Eugenol, Methyl eugenol**, (E)- β-Caryophyllene, β-Elemene
Ocimum basilicum (6)	**(E)-Methyl cinnamate,** Linalool, (Z)-Methyl cinnamate, *epi*-α-Cadinol
Ocimum americanum (7)	**Camphor**, *epi*-β-eudesmol, β-Selinene, α-Selinene, Limonene, β-Caryophyllene, ρ-Cymene, Camphene, β-Pinene
Ocimum gratissimum (6)	**Eugenol**, (Z) -β-Ocimene, Germacrene D, (E)- β-Caryophyllene, (E)- β-Ocimene
Ocimum kilmandscharicum (2)	**Camphor,** (E)- β-Caryophyllene
Ocimum citriodorum (5)	**Geranial, Neral**, Linalool, (Z)-α-Bisabolene, Nerol, Geraniol, *cis*-α-Bergamotene, (E)-β-Caryophyllene,

finger millet (1,000), chickpea (290) and okra (411) were evaluated at AICRP centres/hotspots for biotic and abiotic stresses. In addition, biochemical analysis of grain samples of durum and dicoccoum wheat core (541 acc.) grown at ARI, Pune were carried out at IIWBR, Karnal for protein content, sedimentation value and hectolitre weight. Some value rich accessions were identified for test weight/hectolitre weight with values >83.0 including IC535647 IC534569, IC416334. Promising accessions identified for various traits are given in the table 4.8.

Values in parentheses show number of accessions found promising for the respective trait. Only few accessions are shown here.

4.3 Pre-breeding and genetic enhancement

During the period, wild *Vigna* accessions (20 acc. representing 10 species) evaluated for root knot nematode resistance. Among 199 lines of different species of capsicum (*Capsicum annuum* L., *Capsicum baccatum* var. *pendulum* L., *Capsicum annuum* var. *glabriusculum* L., *Capsicum pendulum* L., *Capsicum chinense* L., *Capsicum pubescens* L), accessions EC772739, EC772283 and EC772772 of *Capsicum annuum* var. *longum* and EC772730 of *Capsicum chinense* were found resistant to leaf curl virus disease and set fruit at high temperature (>40^{0}C), EC772807 of *Capsicum annuum* var *glabriusculum* for resistant to leaf curl virus

Table 4.8: Promising accessions in different crops for various important traits.

Crops	Locations	Promising accessions
Rice	CRRI, Cuttack IIRR, Hyderabad PAU, Ludhiana RWRC, Malan CSSRI, Karnal	**Blast (33)**: IC278775, IC343466, IC256826, IC326417, IC337615, IC340694, IC283250, IC282434, IC282481, IC283064, IC426069 **Sheath Blight (5)**:IC326423,IC328519,IC426155,IC343459, IC326477 **Blast (40)**: IC256842, IC283251,IC256780, IC273558, IC282438, IC331140, IC277304, IC283009, IC298485, IC346230, IC283262 **Brown spot (15)**: IC346216, IC282438, IC343395, IC337588, IC283007, IC298485, IC283204, IC346913, IC344726, IC282512 **Brown Plant Hopper (39)**: IC256849, IC280565, IC256621, IC256842, IC337613, IC343499, IC283251, IC426092, IC346252, IC346248 **Salinity stress (25):** IC256617, IC321674, IC277313, IC340680, IC298582, IC340683, IC346831, IC283120, IC340695, IC447326
Wheat	PAU, Ludhiana; IARI RS, Wellington; VPKAS, Almora; CSSRI, Karnal; IIWBR, Karnal	**Yellow rust, brown rust and Karnal bunt:** EC0635642, EC0635706, EC0635712, EC0635691, EC0635640, EC0635757, IC0145953, IC0082402-B, EC0635665, EC0635611 **Powdery mildew :** IC128150, IC576640, IC406688, IC542076, IC532019, IC28872 IInd year -EC277127, IC549437, EC299114 **Loose smut:** IC531432, EC190963, IC531542IC542820, IC529090, IC 535678 EC575873, EC576195, IC 75221, EC574014, IC573553, IC535702, IC531154, IC531884, IC533544, EC190995, EC257881, EC 556510 **Salinity tolerance:** IC0445425, IC0128150, IC0531524, IC0542051, IC0128280, EC339611, EC6903, IC0075221, IC0346064, IC-0138909-B, EC0597864, EC0595177, EC0582359, EC0595181, EC0595260, IC0591096, IC0598582, EC0635626, IC0598581, EC0595298

Crops	Locations	Promising accessions
		Protein content (>18%): IC535848, EC534537, EC299141EC574041, IC112060, IC78714, EC299182, IC321891, IC549437, EC467720, EC574735, EC299324
Chick pea	JNKV, Jabalpur; RARI, Durgapura; IIPR, Kanpur; PAU, Ludhiana	**Ascochyta blight:** IC275447, IC117744, EC223490, EC223497, EC267186, EC267301, IC209670, IC3775, ICC3687, ICC4330 **Dry Root Rot:** IC271922, IC487359 **Collar Rot:** IC267112, IC271922, IC305587, IC327563, IC486170, IC487359, IC512061 **Fusarium wilt:** IC267112, IC271922, IC327563, IC486759, IC487359, IC512061 **BGM:** IC327930, IC546321

disease, *Capsicum annuum* var. *grossum* (sweet pepper) for fruit set at high temperature (>40^{0}C)).

Interspecific hybridization for trait introgression and genetic base enhancement in *Vigna radiata* and *V. mungo*

Total 545 crosses were attempted to transfer useful traits from other *Vigna* species to *Vigna radiata* (mungbean) and *Vigna mungo* (urdbean). *V. umbellata* (ricebean) was used as donor species for transferring its MYMV resistance trait to mungbean (Fig. 4.9 and 4.10). Other combinations were also attempted for example: *V. radiata* × *V. mungo* (125 crosses) for MYMV resistance, *V. mungo* × *V. trilobata* (97 crosses) for traits like thermo-insensitivity, peduncle length, pods/cluster (Fig. 4.11), *V. mungo* × *V. mungo* (15 crosses) for understanding inheritance pattern of R genes governing MYMV resistance (Fig. 4.12). However, very limited success could be made in getting F_1 seed; one seed for *V. radiata* × *V. umbellata*, 2 seeds (1 pod) for *V. mungo* × *V. trilobata* and 14 seeds (3 pods) *V. mungo* × *V. mungo* type cross. In addition, two accessions IC253952 and IC539855 of brinjal wild species *Solanum incanum* field resistant to brinjal shoot and fruit borer (FSB) were used in pre-breeding program as male parent to transfer the FSB resistance to cultivated species.

Fig. 4.9: Partial view of *Vigna* spp. in field at New Area Farm, New Delhi

4.4 Germplasm registered for unique traits

Table 4.9 shows the different accessions registered during the year by the plant germplasm registration committee for various traits.

Fig. 4.10: Interspecific hybridization between *V. radiata* and *V. umbellata*

Fig. 4.11: Interspecific cross combination of *Vigna mungo* and *V. trilobata* to transfer traits like thermo-insensitivity, peduncle length and peduncle density

Fig. 4.12: Contrasting type of urdbean genotypes Mash 114 (resistant) and BLR/PBS-14 (susceptible) used for crossing

4.5 Documentation

A total of 6690 accessions of various crops were characterized and evaluated during *Kharif 20*17 at ICAR-NBPGR, New Delhi (3908) and its Regional Stations namely Akola (305), Bhowali (554), Cuttack (110), Hyderabad (273), Ranchi (100), Shillong (204), Shimla (1056), Thrissur (180). The same was compiled and documented as "Annual Report on Characterization and Evaluation of *Kharif* Crops (2017)".

4.6 Germplasm supply

During the period, a total of 6,991 accessions of various crops, viz., wheat (2,409), barley (470), maize (124), rice (837), pulses (546), oilseeds (309), vegetable crops (656) and medicinal and aromatic plants (71) were supplied to 89 indenters belonging to ICAR Institutes, SAUs and other research organizations engaged in crop improvement programmes.

Table 4.9: Genetic stocks registered.

SN	Crop	Nat ID	INGR	Unique Traits
1.	Wheat	IC0564121	18014	Highly resistant to spot blotch
2.	Wheat	IC0443669	18015	Highly resistant to spot blotch
3.	Indian mustard	IC0265495	18032	White rust resistance
4.	Indian mustard	IC0313380	18033	White rust resistance
5.	Blackgram	IC011613	18027	Resistant to MYMV
6.	Blackgram	IC0485638	18028	Resistant to MYMV
7.	Linseed	IC096539	18034	Early maturity
8.	Cucumber	IC0420405	18029	High carotenoid content and orange flesh colour
9.	Cucumber	IC0257296	18030	Two female flowers/ node, earliness and small fruit
10.	Sweet Basil	EC338785	18042	High methyl chavicol content (> 88.81±2.34 %)

4.7 Active germplasm holding

A total of 41,011 accessions of various crops comprising wheat (8,273), barley (7331), maize (2,350), pulses and legumes (7,591), okra (2,499), brinjal (2,932), tomato (548), bottle gourd (400), ridge gourd (261), sponge gourd (310), ash gourd (236), *Brassica* (3,880), sesame (750) linseed (400), potential crops (1,487) and medicinal and aromatic plants (270) were maintained in medium term storage. In addition, *Vetiver* (131), *Palmarosa* (55), *Asparagus* (22), 25 accessions of giloe, 50 accessions of Aloe and 40 accessions of other medicinal and aromatic plants were maintained in field gene bank.

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

PGR/GEV-BUR-DEL-1.00: 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-1.01: Characterization, evaluation and documentation of wheat, barley and triticale germplasm (**Jyoti Kumari**, Sandeep Kumar, Sundeep Kumar, Vikender Kaur, Ruchi Bansal, SK Kaushik and *Y S Rathi*)

PGR/GEV-BUR-DEL-1.02: Characterization, evaluation and documentation of maize germplasm (**Ashok Kumar**, Jyoti Kumari, Ishwar Singh and *RK Sharma*)

PGR/GEV-BUR-DEL-1.03: Characterization, evaluation and documentation of pulses germplasm (**Gayacharan** (w.e.f. 1 May 2018), NK Gautam (till 30 April 2018), Rakesh Bhardwaj, Ruchi Bansal, Soma Marla, Jameel Akhtar, Kuldeep Tirpathi, Kumari Shubha (till July 2018), Z. Khan (w.e.f. 11 August 2018), Nand Lal Meena (w.e.f. 2 July 2018), T Bhupathi (w.e.f. 11 August 2018), Mamta Singh and *Babu Ram*)

PGR/GEV-BUR-DEL-1.04: Characterization, evaluation, and documentation of oilseeds germplasm **(Rashmi Yadav**, Sandeep Kumar, Vijay Singh Meena, Vikender Kaur, Kuldeep Tripathi (till September 30, 2018), Mamta Singh (w.e.f. 20 August 2017), Jameel Akhtar (w.e.f. 11 August 2018), Sapna (w.e.f. 29 June 2018) and *BL Meena*)

PGR/GEV-BUR-DEL-1.05: Characterization, evaluation and documentation of vegetable and ornamental crop germplasm (**KK Gangopadhyay,** Rakesh Srivastava, Vijay Singh Meena, SK Yadav, Vinod Kumar, Pragya, Pooja Kumari, Bharat Gawade, Bharat Bhushan, Kumari Shubha (till 13 July 2018), Rajkiran (w.e.f. 23 June 2018), T Boopathi (w.e.f. 07 August 2018) and Nand Lal Meena (w.e.f. 02 July 2018))

PGR/GEV-BUR-DEL-1.06: Biochemical evaluation of field and vegetable crops germplasm **(Rakesh Bhardwaj**, Sandeep Kumar, Manjusha Verma, Bharat Bhushan (till 07 July 2018)), Vijay Singh Meena, Sapna (w.e.f. 29 June 2018), Nand Lal Meena (w.e.f. 02 July 2018) and *Poonam Suneja*)

PGR/GEV-BUR-DEL-1.07: Characterization and evaluation of medicinal and aromatic plants germplasm **(Archana P Raina**, Ashok Kumar, Ishwar Singh, Rakesh Singh and *BS Panwar*)

PGR/GEV-BUR-DEL-1.08: Evaluation for abiotic tolerance in field crops germplasm stress (**Ruchi Bansal**, Vikender Kaur, Rashmi Yadav, Jyoti Kumari, Gayacharan, Kuldeep Tripathi, MC Yadav, Mamta Singh and Nand Lal Meena (w.e.f. 02 July 2018)

PGR/GEV-BUR-DEL-1.09: Characterization of wild species and pre-breeding in selected crops **(Vinod Kumar**, Gayacharan, KK Gangopadhyay, NK Gautam (till 30 April 2018), Mohar Singh, MK Rana, Kuldeep Tripathi, M Latha and R Gowthami (w.e.f. 11 August 2018)

PGR/GEV-BUR-DEL-1.10: Characterization, evaluation and documentation of underutilized crops germplasm (**SK Kaushik**, BS Phogat, SK Yadav, Hanuman Lal, Archana P. Raina and Rakesh Srivastava)

PGR/GEV-BUR-DEL-1.11: Application of statistical techniques in management of information on plant genetic resources (**Hanuman Lal**)

DIVISION OF GENOMIC RESOURCES 5

Summary: A total of 195 samples consisting of 20 crops received from public and private sector organizations were DNA fingerprinted. Genetic diversity was studied for rice (330), soybean (96), foxtail millet (20), sesame (96) and *Garcinia indica* (43). SSR marker development and validation were executed in little millet (92 genes-SSRs), kodo millet (58) and *Andrographis paniculata* (68). *Fructosyltransferase* gene was identified as a key differentially expressed gene in heat susceptible and tolerant genotypes of wheat. The expression pattern of lipid biosynthetic genes during seed's developmental stages revealed the genes critical during maturing stages of seed. Seven candidate genes involved in root nitrogen uptake and transportation were mapped onto wheat chromosomes and their synteny with other cereals was compared. In an association panel of wheat 23 SNPs for grain size and shape related traits were found. A total of 1,816 accessions of little millet was morphologically characterized at two locations for trait association/tagging studies. Calyx number and locule number diversity were characterized in sesame (700) accessions. A marker of 280 bp was found linked to solitary fruiting gene in an F_2 population of a inter-specific cross of *Luffa*. Chromosome identification and karyotyping of *L. cylindrica* delineated twelve meta-centric and one sub-metacentric chromosome *pairs* with varying chromosome lengths. Sequence diversity in myrosinase gene family from *Brassica oleracea* var. *capitata* and its related species was studied to develop gene specific markers. 35K array data of 224 accessions of wheat minicore set was completed with 35,143 SNPs markers in an endeavour to accomplish GWAS for spot blotch resistance in wheat. Prebreeding for terminal heat tolerance was done by characterizing 12 plant and grain characteristics in 1,459 plants of F_4 populations of bread wheat; and 485 F_3 progenies from 3 additional crosses. MAGIC population development for terminal heat-stress tolerance was advanced in wheat. Study of putative regulators of Kranz anatomy in *Poaceae* family revealed differences at phosphorylation sites in proteins in C_4 group of crops compared to C_3 crops. Identification of accessions for different traits was done in Linseed. A total of 462 genomic resources representing 6 crops was added to NGRR during 2018 . An efficient and rapid screening method was developed using LAMP targeting *CaMV*35S promoter and *cry1Ac* gene in cotton. More than 100 accessions of nine imported consignments of transgenics of different crops were tested for the absence of embryogenesis deactivator gene. GM Detection Research Facility at ICAR-NBPGR has been accredited (ISO/IEC 17025:2005) by National Accreditation Board for Testing and Calibration Laboratories.

5.1 DNA fingerprinting

5.1.1 DNA fingerprinting service: One hundred ninety-five samples of twenty agri-horticultural crops were profiled during the period under report for various public and private sector organizations (Table 5.1). By rendering DNA fingerprinting services, resources to the tune of Rs. 6,94,588/- were also generated.

5.1.2 Fingerprinting of cabbage cultivars: Screening for identification of polymorphic markers for cabbage fingerprinting was undertaken using previously reported 85 SSR primer pairs from across nine linkage groups in cabbage. Of the tested primer pairs, only four primer pairs exhibited polymorphism indicating the narrow genetic base among the fourteen cultivars studied. A representative profile is given in Fig. 5.1.

5.1.3 DNA fingerprinting for oilseed *Brassica*: Cultivar Raj Vijay Toria-2, was subjected to DNA profiling with two check cultivars using 14 genic-SSR primer pairs (Fig. 5.2). Primers PUT-19, PUT-96, PUT-149, PUT-169, PUT-181 and PUT-271 are useful in generating unique profile for Raj Vijay Toria-2. Similarly, the Indian mustard Raya varieties, RH725, RH406 and RGN48 were subjected to DNA profiling with ten genic-SSR primer pairs. Primers PUT-3, PUT-94, PUT-154 and PUT-188 are useful in generating unique profile.

Table 5.1: Details of samples DNA fingerprinted during 2018

Crop	Scientific Name	Number of samples
Paddy	*Oryza sativa*	18
Wheat	*Triticum aestivum*	04
Maize	*Zea mays*	68
Pearl millet	*Pennisetum glaucum*	08
Oats	*Avena sativa*	03
Mungbean	*Vigna radiata*	03
Urdbean	*Vigna mungo*	01
Chickpea	*Cicer arietinum*	02
Cowpea	*Vigna unguiculata*	02
Pigeonpea	*Cajanus cajan*	06
Sesame	*Sesamum indicum*	02
Soybean	*Glycine max*	27
Mustard	*Brassica sp.*	08
Cotton	*Gossypium sp.*	21
Bitter gourd	*Momordica charantia*	05
Brinjal	*Solanum melongena*	10
Chilli	*Capsicum annuum*	02
Long melon	*Cucumis melo*	01
Round melon	*Praecitrullus fistulosus*	01
Sponge gourd	*Luffa cylindrica*	03
Total		**195**

5.2 Genetic diversity analysis

5.2.1 Genetic diversity in soybean [*Glycine max* (L.) Merr.] varieties: Genetic diversity and relationships among 96 soybean genotypes were assessed using 49 SSRs distributed on 20 soybean chromosomes. Total number of alleles detected were 230 with number of alleles ranging from 2 to 7 (Fig. 5.3), and an average of 4.7 alleles per primer. The band sizes ranged from 80-480 base pairs. The maximum and minimum Polymorphic Information Content (PIC) values were found to be 0.13 and 0.77 with an average of 0.61. The average genetic similarity coefficient (Simple Matching) from all possible combinations was found to be 0.71 with a range of 0.59 to 0.94. Out of 49 polymorphic SSR markers, six primers exhibited seven unique alleles. A dendrogram based on SSR profiling showed five major clusters.

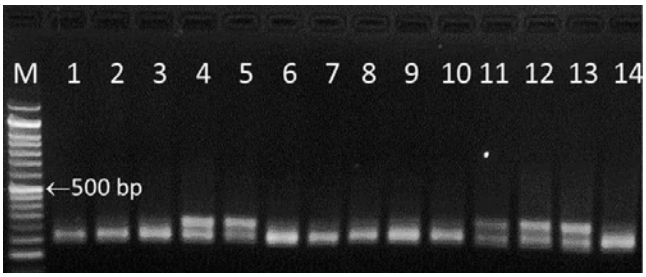


Fig. 5.1: Representative gel profile for a SSR primer pair from linkage group 2 showing polymorphism among the cabbage cultivars. M: 50bp ladder; 1-14: cabbage cultivars

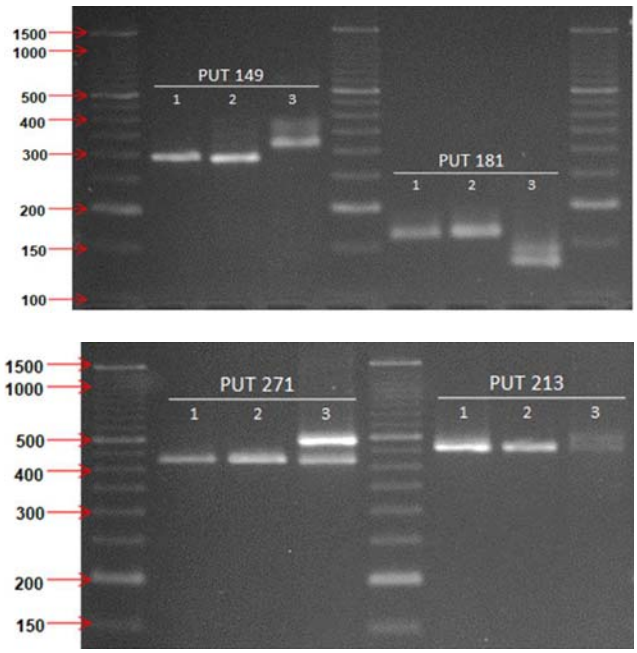


Fig. 5.2: DNA profile for Toria (Raj Vijay Toria-2) (lane 3) along with controls [Basant (lane 1), PM-67 (lane 2)] generated with primer pairs of genic-SSRs (PUTs). Molecular marker sizes are depicted in bp

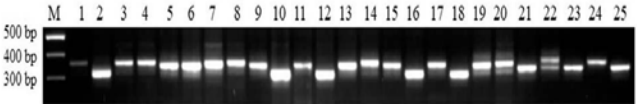


Fig. 5.3: A section of DNA profile of soybean [*Glycine max* (L.) Merr.] cultivars generated using SSR primer SATT 268

5.2.2 DNA profiling of foxtail millet varieties: Allele scoring of 20 foxtail millet varieties (Andhra Pradesh, Rajasthan, Tamil Nadu, Uttarakhand and Karnataka) released from 1942 to 2012, with 27 genome-wide SSR loci revealed 3.11 alleles per locus. UPGMA clustering grouped these varieties into three clusters (Fig. 5.4). Most of the varieties from Tamil Nadu followed by Andhra Pradesh were grouped closely. PIC value ranged from 0.07 to 0.775. Fifteen SSR markers showed PIC value more than 0.45 and may be used as reference set of SSR markers for DNA fingerprinting of foxtail millet varieties.

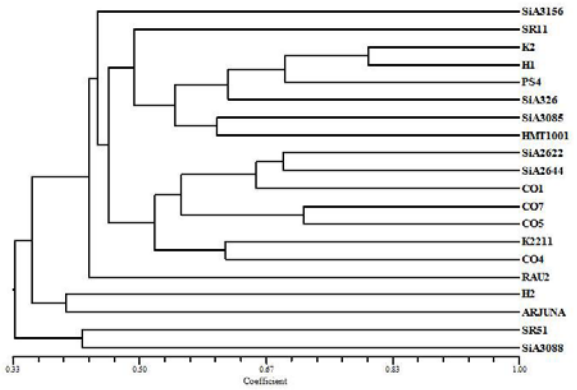


Fig. 5.4: Dendrogram depicting genetic relationship among 20 foxtail millet varieties based on SSR markers

5.2.3 Molecular characterization of 330 rice landraces using SSR markers: 330 rice landraces from Uttarakhand (151), Eastern UP (48), Jharkhand (71), West Bengal (37), and A&N Islands (23) were characterized using 30 HvSSR markers. The genetic tree showed that landraces were corresponding to their geographical origin (Fig. 5.5).

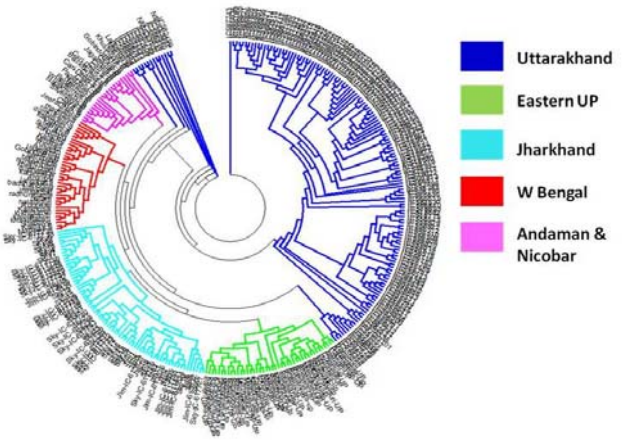


Fig. 5.5: Diversity analysis of 330 rice landraces collected from Uttarakhand, Eastern UP, Jharkhand, West Bengal and Andman & Nicobar Islands using SSR markers

5.2.4 Molecular diversity studies in sesame: Twenty-five reported SSR primer pairs were used to assess the molecular diversity across 96 sesame germplasm from NGB, ICAR-NBPGR. A total of 135 alleles (ranging from 2-10 alleles) were obtained using 25 primer pairs. Dendrogram drawn using NJ method grouped 96 genotypes into two major clusters with 42 and 54 genotypes (Fig. 5.6). Genotypes 17 and 18 represented with least genetic distance and fall under cluster I. Nine genotypes were marked most diverse among the 96 genotypes studied.

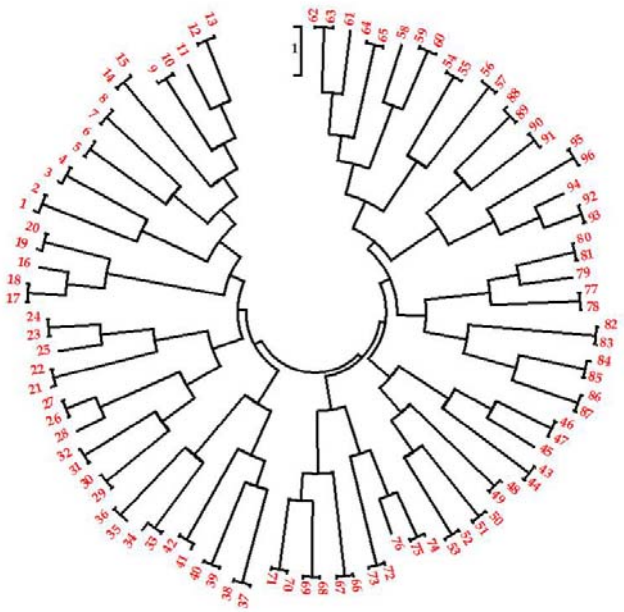


Fig. 5.6: Dendrogram drawn in MEGA 7.0 software using Neighbor-Joining method for the 96 sesame genotypes studied using 25 SSR primer pairs

5.2.5 Genetic diversity studies in *Garcinia*: *Garcinia indicia* commonly known as Kokum, a slender evergreen dioecious tree endemic to Konkan region where it occurs in semi-wild state. It is mainly used as garnish in food preparations, a source of dye and fat (Kokum butter), rich source

of (-) HCA that has anti obesity properties. Garcinol present in Kokum has anticancer and antioxidant properties. Forty-three accessions of *G. indica* maintained in the field gene bank at ICAR-NBPGR RS, Thrissur were analyzed using 12 morphological, 14 ISSR and 5 SSR markers. These have been collected from 9 districts of the Konkan and Malanad region namely North Goa, Ratnagiri, Shimoga, Uttar Kannada, Udupi, Dakshin Kannada, Kodagu, Kasadgod and Thrissur.

Fig. 5.7: A. Variability in leaf morphology of *Garcinia indica*; B. Amplification profile in *Garcinia indica* accessions with ISSR primer UBC 822

5.2.6 Morphological characterization of aromatic rice landraces from Indo-Gangetic Plains of India: For phenotyping, 95 aromatic rice landraces were grown in an experimental field at Division of Genetics, ICAR-IARI, New Delhi during *Kharif* 2017 using ABD and data for 17 plant and 5 seed morphological traits were recorded at appropriate stages. The 1000-grain weight varied from 4.98g (Tulsibhog) to 27.68g (Hansraj-a). The length-breadth ratio varied from 0.61 in ARG8 (IC574862; Kalanamak-1) to 5.22 in Taraori Basmati. The qualitative traits like basal-leaf sheath colour and auricle colour also differed in the landraces of aromatic rices collected from Indo-Gangetic plains of India. Majority of the landraces produced green (85) coloured basal-leaf sheath, while six accession showed purple lines and four accession with purple colour. Auricle colour was pale green in all accessions except two that were are with purple color.

5.3 Generation and validation of molecular markers

5.3.1 Development of SSR markers and polymorphism study in kodo millet (*Paspalum scrobiculatum*): Leaf transcriptome data of kodo millet was re-assembled using Trinity and resulted into 22,672/38,296 unigenes/transcripts with N50 value of 2,823. 77% transcripts mapped on to the foxtail millet transcriptome. 10,947 genic-SSR loci were identified. A random set of ninety genic-SSR loci (18 di- and 72 tetra- repeat type) was selected and amplified in six diverse kodo millet accessions (Madhya Pradesh, Chhattisgarh, Karnataka, Bihar, Gujarat) to validate the genic-SSR loci identified. Fifty-eight genic-SSR loci could be amplified/ developed and six loci were found polymorphic (Fig. 5.8). SSRs containing di-repeat were more polymorphic compared to tetra repeat.

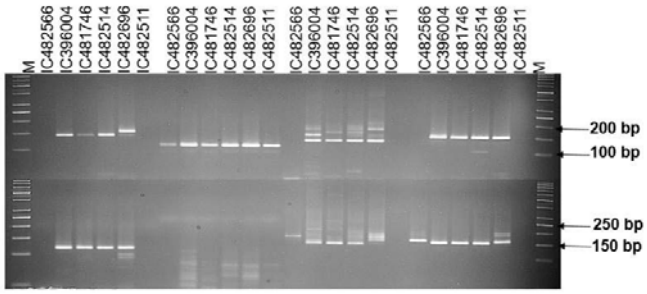


Fig. 5.8: Development of SSR markers and polymorphism study in kodo millet

5.3.2 Development of SSR markers and polymorphism study in little millet (*Panicum sumatrense*): An additional set of ninety-two genic-SSRs markers were validated/developed in 12 diverse genotypes (OLM 203, CO 2, JK 8, IC589819, IC589875, IC589873, IC589863, IC589832, IC382889, IC426656, IC432079, IC438716) of little millet and fifteen were found polymorphic (Fig. 5.9).

An average of 3.46 alleles per locus was observed and PIC value ranged from 0.121 to 0.801. The markers developed would be useful for large-scale characterization of little millet.

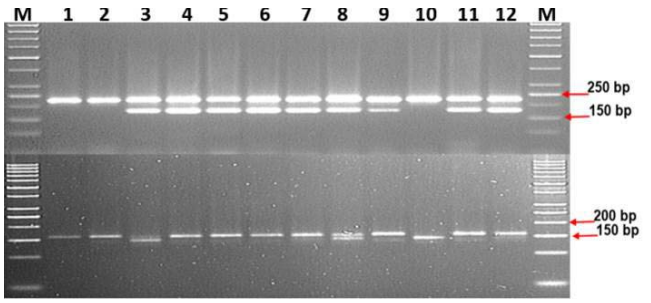


Fig. 5.9: Development of SSR markers and polymorphism study in little millet

5.3.3 Development of SSRs through microsatellite enrichment libraries in *Andrographis paniculata*: Novel microsatellite markers have been developed to assess genetic diversity among different genotypes of *A. paniculata*. Four different microsatellite $(CT)_{14}$, $(GT)_{12}$, $(AG)_{15}$ and $(AAC)_8$ enriched genomic libraries were constructed from the genomic DNA of *A. paniculata* genotype IC111291. Initially, a total of 183 recombinant clones was screened for presence of microsatellite repeats, out of which only 47 were found positive. Some of the SSR positive clones were containing more than one SSR repeats. Further, these positive clones were used to design SSR markers to assess genetic diversity and population structure among 42 *A. paniculata* accessions. Out of 68 primer pairs, only 41 were amplified and found polymorphic. The novel SSR markers showed substantial genetic diversity among 42 *A. paniculata* accessions. The PIC values ranged from 0.09 to 0.37 with an average of 0.32. Cluster analysis classified 42 accessions into 3 major groups (Fig. 5.10), whereas population structure study differentiated these accessions into 6 populations showing considerable diversity among these accessions.

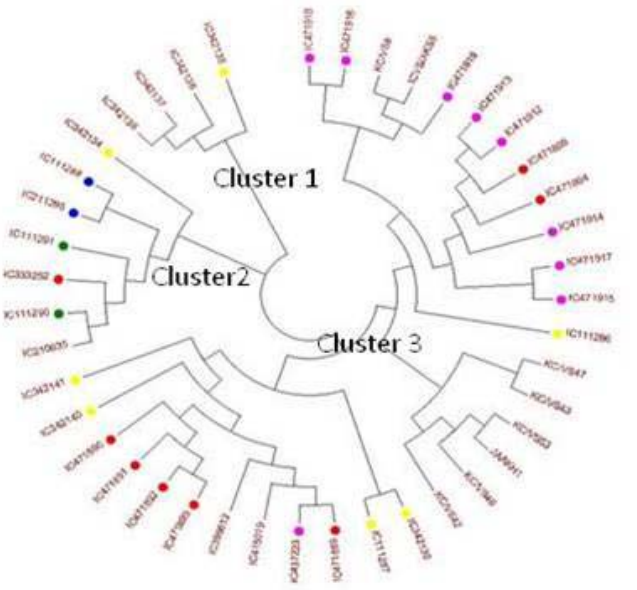


Fig. 5.10: Diversity analyses of 42 accessions of Kalmegh (*Andrographis paniculata*) with 41 novel SSR markers

5.4 Genomic resource generation, conservation and validation

5.4.1 Transcriptome analysis in wheat during grain filling: Transcriptome analysis was performed using the recently published (IWGSC, 2018) wheat transcriptome sequence as reference. Three genotypes with varied levels of heat tolerance were subjected to heat stress for three days during early grain filling (11-14 days-post-anthesis, dpa) in

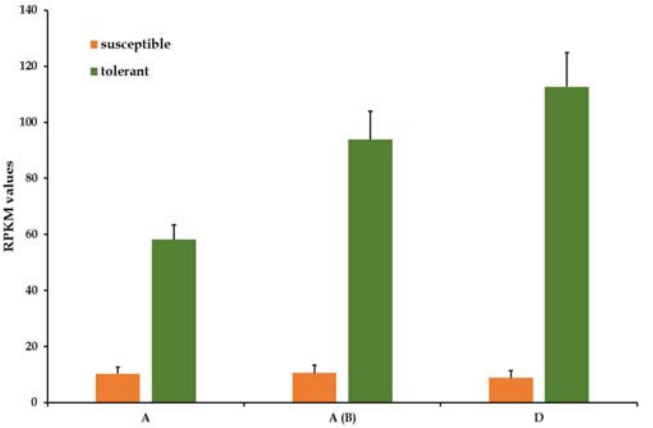


Fig. 5.11: Transcriptome study revealing the expression pattern (in RPKM values) across three wheat sub-genomes for *fructosyltransferase* gene between susceptible and tolerant genotypes subjected to heat stress during grain-filling for three days (11-14 days-post-anthesis, dpa), sampled at 14dpa

triplicates. Differential gene expression analysis between tolerant and susceptible genotypes were performed and list of genes that are significantly differentially expressed at FDR cutoff of 0.01 was used to associate the key genes differentially expressed during heat stress that affects grain yield and quality. *Fructosyltransferase* gene involved in fructan biosynthesis was found to be the key gene differentially expressed between susceptible and tolerant genotypes (Fig. 5.11).

5.4.2 Molecular profiling of lipid biosynthetic genes/transcripts of Indian mustard (*Brassica juncea*): Vegetable oils are mainly composed of triacylglycerol (TAG) and TAG biosynthesis in plants occurs *de novo* through Kennedy pathway, which involves acyltransferases, i.e., glycerol-3-phosphate acyltransferase (GPAT), lysophosphatidic acid acyltransferase (LPAAT), and diacylglycerol acyltransferase (DGAT). GPAT and

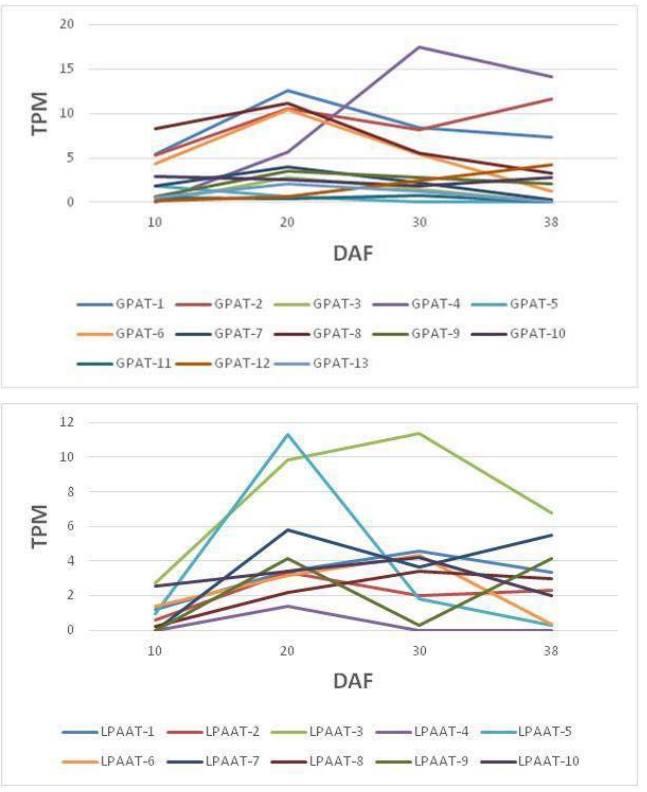


Fig. 5.12: Transcript abundance during seed's developmental stages marked by days after fertilization (DAF). A: *GPAT*; B: *LPAAT*

LPAAT are involved in first and second acylation in Kennedy pathway. Assembled transcripts from developing seed stages (10, 20, 30 and 38 DAF) of *Brassica juncea* var. Varuna, were analyzed for transcript abundance. From this study, it was discovered that in seeds there were thirteen *GPAT* (Fig. 5.12A) and ten *LPAAT* (Fig. 5.12B), respectively. Their expression pattern during seed's developmental stages revealed that among *GPAT*s, *GPAT*-1, 2 & 4 and among *LPAAT*s, *LPAAT*-3, 7 & 9 are critical during maturing stages of seed, when there occurs rapid accumulation of TAG.

5.4.4 Documentation and maintenance of database for NGRC: A total of 462 genomic DNA from 6 species (cotton 25; sunflower 96; rice 151; linseed 65; *B. juncea* 25; wheat 100) was collected during 2018, and conserved both at -70 °C as well as -180 °C. The current status of the total collection in National Genomic Repository is 5,936 from 48 species as on Dec 31, 2018 (Fig. 5.13). National genomic resource repository online database is regularly updated and available for users, providing relevant available genomic resource information on ICAR-NBPGR web page at (http://www.nbpgr.ernet.in:8080/NPGRR/Home.aspx).

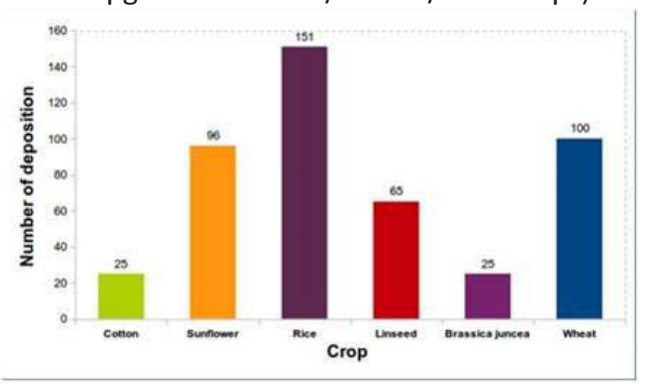


Fig. 5.13: Status of NGRR during 2018

5.4.5 Candidate genes for nitrogen metabolism in wheat and its comparative genomics: Seven candidate genes involved in root nitrogen uptake and transportation were mapped onto wheat chromosomes (Table 5.2). Comparative analysis of major cereals for synteny of wheat N genes is presented (Fig. 5.14).

Table. 5.2: Chromosomal mapping and characterization in wheat for identified candidate genes (root intake and transport).

Gene	Map location (IWGSC)*	Functional Domain	Pathway	Source
Glutamine synthase (Glutamine synthetase GS) Q45NB2	Chromosome 2D:595, 161,239-595,166,439 (+)	Glutamine synthetase beta-grasp domain PF03951	GS pathway	Ensembl
GDH HQ821868 E9NX12	Chromosome 5A: 617,207, 007-617,211,126 (-)	Glutamate dehydrogenase PF00208	GDH pathway	Ensembl
Aspargine synthetase (ASN1), A0A1D5YL35	Chromosome 5A: 105,689, 092-105,697,096 (-)	Asparagene synthase PF00733	Asparagine synthetase pathway	Ensembl
Alanine aminotransferase (AlaAT) W5FWW5	Chromosome 1A: 71,690, 097-71,694,523 (+)	Amino transferase class–I/II (PF00155); Pyridoxal phosphate dependent transferase SSF53383	Alanine amino transf pathway	Ensembl
AMT A0A1D5V877 (Transporter super family)	Chromosome 1A: 490,411, 623-490,414,146 (+)	Ammonium transporter AmtB-like domain PF00909	NH3 channel pathway	Ensembl
NRT1 A0A1D5T6F9 (Transporter super family)	NA	Proton-dependent oligopeptide transporter family PF00854	NA	Ensembl
NRT2 A0A1D6BME9 (Transporter super family)	Chromosome 6B: 26,616, 876-26,618,399 (+)	Major facilitator super family PF07690	NA	Ensembl

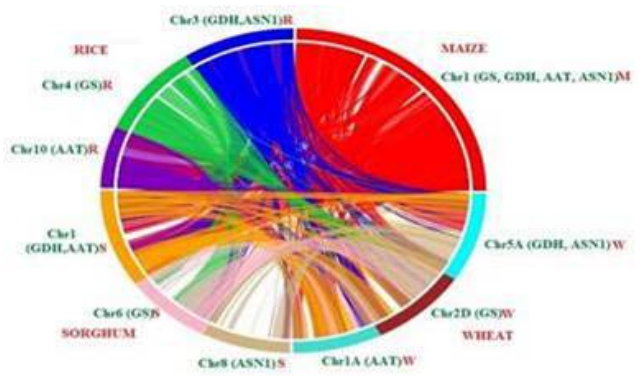


Fig. 5.14: Chromosomal synteny of four predicted candidate genes from N metabolism with other cereals

5.5 Molecular mapping, QTL analysis and trait association

5.5.1 Association mapping for grain size and shape in wheat: Association mapping in wheat was performed for the identification of genomic regions associated with grain size and shape related traits such as grain length (GL), grain width (GW), thousand grain weight (TGW) and length-width ratio (L/W ratio). The wheat association panel used in this analysis consisted of 96 genotypes representing a sub-set of mini core constituted from the entire wheat collection available in the Indian National GeneBank. Association panel was evaluated for seed size associated traits at Delhi location for three consecutive years; 2015-16, 2016-2017 and 2017-18. Genotyping of the association panel was performed using 35K Axiom SNP arrays. Mean of the three year phenotyping data was used for scanning genome-wide marker-trait associations following mixed linear model (MLM) implemented in Tassel software. Total 11 SNPs were associated with thousand grain weight (TGW), distributed on chromosome IA, IB, 2A, 2B, 3B, 5A, 7B and 7D (Fig. 5.15). Whereas, fewer SNPs were associated with

other grain associated traits; three SNPs each identified for GL (4A, 5A and 7A) and GW (3B, 4B and 7A); and six SNPs for length-width ratio (1D, 2D, 4B, two on 5B and 6A).

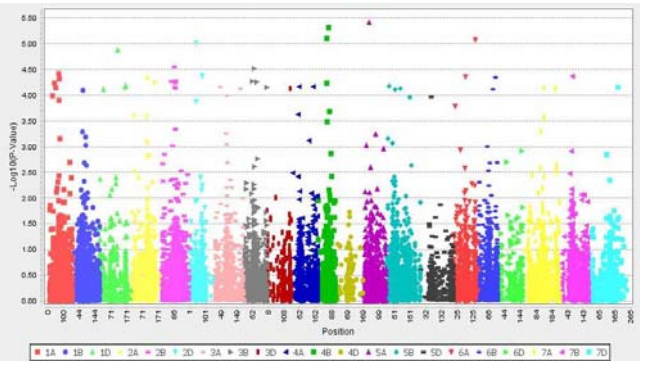


Fig. 5.15: Manhattan plot for thousand grain weight. The chromosomal location of SNPs is indicated on X axis and their corresponding *P* values on the Y-axis. SNP markers with *P*-value >4.5 were considered significantly associated

significant variability was observed among the accessions characterized.

5.5.3 Study of inheritance of cluster bearing habit and molecular mapping of fruiting behavior in *Luffa*: To elucidate the inheritance pattern of cluster bearing habit in *Luffa*, F_2 populations were developed by crossing a ridge gourd variety (solitary fruiting) X satputia (cluster fruiting). The inheritance pattern of fruit bearing habit in *Luffa* revealed the dominance of solitary fruit habit in F_1 while the segregation of F_2 population in the ratio of 3:1 (solitary vs cluster) indicated that the trait is governed by a single gene. To identify the molecular marker linked to fruit bearing habit in *Luffa*, the F_2 populations were genotyped using SRAP markers and a marker combination differentiated solitary and cluster bulks was developed that generates an amplicons

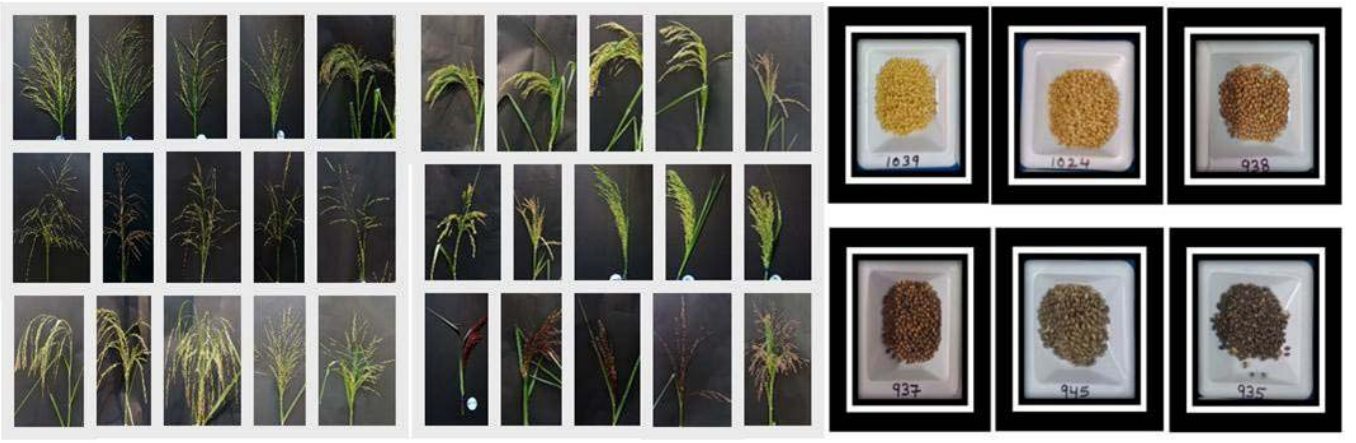


Fig. 5.16: Panicle and seed coat colour variability in little millet germplasm characterized at Issapur Experimental Farm, ICAR-NBPGR

5.5.2 Germplasm characterization of little millet conserved at NGB for trait association studies: A total of 1,816 accessions of little millet procured from NGB was sown at two locations viz. ICAR-NBPGR-RS, Akola and Experimental Farm-Issapur, ICAR-NBPGR, New Delhi for trait association/ tagging studies. Seed coat colour variability for 1,816 accessions was recorded through seed images and documented as golden yellow, cream, light brown, brown, grey, dark grey color. Days to 50% flowering, plant height, tiller number, flag leaf length, flag leaf width, panicle length and panicle compactness were recorded (Fig. 5.16) and

of 280bp specific to solitary types (Fig. 5.17). For linkage analysis, genotyping of 218 F_2 populations was done using the putatively linked polymorphic marker. Genotypic and phenotypic data from 176 plants indicated that the marker at 280bp was linked to solitary fruit bearing gene (*Cl*) at 4.6 cM.

5.5.4 Chromosome identification and karyotyping of *Luffa cylindrica*: Ribosomal DNAs are categorized into two different families that include the 45S (18S-5.8S-26S) rDNA, which forms the nucleolar organizer region (NOR) and

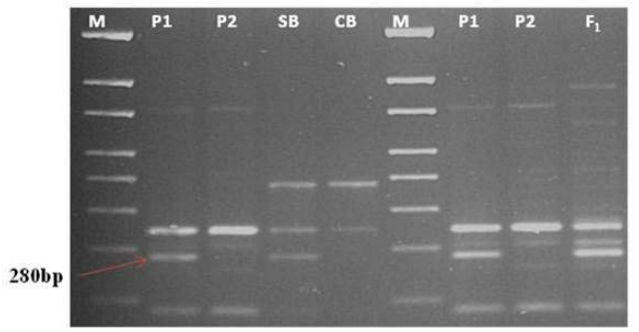


Fig. 5.17: Gel image showing P_1: ridge gourd, P_2: satputia, SB: F_2 solitary bulk, CB: F_2 cluster bulk, and F_1. Red arrow shows the marker ME10-EM4 at 280bp. M: 100bp ladder

quantitatively varies among species. One pair of 5S and five pairs of 45S rDNA signals were detected in *L. cylindrica*. In *L. cylindrica*, the chromosome complement is 2n = 2x = 26 with chromosome lengths ranging from 1.60 ± 0.20 ìm to 2.06 ± 0.26 ìm, and a total length of 23.52 ± 0.72 ìm. The homologous chromosome complement comprised twelve meta-centric (chromosomes a-c, e-m), and one sub-metacentric (chromosome d) pairs. One 5S rDNA signal was on pair e while five 45S rDNA signals were on chromosomes a, b, c, d, and f (Fig. 5.18). Chromosomes were mostly heterochromatic as counterstained with DAPI.

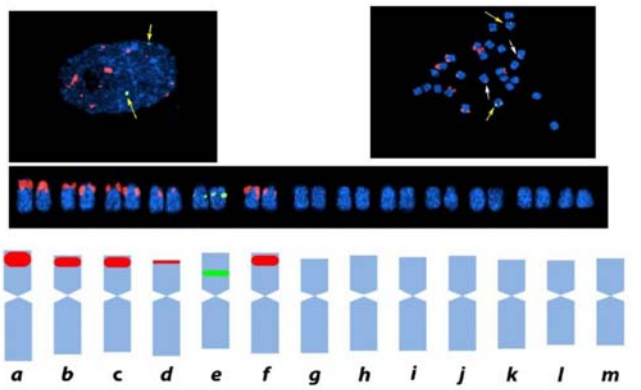


Fig. 5.18: FISH mapping, karyotyping and FISH Ideogram of *Luffa cylindrica*

5.5.5 Sesame variability and diversity: Around 700 genotypes of sesame were evaluated and studied for trait variability. During the study, association of calyx number and locule number in sesame capsules were identified and characterized. Two to twenty locular capsules were identified (Fig. 5.19); with two locular sesame capsules being documented here for the first time; while, four to eight locules are most commonly found, although up to 24 locules were reported earlier.

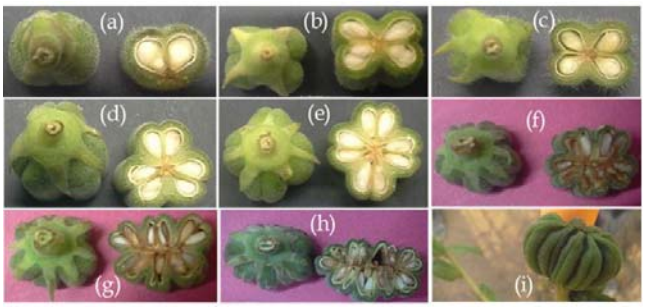


Fig. 5.19: Sesame germplasm expressing variability for locule number and its association with calyx lobe number (CLN). (a) 2 locular capsule with 3 sepals (IC500985); (b) 4 locular with 4 CLN (IC132321); (c) 4 locular with 5 CLN (IC501119); (d) 6 locular with 5 CLN (IC204522); (e) 8 locular with 7 CLN (IC204522); (f) 10 locular with 8 CLN (EC334991); (g) 12 locular with 9 CLN (EC334991); (h) 16 locular with 9 CLN (IC204639); (i) 20 locular with 10 CLN (IC132182)

5.5.6 Sequence diversity in *myrosinase* gene family: *Mysosinase* genes are involved in glucosinolate-myrosinase system across *Brassicaceae* members, and are used in plant defense against insect and pest attack. Broadly, there are two sub-classes *MyrI* and *MyrII*; with *MyrI* sub-class comprises three genes *viz*., *MyrA*, *MyrB*, and *MyrC*, although at times A, B, and C are used to label the genome types as well depending on the species that warrants for a unified system of nomenclature for this gene family. Presently, sequence diversity studies were performed for the myrosinase gene (*MyrA*, *MyrB* and *MyrC*) sequences extracted from publicly available databases. The study had clustered all sequences into three clusters (Fig. 5.20) identifying the three sub-sets of the *MyrI* sub-class. Based on homology, gene-specific markers could be developed for further use.

5.5.7 Genetic stocks registered in wheat for unique traits identified: Rust resistant wheat germplasm: **IC252459 (INGR18013)** resistant to stripe rust resistant pathotypes K (47S102), P(46S103), L (70S69), 13 (67S8), I (38S102), 46S119 & 78S84 and **EC339604 (INGR18012)** resistant to all prevailing races of leaf rust having *Lr22, Lr46+, Lr67+* genes which is a rare combination for

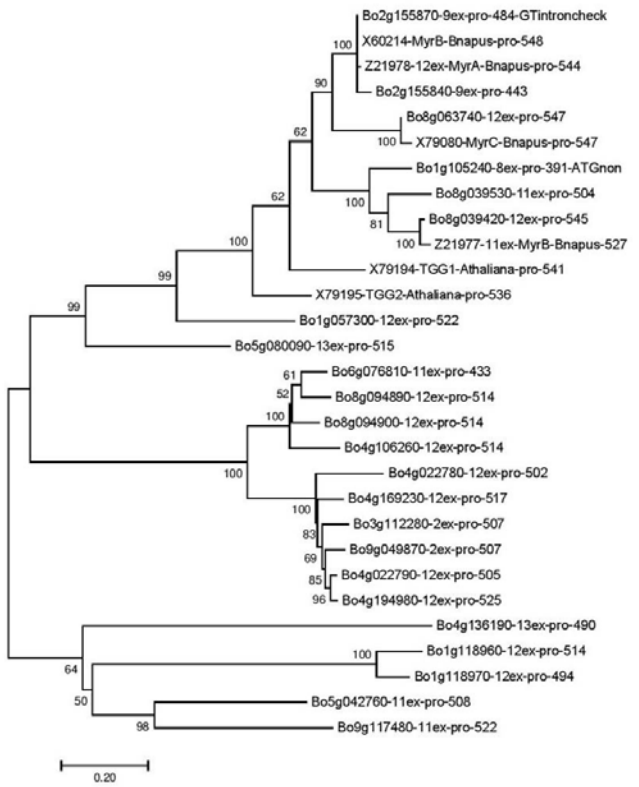


Fig. 5.20: Dendrogram depicting three clusters of *Myrosinase* genes representing *MyrA*, *MyrB*, and *MyrC* sequences; analyzed using deduced amino acid sequences for myrosinase gene family from *Brassica oleracea* var. *capitata* (02-12) and its related species

ensuring durable rust resistance in wheat cultivars. **Spot blotch resistant wheat germplasm: IC0624570 (INGR18008),** was highly resistant to spot blotch and can be used as source for spot blotch resistance in wheat improvement programme. **Drought tolerant wheat germplasm: EC531185 (INGR18011)** is drought tolerant (Low DSI for yield and yield attributing traits) genotype and can be used as sources of tolerance for developing promising drought tolerant wheat cultivars.

5.5.8 GWAS for Spot Blotch resistance in breadwheat: The field trials were conducted at BHU, Varanasi and UBKV, Cooch Behar in bread wheat for spot blotch resistance using GWAS (Fig. 5.21). 35K array data of 224 accessions of wheat minicore set was completed with 35,143 SNPs markers. Disease severity was observed at the Z83 dough stage. QTLs were identified for AUDPC (Area Under Disease Progress Curve).

5.5.9 DNA barcoding in *Triticum* species: DNA barcoding studies were undertaken in wheat (*Triticum* species) utilizing ITS region from nuclear genome and *trn*H-*psb*A spacer region from the chloroplast genome. ITS region sequences were amplified using ITS1 forward and ITS4 reverse primers. Amplification of *trn*H-*psb*A spacer region was done using universal primers. PCR products were purified and sequenced.

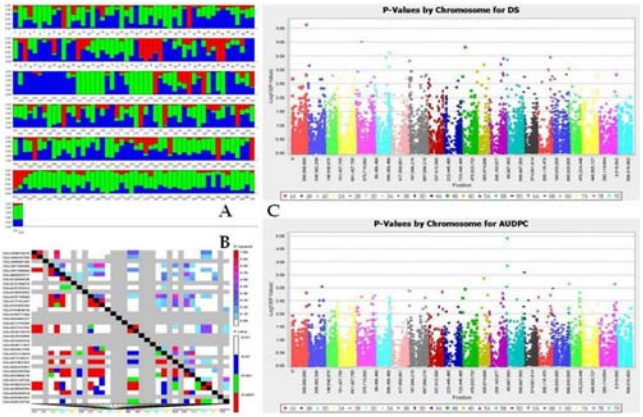


Fig. 5.21: GWAS for spot blotch resistance in breadwheat. A: Three sub-populations indicated by different colors; B: LD plots of significant SNP markers associated with spot blotch AUDPC; C: Manhattan plots for the spot blotch disease severity and AUDPC trait across the locations

5.5.10 Pre-breeding for terminal heat-stress tolerance in wheat: In order to create germplasm resources with enhanced tolerance to heat-stress; exotic material was used to augment tolerance in the well-adapted varieties. Totally, 1459 plants of F_4 populations from two crosses between heat-stress tolerant and susceptible bread wheat were characterized for 12 plant and grain characteristics. Similarly, 485 F_3 progenies from 3 crosses along with parental lines of bread wheat were characterized for 12 morphological traits under very late sown condition during Jan – April, 2018.

5.5.11 Development of MAGIC populations in wheat: Four crosses were made between the parental lines possessing component traits of

terminal heat-stress tolerance in bread wheat, *viz.*, Pusa T3336, WR544, Iepace Robe NW1014, HD2864, UP2338, and DL788-2, HD2864. In total, 74 crosses between F_1 spikes of the three above stated crosses (as the first cross exhibited necrosis) were made at ICAR-IARI-RS, Wellington, Tamil Nadu. These crosses were further inter-crossed to develop MAGIC population for heat-stress tolerance at Delhi during March, 2018 (Fig. 5.22).

Fig. 5.22: Field view of crossing to develop MAGIC populations in breadwheat at NBPGR field New Delhi

5.5.12 DNA analysis using genome-wide SSR markers of reference sets for terminal-heat stress tolerance in wheat: The reference set of bread wheat for terminal heat-stress consisting of 381 accessions was analysed with 48 genome wide hyper-variable SSR markers. High amount of molecular variation was observed between different accessions at number of microsatellite loci (Fig. 5.23).

5.5.13 Identification of early flowering and maturing accessions in Linseed (*L. usitatissimum*): Early flowering and maturity are considered important traits in linseed as it protects crops from several biotic and abiotic stress conditions. In this direction, we have evaluated 221 diverse linseed accessions along with three checks for flowering, maturity and yield related traits in ABD at NBPGR research farm during *Rabi* 2017-18. Observations were recorded on seventeen qualitative and seven quantitative traits. Multivariate analysis of the variables showed that more than 84 % variation is contributed by first five principal components (PC) having eigenvalues more than one. The variability contributing characters were capsule per plants (PC1) and flowering and maturity related traits (PC2). The study helped identification of germplasm accessions EC0000526, EC0041735, IC0096539 IC0096496, as early flowering (<60 days for 50% flowering) and IC0525939, IC0525915, IC0523801 as early maturing compared to the early check variety RLC76 in Delhi conditions(Fig. 5.24A). Four accessions (EC0041735, EC0041753, IC0096539 and IC0096523) have shown photo-insensitivity as flowering initiation occurred in short days (before December 19, 2018). Further, accession IC0280320 was identified for high number of capsules (>400 capsules per plant). Three accessions, EC0041469, EC0041700 and EC0041720 were identified for high seed weight (>10 g for thousand seed weight). The selected sets of accessions were also validated in *Rabi* 2018-19 at NBPGR regional station, Akola,

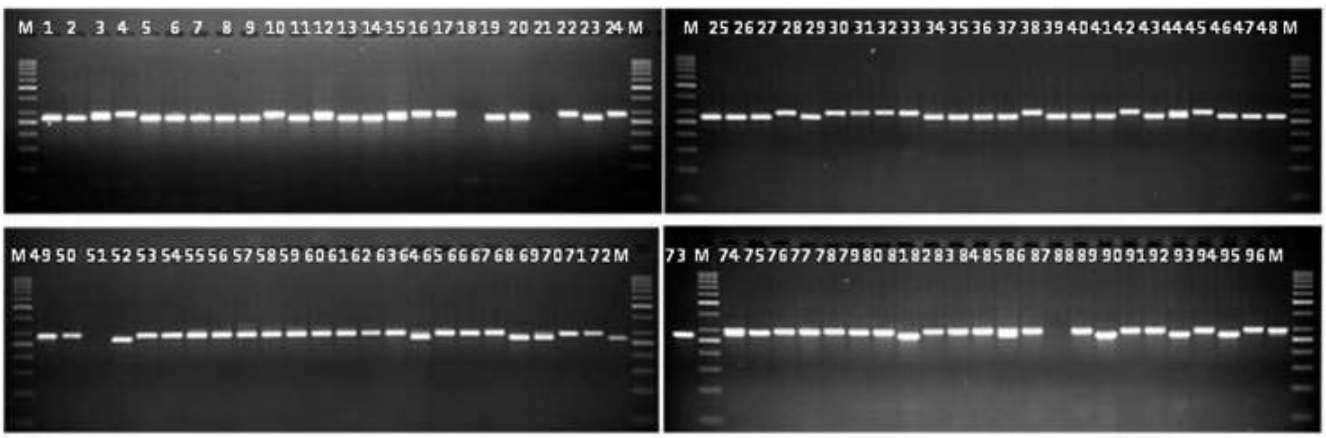


Fig. 5.23: Representative molecular profile for *wmc285* marker using 96 wheat accessions

where accessions IC0096496 and EC000526 were found earliest in flowering (<52 days for 50% flowering). Three accessions IC0280927, IC0384578 and IC0280320 were identified for high capsules numbers (>400 capsules per plants) in Akola. Molecular profiling of early (15 No.) and late (8 No.) flowering/maturing accessions was done using 29 SSR markers to study molecular diversity (Fig. 5.24B).

5.5.14 Study of putative regulators of Kranz anatomy in *Poaceae* family: In continuation with the earlier bioinformatics work of putative regulators of Kranz anatomy in C_4 crops (Maize, Foxtail millet and Sorghum) and C_3 crops (rice, barley wheat and Arabidopsis), possible change in phosphorylation sites among orthologs of putative regulators between C_3 and C_4 groups were studied. It was found that among the orthologs of putative positive regulators, 40 proteins had gained at least one phosphorylation site in C_4 group of crops compare to C_3 crop group. Simultaneously, 29 proteins lost at least one phosphorylation site in C_4 group of crops compare to C_3 crop group. Similarly, among the putative negative regulators of Kranz anatomy, 4 and 2 proteins have respectively gained and lost at least one phosphorylation site in the C_4 group in comparison to C_3 group.

5.6 Marker development for GM detection

5.6.1 Construct-specific LAMP based GM detection: Efficient and rapid GM detection method employing visual and real-time loop-mediated isothermal amplification (LAMP) targeting the construct region between *CaMV*35S promoter and *cry1Ac* gene (*P35S-cry1Ac*) was developed. Visual LAMP reactions were optimized at constant temperature of 65^{O}C for 60 min and for real-time LAMP, incubation was done for 30 min. These assays showed acceptable specificity (Fig. 5.25) with limit of detection (LOD) of 0.01%. The practical applicability of assays was confirmed using spiked samples of cotton. These assays could facilitate rapid/on-site GM detection and to test presence of commercialized *Bt* cotton events in the country.

5.6.2 Molecular testing of imported transgenic planting material: More than 100 accessions of nine imported consignments of transgenics of different crops including *Arabidopsis thaliana*, *Gossypium hirsutum* and *Zea mays* were tested for the absence of embryogenesis deactivator gene employing primers specific for *cre* gene. None of them showed for the presence of the gene. All these imported accessions were also tested for presence of specific transgene/ promoter/

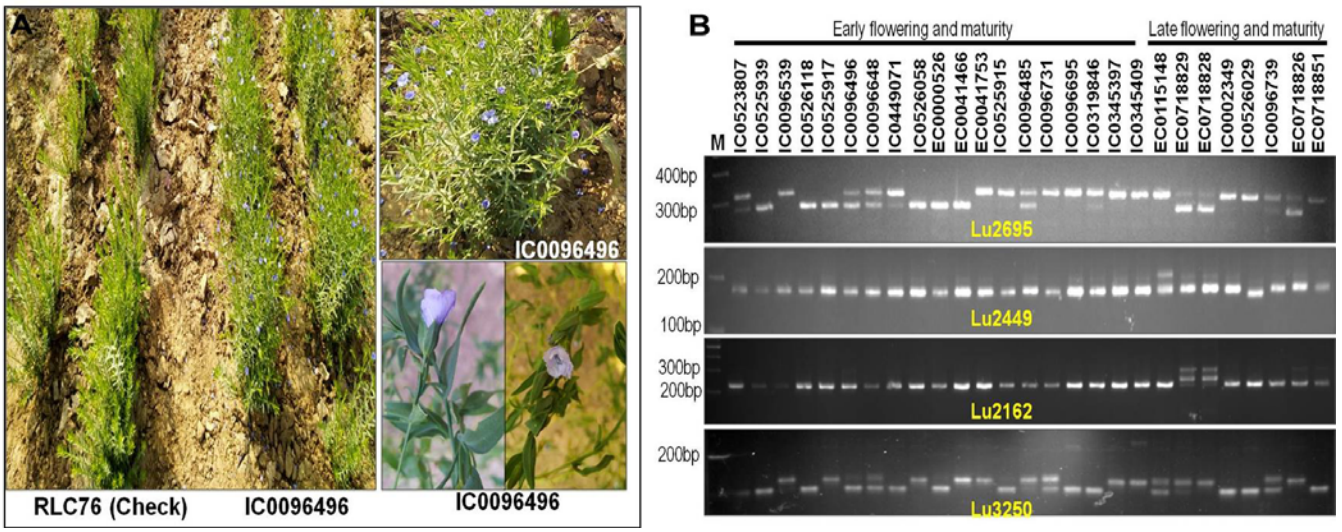


Fig. 5.24: Identification of early flowering and maturing germplasm accession and genetic diversity study in linseed. A: Early flowering linseed accession, IC0096496 B: SSR profiling of early-late flowering and maturing linseed accessions

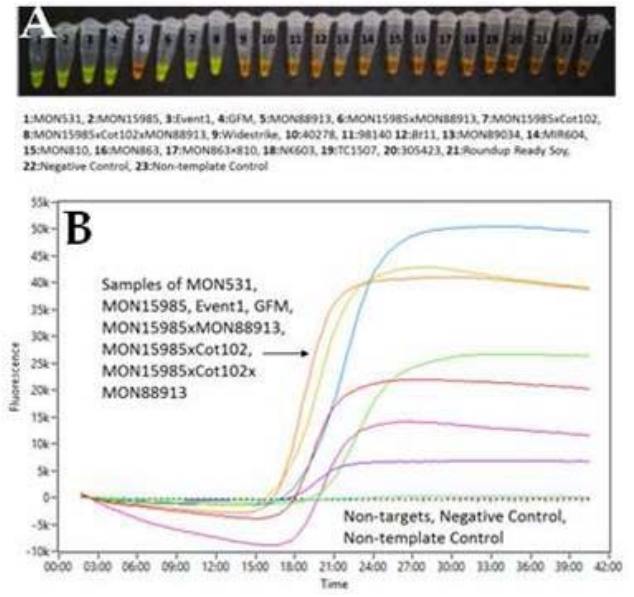


Fig. 5.25: LAMP assay with construct-specific region for *CaMV35S-Cry1Ac* gene. A: Visual LAMP; B: Real-time LAMP

terminator/ marker gene/events using qualitative PCR/Real-time PCR assays (Fig. 5.26).

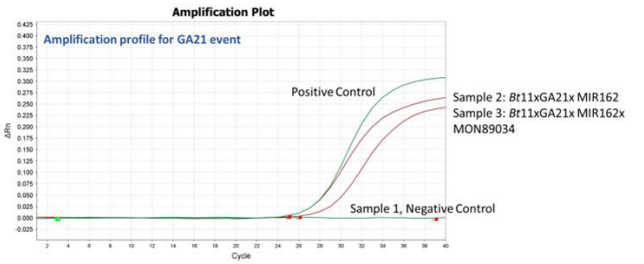


Fig. 5.26: Molecular testing of imported GM seeds of Maize (IQ 438/2018) using RT-PCR

5.6.3 Participation in two international proficiency testings for quality assurance and global harmonization: As per ISO/IEC 17043:2010, two international proficiency testings were undertaken that was organized by *the USDA, Agricultural Marketing Service, Federal Grain Inspection Service (USDA-AMS-FGIS)*. **(i)** In April 2018, qualitative testing was conducted for ten GM maize events, *viz.,* T25, MON810, NK603, TC1507 (Herculex), MON863, MIR604, Event 3272, MON88017, MON89034 and MIR162 in two maize test samples, and four GM soy events, *viz*., Roundup Ready™, Liberty Link™, Roundup Ready™II and DP305423, in two soybean test samples. Qualitative screening for *P-35S* and *T-nos* was also satisfactorily done. Quantitative analysis for three GM maize events (MON810, NK603, MON863) and one GM soy event (Roundup Ready) were conducted in two test samples with satisfactory Z-score (from -2 to +2). **(ii)** In October, 2018, qualitative testing was conducted for twelve GM maize events, *viz.,* T25, MON810, GA21, NK603, TC1507 (Herculex), MON863, 59122 (Herculex®RW), MIR604, Event 3272, MON88017, MON89034 and MIR162 in two maize test samples, and four GM soy events, *viz*., Roundup Ready™, Liberty Link™, Roundup Ready™II and DP305423, in two soybean test samples. Qualitative screening for *P-35S, T-nos* and *P-FMV* was also satisfactorily done. Quantitative analysis for eight GM maize events (MON810, GA21, NK603, TC1507, MON863, 59122, MIR604, Event 3272) and one GM soy event (Roundup Ready) were conducted in two test samples with satisfactory Z-score.

5.6.4 GMO testing of samples: 17 samples of seven consignments of papaya, cotton, *Mentha arvensis* (mint) and soybean were tested for checking the GM status. A total of rupees 23,600/- was generated through GMO testing of these samples.

5.6.5 ISO/IEC 17025: 2005 accreditation of GM Detection Research Facility: GM Detection Research Facility at ICAR-NBPGR has been accredited (Fig. 5.27) in accordance with the international standard ISO/IEC 17025:2005 by National Accreditation Board for Testing and Calibration Laboratories (NABL), a Constituent Board of Quality Council of India in the discipline of Biological Testing (GMO Testing).

Fig. 5.27: ISO/IEC 17025:2005 accreditation by NABL for GM detection research facility

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

PGR/DGR-BUR-DEL-01.00 Development of genomic tools for identification, protection and enhanced utilization of PGRs (**Gurinder Jit Randhawa**)

Research Projects (Code, Title, **PI**, CoPIs and *Associates*)

PGR/DGR-BUR-DEL-01.01 Development of genomic tools for discovery and validation of genes of economic importance for enhancing the use of plant genetic resources of pulses, oilseeds and fibre crops (**Rajesh Kumar**, S Marla, J Radhamani, JK Yasin, DP Wankhede, Rashmi Yadav, S Rajkumar, R Parimalan, Amit Kumar Singh (w.e.f. August 11, 2018), Vikender Kaur (w.e.f. August 23, 2018) and *SK Singh (w.e.f.* August 11, 2018))"

PGR/DGR-BUR-DEL-01.02 Development of genomic tools for enhanced utilization of cereals (**Rakesh Singh**, MC Yadav, Sundeep Kumar, AK Singh, R Parimalan and Sheel Yadav (on study leave w.e.f. July 28, 2018))

PGR/DGR-BUR-DEL-01.03 Development of genomic tools for enhanced utilization of millets (**Lalit Arya**, Monika Singh, Mamta Singh and Sapna (w.e.f. June 29, 2018))

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

PGR/DGR-BUR-DEL-01.05 Development of genomic tools for species delineation and genetic erosion studies in selected crops (**MC Yadav**, S Rajkumar, S Marla, J Radhamani, DR Pani, N Dixit (till June 30, 2018) and M Latha)

PGR/DGR-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, Rakesh Singh, AK Singh, JK Yasin, R Parimalan, Sheel Yadav (on study leave w.e.f. July 28, 2018), DP Wankhede, Monika Singh, Rekha Chaudhury and *SK Singh*)

PGR/DGR-BUR-DEL-01.07 Development of DNA based diagnostics for transgene detection and impact analyses of GM crops on plant biodiversity (**GJ 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 (on study leave w.e.f. July 28, 2018), DP Wankhede, JK Yasin and *SK Singh*)

Externally funded projects

- Belgian-Indian networking in the field of the GMO research and analysis (Project Coordinator: Gurinderjit Randhawa; PI: Monika Singh)
- Candidate gene association study and generation of genomic resources for flowering time traits in Linseed [*Linum usitatissimum*. (L)] (DP Wankhede)
- Characterization of heat-linked QTLs and enzymes associated with starch biosynthesis pathway in wheat (Rakesh Singh)
- Characterization, evaluation of genetic resources for genetic enhancement and improvement of minor pulses (DP Wankhede, Rakesh Bharadwaj, Neeta Singh, S Rajkumar, Amit Kumar Singh, Gayacharan, Kuldeep Tripathi, Sunil Gomashe, Dinesh Chand, Mohar Singh, Z Khan, Bharat Gawade, Latha M, Kavita

Gupta, Celia Chalam, Yasin Jeshima, Kodaru Anitha, Harish GD, Shashi Bhushan Choudhary, Om Vir Singh, Neelam Shekhawat)

- Development of heat tolerant wheat for South Asia (Sundeep Kumar, Jyoti Kumari and TPS Yadav)
- Development of short duration, early maturing, high yielding, biotic and abiotic stress tolerant redgram varieties – Indo- Swiss Collaboration in Biotechnology (Yasin JK)
- Genomics-led improvement of biotic and abiotic stress tolerance in mustard rape for economic and environmental sustainability (Rajesh Kumar)
- ICAR Consortium Research Platform on Genomics (AB Gaikwad, R Parimalan and DP Wankhede)
- Identification of defense genes/QTLs associated with rust resistance in wheat under CABIN scheme (Sundeep Kumar and Amit Kumar Singh)
- Indo-UK centre for nitrogen use efficiency in wheat (S Marla)
- Integrated Genomics Strategy for accelerating domestication of rice bean (*Vigna umbellata*) (Amit Kumar Singh and Mohar Singh, D. P. Wankhede, Rakesh Bhardwaj, S. Rajkumar, Gayacharan, D. P. Semwal, Neeta Singh and Vandana Tyagi)
- National containment/quarantine facility for transgenic planting material; component: molecular testing (Gurinder Jit Randhawa and Monika Singh)
- Rationalisation of rice collections originating from major areas of diversity and allele mining in selected unique set of accessions for biotic, abiotic and quality traits using molecular markers. (Rakesh Singh)
- Referral Laboratory for DNA-based Detection of Genetically Modified Crops (Gurinderjit Randhawa; Monika Singh)
- Towards Understanding the C_3-C_4 intermediate pathway in Poaceae and functionality of C_4 genes in rice (D.P. Wankhede and R. Parimalan)
- Development of amaranth core collection using SSR and SNP markers and evaluation of core set for nutritional, yield traits and abiotic stress tolerance (Rakesh Singh, Rajkumar, Amit Kumar Singh, Sandeep Kumar, Rakesh Bharadwaj, S K Kausik, Veena Gupta).

DIVISION OF GERMPLASM CONSERVATION 6

Summary: A total of 20,886 accessions of germplasm, including 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 11,924 accessions of different agri-horticultural crops to the base collection, thereby, raising the total germplasm holding to 4,39,717. Of the conserved accessions, 4,764 were new and 7,160 accessions were received after regeneration. Monitoring of germination and seed quantity in stored germplasm (10,041 accessions) and distribution (62,556) for characterization/evaluation/regeneration/research were other prioritized activities. The germplasm supplied included those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). A free and open source software 'viabilitymetrics' was developed as an add-on package of the statistical programming language 'R' for the seed viability equation fitting and calculations and for computing germination indices and fitting cumulative germination curves. Value addition in genebank collections was done by screening for superior malting trait in indigenous 2-row barley collection, in sesame germplasm conserved in LTS for phyllody disease tolerance under natural conditions and for PPO enzyme activity in wheat germplasm. Quick viability testing protocol was standardized in Hemp. An exploration for identifying permafrost site for National Genebank was done in Bhyundar Valley-Hemkund, Mana-Badrinath and Joshimath-Auli areas of Uttarakhand.

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

6.1 Germplasm augmentation

A total of 20,886 germplasm accessions of various agri-horticultural crops were received for long-term conservation in the National Genebank (Table 6.1); 11,924 accessions qualified for conservation as per the genebank standards and were conserved at –18±2^{O}C as base collections. Of the conserved accessions, 4,764 were new and 7,160 accessions were received after regeneration, which were already conserved in National Genebank. A total of 64 accessions were rejected as they did not meet the NGB standards and 53 accessions were rejected due to infestation.

Among the new accessions added to the genebank, cereals (2,400) and millets (670) comprised a major portion of germplasm followed by legumes (547), oilseeds (258), vegetables (238), pseudo-cereals (235), forages (141), fibres (120), medicinal & aromatic plants (97) and spices & condiments (48) including released varieties (481) and genetic stocks (477) (Table 1). The total germplasm holdings in the National Genebank are 4,39,717; representing 1,936 species (including 10,771 trial material and 10,235 accessions of lentil and pigeonpea as safety duplicates). Accessions received after regeneration (7160) belonged to cereals (2,093), millets (294), pulses (486), oilseeds (3,138), vegetables (833), medicinal and aromatic plants (2), spices and condiments (2), fibre (277), forages (1) and pseudo- cereals (5) crop groups.

14,343 exotic vouchers of agri-horticultural crops received from different parts of the world were physically verified and distributed to the respective crop curators for further multiplication and maintenance. The received accession comprised of cereals (10298), vegetables (2,679), grain legumes (220), spices (718), oilseeds (338), fibers & forages (82) and others (21).

Table 6.1: Status of germplasm holdings in the National Genebank (as on Dec. 31, 2018)

Crop/Crop Group	No. of accessions conserved during 2018				Present status of conservation
	Regenerated	New	New Species	Total Species	
Cereals	2093	2400	6	123	164218
Millets	294	670	2	26	59113
Forages	30	141	4	194	7066
Pseudocereals	5	235	-	54	7530
Legumes	486	547	3	100	66222
Oilseeds	3138	258	-	79	58832
Fibre crops	277	120	8	77	15693
Vegetables	833	238	1	207	26309
Fruits and nuts	0	2	-	65	275
Medicinal, aromatic and narcotics plants	2	98	7	673	8028
Ornamental	0	4	1	120	657
Spices and condiments	2	47	1	28	3122
Agroforestry	0	4	1	190	1646
Duplicate safety samples (Lentil, pigeonpea)	0	0	-	-	10235
Trial material (Wheat, Barley)	0	0	-	-	10771
Total	7160	4764*	34	1936	439717

* The figure includes of varieties proposed to be released/notified and genetic stocks

6.2 Monitoring of germplasm

Germplasm conserved in the long-term storage condition for ≥10 years (10,041accessions) were monitored for seed viability and seed quantity, to ensure the status of the conserved germplasm as per 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 62,556 accessions was distributed for utilization by different stakeholders. Most of the accessions were distributed for regeneration, characterization and evaluation under CRP on Agrobiodiversity. The details are given in Table 6.3.

6.4 Supportive research for conservation

6.4.1 Software package for seed viability equation fitting and calculations: A free and open source software 'viabilitymetrics' was developed as an add-on package of the statistical programming language 'R' for the seed viability equation fitting and calculations. It primarily

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

Crop	No. of accessions tested for viability	Initial viability	Present viability	No. of accessions identified for regeneration
Paddy	1438	80-100	60-100	956
Maize	1209	85-100	80-100	-
Barley	752	90-100	75-100	12
Castor	100	85-100	80-100	4
Groundnut	180	85-100	82-100	6
Sesame	120	85-100	80-100	5
Linseed	100	85-100	85-100	-
Indian mustard	100	85-100	85-100	-
Soybean	250	85-100	75-100	27
Cotton	736	65-100	20-64	410
Jute	85	85-100	85-100	-
Kenaf	105	85-100	12-84	67
Sunhemp	3	85-100	85-100	-
Roselle	30	85-100	8-80	20
Oats	371	85-100	40-80	90
Pearl millet (forage)	70	85-100	52-84	6
Sorghum (forage)	32	85-100	40-82	5
Blue/Giant panic grass	26	20-65	20-60	-
Lucerne	39	85-100	70-100	16
Sain grass	9	20-60	20-60	-
Sugarcane	69	20-70	20-60	-
Forage species	146	20-100	20-100	-
Sweet clover	837	85-100	20-80	537
Chilli	306	80-100	80-100	14
Chenopodium	02	70-100	70-100	-
Buckwheat	119	80-100	85-100	105
Kulthi	779	80-100	62-100	223
Cowpea	2028	50-100	35-100	467
Total	10041			

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

Crops (no. of accessions)	Purpose	No. of accessions
Maize (1,337), finger millet (2,013), foxtail (2,597), little millet (1,816), okra (432), pigeonpea (1,200)	CRP (AB)	9,395
Sesame (1,805), soybean (305), *Ocimum sanctum* (50), horsegram (157)	Regeneration and/or Evaluation	2,317
Cucumber (177), bottle gourd (100), Chilli (302), *Abelmoschus moschatus* (47) sesame (671), mustard (593), Job's tear (47), *Chenopodium* (130), Chilli (47), sweet clover/*Melilotus* spp (837), *Vigna angularis* (10), chickpea (171), cowpea (2021)	Multiplication	5,153
Paddy (11,742), wheat (1,899), maize (66), barley (2,438) sorghum(4,326), linseed (2,567), sesame (1,925), *Eclipta alba* (19), teff grass (78), forage maize (337), urdbean (2,675), pea (210)	Characterization	28,282
Ocimum (24)	Taxonomic identification	24
Paddy (729),	DNAFP	729
Paddy (3,410), wheat (2,325), maize (131) , finger millet (1,505), barnyard millet (1,002), foxtail millet (1,002), proso millet (1,000), little millet (500), *Solanum* ssp (50acc), brinjal (97), *Luffa* spp (25), Yard long bean (2), *Cucumis* (50), cherry tomato (20), carrot (15), Indian mustard (1,000), sunflower (1), *Chenopodium* (30), *Withania somnifera* (03), *Andrographis paniculata* (03), *Ocimum* (112), cotton (700), wild jute (24), Teosinte (2), *Pennisetum glaucum* (1), roselle (15), horsegram (682), guar (89), chickpea (15), pea (5), pigeonpea (180), ricebean (2588), mungbean (56), urdbean(23)	Research	16,656
	TOTAL	62,556

implements the viability equation of Ellis and Roberts (1980) for the calculation of several seed viability metrics such as storage period, final viability, storage moisture content, storage temperature and days to lose one probit viability. The package further includes various conversions and transformations associated with seed viability calculations.

6.4.2 Software package for computing germination indices and fitting cumulative germination curves: Developed a free and open source software 'germinationmetrics' as an add-on package in for the 'R' statistical programming language for the computation of various germination indices as well as fitting and visualization of cumulative germination curves. It facilitates computation of germination indices such

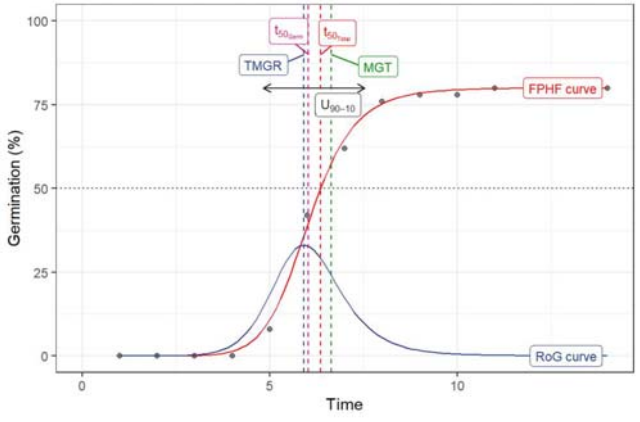


Fig.6.1: Fitting of four-parameter hill function curve to cumulative germination counts using 'germinationmetrics' package

as germinability, median germination time, mean germination time, mean germination rate, speed of germination, Timson's index, germination value, coefficient of uniformity of germination, uncertainty of germination process, synchrony of germination etc. from germination count data. Further, it includes functions for fitting cumulative seed germination curves using four-parameter hill function and computation of associated parameters.

6.4.3 Software package for the analysis of experimental data from augmented randomised complete block designs: Augmented randomized complete block designs (Federer, W.T., 1961) are the most frequently used experimental designs for the characterization and evaluation of crop plant genetic resources collections. A free and open-source add-on package called 'augmentedRCBD' was developed in the 'R' statistical programming language for the analysis of data from such designs. It implements functions for computation of analysis of variance, adjusted means, descriptive statistics, genetic variability statistics, etc. It further includes data visualization and MS word report generation functions.

6.4.4 I. Value addition in germplasm conserved at NGB

Screening for superior malting trait in indigenous 2-row barley collection: Rate of germination is an industrially important parameter in 2-row barley genotypes since it determines the efficiency of malting process. Two sets of 162 indigenous 2-row barley accessions (one set of original accessions from base collection and one set of accessions regenerated at Issapur farm) were screened in replicates, using mean germination time (MGT) index, which indicates the speed of radicle emergence. Two elite lines received from Madhya Pradesh (IC113048 and IC113049); four landraces collected from Himachal Pradesh (IC108111, IC381116, IC381122 and IC258194) and one landrace from Uttarakhand (IC24167) had significantly and consistently superior germination rate, indicating their potential utilization as donors in malting barley production.

Screening for PPO enzyme activity in wheat germplasm: Wheat Poly Phenol Oxidase (PPO) enzyme is responsible for browning and discolouration and hence high seed PPO is not desirable in the processing industry. But PPO is known to be involved in defense against pathogens and has a significant role in plant establishment. Hence screening for PPO content will facilitate end-use assessment of wheat genotypes. Our study conducted on 250 accessions from diverse agro-ecological zones revealed wide variation in PPO content and a positive correlation with seed vigour.

Screening of sesame germplasm for phyllody disease tolerance: During *Kharif* 2018, 2,000 accessions of sesame germplasm comprsing of 1,789 exotic accessions from 16 countries, 211

indigenous accessions (including 71 accessions of 3 wild species) conserved in the LTS were screened at the NBPGR New Area farm for phyllody disease tolerance under natural conditions in collaboration with Division of Germplasm Evaluation and Division of Plant Quarantine. The experiment was laid out in augmented randomised complete block design with 50 blocks and 40 accessions per block. Each block included one row of four infector lines (VRI 3, Phule Til 1, Vinayak and Adarsh) alternatively after every three accessions of two rows each and two tolerant checks (HT1 and PB Til 1) laid out randomly. 1190 accessions were found to be free from the disease at flowering and pod formation stage, which will be subjected to further screening in the subsequent seasons (Fig. 6.2).

6.4.5 II. Standardization of processing protocols at NGB

Quick viability testing protocol standardized in Hemp (Cannabis sativa): Standard germination testing of *Cannabis sativa* requires a minimum of 7 days under controlled environment. Hence, a protocol was developed using 0.1% 2, 3, 5 Triphenyl tetrazolium chloride (TTC), wherein 100% comparable results could be obtained within 48 hrs (Fig. 6.3).

Dormancy breaking protocols standardized in multiple species: In six species, dormancy breaking protocols were standardized. For *Asparagus racemosus*, 4°C for first 10 days and then 10°C for another 20 days protocol proved best. For wild

Fig. 6.3: TTC stained seeds of *Cannabis sativa*

Vigna spp (*Vigna stipualcea*, *V. trilobata, V. sublobata and V. mungo* var *sylvestris, V. angularis* var *nipponensis*), mechanical scarification was found suitable.

6.4.6 Exploration for identifying permafrost site for National Genebank: A unique exploration mission was undertaken by the NBPGR team for identifying a safety duplicate permafrost site for National Genebank, in the Garhwal zone of the Western Himalayan region, in Uttarakhand. The team surveyed Bhyundar Valley-Hemkund, Mana-Badrinath and Joshimath-Auli areas during 5-11 October, 2018. The team conducted detailed survey and discussed with various state departments, concerned Army/ITBP units and forestry officials about technical feasibility of each area. Around 18 germplasm of various crop plants and wild species belonging to the high-altitude areas, *viz., Malus baccata, Aconitum violaceum, Rheum emodi* (rhubarb), *Cicer microphyllum, Elymus* sp., *Hordeum vulgare* (Himalayan naked barley), *Zea*

Fig. 6.2: Screening of sesame germplasm for phyllody disease tolerance

mays (high-altitude maize) *Solanum gilo etc* were also collected for conservation in NGB (Fig. 6.4).

6.4.7 *Upgradation / Modernization of National Genebank Facility*: The existing LTS and MTS facility at NGB was installed and commissioned in 1995-1996 and has been effectively working round the clock for more than 20 years. For increasing the operational efficiency of Genebank modules, upgradation / modernization of the existing LTS and MTS National Genebank facilities has been finalized and work contract has been sanctioned to M/s Controlled Environment Ltd (CONVIRON) Canada. It will include retrofit of the existing facilities with updated technology of refrigeration and operation, including spare parts and accessories.

6.4.8 *Unravelling the genetic architecture of unique indigenous landraces conserved in NGB:* Efforts have been initiated to characterize and evaluate 15,000 paddy landraces and 20 maize landraces collected and conserved in NGB over a period of 30 years, from all over the country, for the purpose of enhancing their trait utilization in hybrid development programmes. The unique named paddy landraces representing all parts of the country were characterized in parts, at two locations, ICAR-National Rice Research Institute, Cuttack and Indira Gandhi Krishi Vishwavidyalaya,

Fig. 6.4: High altitude germplasm collected A: *Taxus baccata*- powdered bark used as substitute for tea powder; B: Asian Barberry collection -*Berberis asiatica;* C: *Rosa webbiana;* D: *Sorbus cuspidata*- rare wild edible fruit of Himalayas; E: NBPGR team with Sh. GS Chauhan, Director, Mountaineering and Skiing Training Institute of ITBP, Auli, Uttarakhand; F: With officials of State forestry department at Mana, Uttarakhand

Raipur under the CRP-Agrobiodiversity project. Observations were recorded for 11 quantitative and 19 qualitative traits (Fig. 6.5). Maize landraces have been bulk multiplied and generation advancement, through selfing, is being done at three locations- Bajaura, HP; Ludhiana, Punjab and New Delhi.

6.5 Plant germplasm registration

Germplasm with unique traits are registered with the objective of recognizing the efforts of scientists who have developed or identified promising germplasm (including parent or inbred lines), to safeguard the national germplasm resources with respect to intellectual property rights and to facilitate flow of germplasm among the scientists working in the crop improvement programmes. For the XXXVIIIth Plant Germplasm Registration Committee (PGRC), the proposals were processed online through GRIS (Germplasm Registration Information System) for the first time. The meeting was held at ICAR-NBPGR, New Delhi on June 02, 2018 under the Chairmanship of Dr AK Singh, DDG (CS) ICAR, New Delhi. Out of that, 82 proposals submitted 54 were considered for registration. Finally, 46 proposals belonging to 21 species were approved for registration. Some notable registered germplasm were: Rice tolerant to low P condition; Wheat resistant to Spot Blotch and early maturining; Barley with extra early heading and short plant height; Jute with high resistance to jute hairy caterpillar; Cucumber with high carotenoid content and orange flesh colour; Opium poppy rich in thebaine content; Malabar Lemon Grass with high essential oil 0.80 %, Methyle eugenol > 75% and high herbage yield 242.5 qtl/ha/year; a novel Cytotype (heptaploid) (2n=7x=56) of guinea grass. List of germplasm registered across crop groups are provided in Table 6.4.

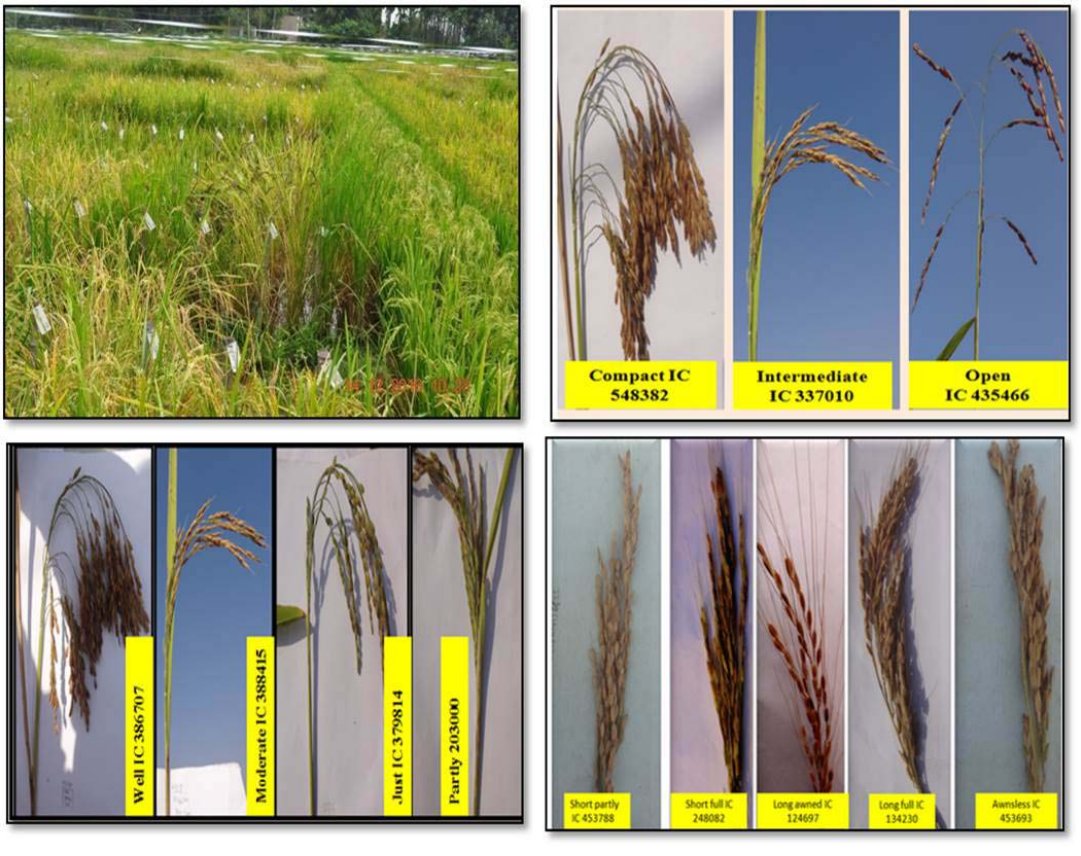


Fig. 6.5: Variability in plant type, panicle type, panicle exertion and awning in rice landraces

IC568489 (IC0568489; INGR18022), a scented sorghum (*Sorghum bicolor*) Germplasm

Jor Lab K-1 (IC0625983; ING18038), a Galanga (*Kaempferia galanga*) Germplasm with higher essential oil yield 2.31 %; higher rhizome yield 6.75 tones/ ha/year and higher dry rhizome recovery 27.50 %

Cucumber (IC0257296; ING18030), (*Cucumis sativus*) with high carotenoid content and orange flesh colour

Table 6.4: Crop group-wise germplasm registered

Crop groupwise germplasm registered			
S.No	Crop groups	Current status	Jan 01 2018-December 31, 2018
1.	Cereals and pesudocereals	502	21
2.	Millets	82	1
3.	Fibre and forages	114	4
4.	Grain legumes	138	2
5.	Vegetables	81	2
6.	Commercial crops	100	1
7.	M & AP and spices	82	11
8.	Ornamentals	56	-
9.	Oilseeds	182	4
10.	Fruits and nuts	42	-
11.	Tubers	37	-
12.	Agro-forestry	7	-
	Grand Total	1423	46

Guidelines developed

Based on the recommendations of the committee constituted by ICAR vide office order No.11/1/2017-Seed (Pt) dated 19/6/17 and approval of the proceedings by the council vide communication F.No. CS-18/02/2018 "Guidelines for deposition and conservation of seeds of RILs, BILs, DHs, NAM and MAGIC, CSSL, association panel, NILs and Mutants at National Genebank, ICAR-NBPGR" have been developed and are available on http://www.nbpgr.ernet.in/Downloadfile.aspx?EntryId=7465.

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

PGR/GCN-BUR-DEL-01.01: Management of Information and National Germplasm Conservation Network **(Anjali Kak Koul,** Sunil Archak, J. Aravind, *BP Dahiya, Rajvir Singh, Smita Lenka 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, Sherry Rachel Jacob and Padmavati G. Gore (study leave w.e.f. June 30, 2018))

PGR/GCN-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods and associated research (**S Vimala Devi,** J Aravind, Sherry Rachel Jacob & *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 w.e.f. June 1, 2018) 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**, K Srinivasan (till 31st May 2018), J Radhamani and Padmavati G. Gore (on study leave w.e.f. June 30, 2018)

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 (on study leave w.e.f. June 30, 2018)

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 (**Sherry Rachel Jacob**)

TISSUE CULTURE AND CRYOPRESERVATION UNIT 7

Summary: Cultures of 1,861 accessions of various plant species were conserved in the *In vitro* genebank at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months. A total of 13,363 accessions were conserved as seeds, embryonic axes, pollen and genomic resources in the Cryogenebank. New accessions (28) added *in vitro* were of *Dioscorea deltoidea* (4), *Hedychium coccineum* (1), *Malus* spp. (6), *Musa* spp. (8), *Prunus* spp. (4), and *Pyrus* spp. (5). A total of 428 new accessions belonging to fruits, industrial crops, legumes, millets, forages, vegetables and wild species were cryostored in the form of seeds, embryonic axes, pollen and genomic resources. Varying degree of pre- and post-freezing success was achieved in cryopresevation experiments using vitrification, encapsulation-dehydration or droplet-vitrification techniques, in *Allium fasciculatum, A. chinense, A. albidum*, *Bacopa monnieri, Colocasia esculenta, Dioscorea deltoidea, D. rotundata, Gentiana kurroo* and *Humulus lupulus*. *In vitro* cryobanking was done in *Allium* spp. (8), *B. monnieri* (2), *D. deltoidea* (4), *Musa* spp. (10) and *Vaccinium ovatum* (1). Genetic stability assessment revealed 70-80% similarity in profiles of cryopreserved and regenerated plantlets and their respective controls in *Musa* (using EST-SSR markers) and *Allium* spp. (using ISSR markers), respectively. Periodic testing for viability of 45 accessions of orthodox and non-orthodox seeds revealed retention of original viability in most of the accessions after 15-26 years of cryostorage.

7.1 Conservation of vegetatively propagated crops

7.1.1 Germplasm maintenance, augmentation and addition: A total of 1,861 accessions of the mandated crops (Fig. 7.1) were conserved *in vitro* in the form of 35,300 cultures and/or *in vitro* cryopreserved meristems/shoot tips in the *In Vitro* Active Genebank (IVAG) or *In Vitro* Base Genebank (IVBG), respectively. Cultures in IVAG are normally conserved at 25±2°C and 16/8 h photoperiod, and in some species at low temperature (8-10°C, in dark). The average subculture period under these conditions varied from 1-24 months, depending on the species/genotype and the conservation strategy employed (Table 7.1).

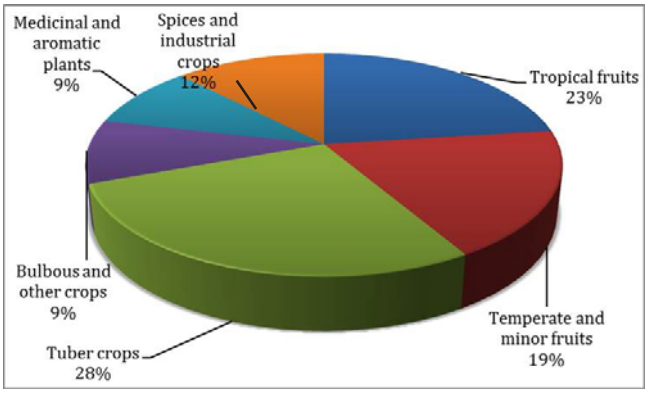


Fig. 7.1: Graphical representation of germplasm collections of major crop groups in the *In Vitro* Genebank (Dec. 31, 2018)

Germplasm augmented for its conservation in IVAG/IVBG during the year comprised 45 accessions including *Malus* spp. (32), *Prunus* spp. (8), *Kopsea arborea* (1), *Hedychium coronarium* (1), *Amorphophallus paeoniifolius* (1), *Aconitum violaceum* (1), and *Allium chinense* (1). The accessions of *Malus* sp. (29) and *Prunus* spp. (8) were procured from ICAR-CITH Srinagar and ICAR-NBPGR RS, Shimla. Exotic accessions of *Malus* (3) were provided by Germplasm Exchange Unit. Recalcitrant seeds of medicinal tree *Kopsea arborea* were received from ICAR-Central Island Agricultural Research Institute, Port Blair; rhizomes of threatened, and high value medicinal plants *Hedychium coronarium*, seeds of *Amorphophallus paeoniifolius* from ICAR-NBPGR Base Centre, Cuttack and rhizomes of *Aconitum violaceum* from Germplasm Exploration Division were also received. Bulbed plants of *Allium chinense* were procured from West Garo Hills, Meghalaya. Based on collections received in previous and current years, a total of 17 new accessions of six genera were added to the IVAG (Table 7.2).

Table 7.1: Status of *in vitro* conserved germplasm in IVAG/IVBG (as on December 31, 2018)

Crop group (Crop)	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)	Major collections (no. of accessions)
Tropical fruits (banana)	2	16	9,000	**428**	*Musa* spp. (428)
Temperate and minor fruits (apple, apricot, blackberry, blueberry, pear, strawberry)	10	42	8,500	**345**	*Actinidia* spp. (6), *Aegle marmelos* (2), *Artocarpous lakoocha* (1), *Fragaria* x *ananasa* (81), *Malus domestica* (29), *Morus* spp. (61), *Prunus* spp. (9), *Pyrus communis* (73), *Rubus* spp. (62), *Vaccinium* spp. (21)
Tuber crops (sweet potato, taro, yam)	5	14	6,000	**518**	*Alocasia indica* (4), *Colocasia esculenta* (90), *Dioscorea* spp. (153), *Ipomoea batatas* (261), *Xanthosoma sagittifolium* (10)
Bulbous and other crops (garlic, gladiolus)	4	14	3,500	**171**	*Allium* spp. (157), *Dahlia* sp. (6), *Gladiolus* sp. (7)
Medicinal and aromatic plants	25	34	4,000	**172**	*Coleus forskohlii* (14), *Plumbago zeylanica* (19), *Rauvolfia serpentina* (13), *Tylophora indica* (10), *Valeriana wallichii* (16)
Spices and industrial crops (ginger, turmeric, pepper, cardamom, vanilla, hops, jojoba)	8	24	4,300	**227**	*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	**54**	**144**	**35,300**	**1,861**	

Table 7.2: Germplasm addition to IVAG

S.No.	Accession no/ Collector no.	Genus/species	Place of collection/ source institute	Remarks (trait/ uniqueness of germplasm
Medicinal Plants				
1.	IC527304	*Dioscorea deltoidea*	ICAR-NBPGR RS, Srinagar	Endangered
2.	IC527307	*D. deltoidea*	ICAR-NBPGR Regional Station, Srinagar	Endangered
3.	IC527310	*D. deltoidea*	ICAR-NBPGR Regional Station, Srinagar	Endangered
4.	IC527313	*D. deltoidea*	ICAR-NBPGR Regional Station, Srinagar	Endangered
5.	IC612509	*Hedychium coccineum*	ICAR-NBPGR Base Centre, Cuttack	Wild species
Bulbous Crop				
6.	IC627868	*Allium chinense*	Nagaland	Chinese onion, wild relative of onion and garlic

S.No.	Accession no/ Collector no.	Genus/species	Place of collection/ source institute	Remarks (trait/ uniqueness of germplasm
Tropical fruit				
7.	IC623466	*Musa acuminata*	Campbell Bay, Nicobar Island	CWR of banana (seeded variety)
8.	MZU-DBT-12	*Musa balbisiana* var. Changtir	Mizoram University	CWR of banana (seeded variety)
9.	RPH-33	*Musa puspanjaliae*	Lower Dibang, Arunachal Pradesh	CWR of banana (seeded variety)
10.	RJJ/0014	*Musa* sp.	Dima Hasao, Assam	Flowers and pseudostem used as vegetable
11.	NRCB-0687	*Musa* (AA) cv Pisang jayee	NRC for Banana, Trichy	CWR of banana
12.	NRCB-0444	*Musa* (BB) Attikol	NRC for Banana, Trichy	CWR of banana
13.	HRB-8	*Ensete glaucum*	ICAR-NBPGR, RS, Shilong	Non-rhizomatous related genera of banana
14.	MZU-DBT-10	*Musa ornata*	Mizoram University	Ornamental banana
Temperate Fruit				
15.	EC944064	*Malus* spp	GEX, NBPGR	Geneva 41
16.	EC944065	*Malus* spp	GEX, NBPGR	Geneva 214
17.	EC944066	*Malus* spp	GEX, NBPGR	Geneva 890

7.1.2 *In vitro* cryobanking: Based on protocols developed earlier, cryobanking was initiated in three accessions of *Allium* comprising *A. albidum* (EC328484), *A. hookeri* (IC623454) and *A. scorodoprasum* (EC328500) and continued in six accessions including two of *A. chinense* (IC623455, IC623458), and one each of *A. hookeri* (IC557018), *A. ramosum* (EC328498), *A. scorodoprasum* (EC328500) and *A. tuberosum* (IC623464). In medicinal plants, cryobanking using vitrification technique was continued in two accessions of *Bacopa monnieri* (IC249250, IC375976), three accessions of *D. deltoidea* (IC527296, IC527297, IC527299) and initiated in two accessions of *D. bulbifera* (IC263440, IC255445) and one new accession of *D. deltoidea* (IC527313). In *Musa,* germplasm was cryobanked as meristems in two

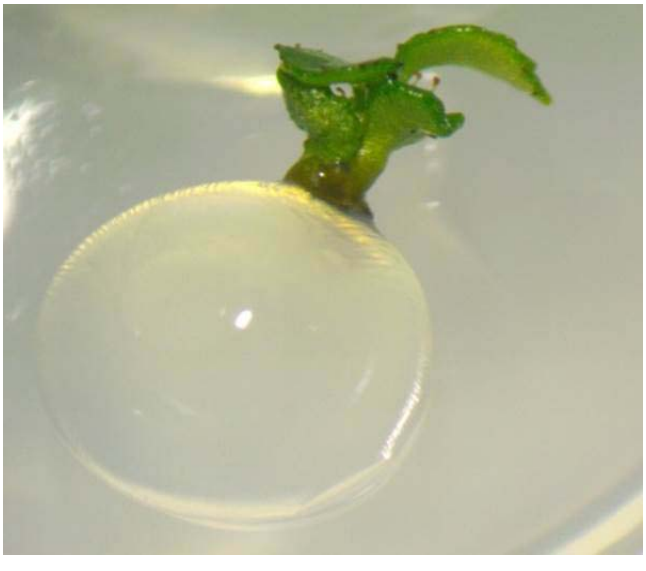


Fig. 7.2: Sprouted shoot from encapsulated shoot tip of *Vaccinium ovatum*

accessions (IC250631, IC251153) using droplet vitrification and in eight accessions (MZU-DBT-10, MZU-DBT-12, RPH-33, RJJ/0014, RJJ/0015, NRCB-687, NRCB-444, HRB-8). Zygotic embryos were air-desiccated and cryopreserved. Shoot tips of one accession of *Vaccinium ovatum* (EC 562094) were cryobanked using encapsulation dehydration method (Fig 7.2). The updated status of germplasm cryobanked in the IVBG is given in Table 7.3.

7.1.3 *In vitro* germplasm supply and hardening:

Colocasia esculenta accessions (40) were supplied to ICAR-NBPGR, RS, Thrissur, for reintroduction in the farmers' field in the form of micro-corms obtained after *ex vitro* hardening of the plantlets. Banana cultures (40 exotic accessions) were provided to NRC for Banana, Trichy, for field evaluation and 15 accessions were provided to Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut for research work. Cultures of *Vaccinium ovatum* (2) and *Rubus* (15) were transferred to ICAR-NBPGR, RS, Shimla for hardening. Cultures of *Rubus* spp. (27) were supplied to DPQ for virus indexing.

Table 7.3: Status of germplasm cryobanked in the IVBG (as on December 31, 2018)

Crop/Species	Acc.added during 2018	Total no. of accessions	Technique(s)*	Explant (s)#
Allium sativum		68	V, DV	ST
A. albidum	1	1	V, DV	ST
A. chinense	2	4	V, DV	ST
A. hookeri	2	2	V, DV	ST
A. ramosum	1	1	V, DV	ST
A. scorodoprasum	1	1	V, DV	ST
A. tuberosum	1	3	V, DV	ST
Bacopa monnieri	2	2		
Dioscorea bulbifera	2	2	V	ST
D. deltoidea	3	6	V	ST
Ensete glaucam	1	1	AD	ZE
Musa spp.	5	70	DV, V, AD	SM, ECS, ZE
M. acuminata	1	6	DV	SM, ZE
M. balbisiana	1	6	AD, DV	SM, ZE
M. ornata	1	1	AD	ZE
M. puspanjaliae	1	1	AD	ZE
M. textilis		1	DV	SM
Rubus hybrid		6	ED	ST
Vaccinium ovatum	1	7	ED	ST
TOTAL	**26**	**189**		

*AD: Air dehydration; **DV:** Droplet vitrification; **V:** Vitrification; **ED:** Encapsulation-dehydration; **EV:** Encapsulation-vitrifcation

ST: Shoot tip; **SM:** Shoot meristem; **ZE:** Zygotic embryo; **ECS:** Embryogenic cell suspension

7.2 Supportive Research

7.2.1 Micropropagation in *Vanilla planifolia*: Protocol for rapid *in vitro* multiplication by induction of multiple shoots was standardized in accession IC573991. Nodal explants as well as shoot apices were grown on 20 different media combinations to determine the better responding explant for multiple shoot induction. Nodal explants were better for shoot multiplication, with highest number of shoots obtained on MS medium + 4.44 µM BAP + 8.06 µM NAA within 12 weeks of culture (Fig. 7.3a, b). On MS medium + 2.22 µM BAP + 8.06 µM NAA, highest shoot length was observed (Fig. 7.3c) was observed. *In vitro* induction of roots was standardized using 12 different MS media combinations. On MS supplemented with 5.37 µM NAA there was 100% root induction (Fig. 7.3d). The rooted *Vanilla* plantlets were hardened in soilrite.

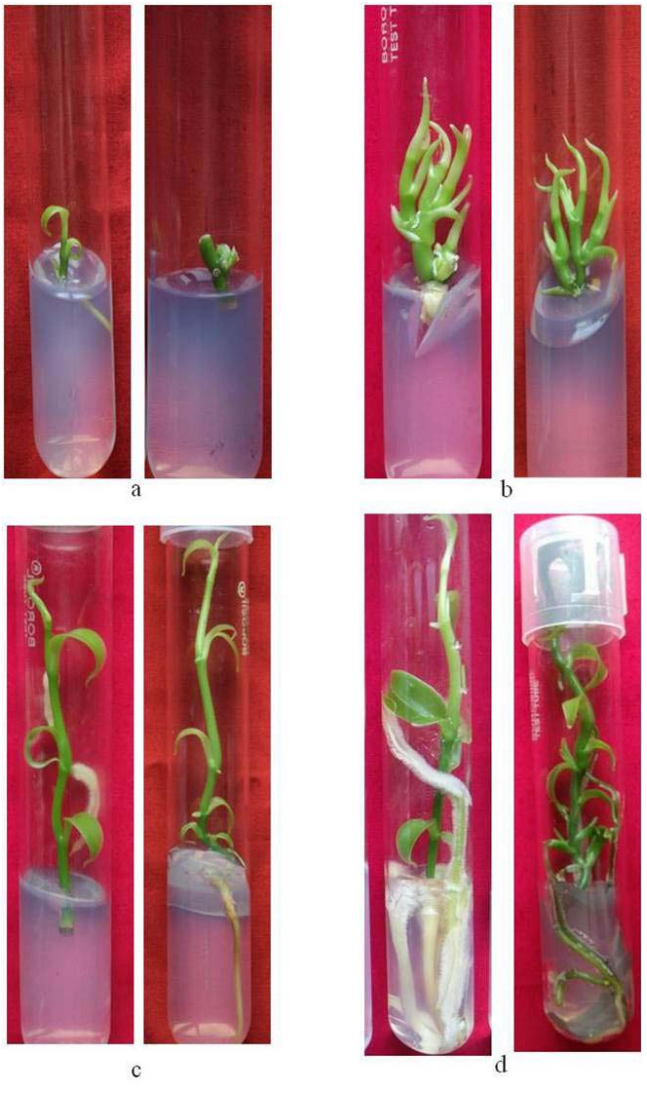


Fig. 7.3: *In vitro* multiplication of *V. planifolia*; a) Culture initiation using shoot apex and nodal explants, b) *In vitro* shoot multiplication on medium containing 4.44 µM BAP and 8.06 µM NAA, c) Elongation of single shoots on medium containing 2.22 µM BAP and 8.06 µM NAA, d) Rooting of multiplied and elongated shoots on medium supplemented with 5.37 µM NAA

7.2.2 Micropropagation in medicinal plants: Experiments were conducted in *Dioscorea floribunda* and *Hedychium* spp., for rapid multiplication using nodal segments and shoot buds as explants, respectively. Of the various media tested in *D. floribunda,* optimum multiplication (~3 shoots/explant) was achieved on MS + 0.5mg/l BA + 0.1mg/l NAA. In *H. coccineum* and *H. spicatum*, > 40% cultures exhibited multiple shoot formation (2-4 shoots/ explant) on MS +BAP (5.0 mg/l) and 60% rooting on MS basal. Experiments are being continued for further optimization in *Hedychium* spp.

7.2.3 Shoot multiplication and desiccation tolerance studies in *Garcinia* spp.: Shoot multiplication protocol was standardized for *G. gummigutta* (KC/OP/P-23/18) and *G. indica* (KC/ OP/P-22/18), two highly recalcitrant seeded species. In *G. indica,* there was optimum shoot induction MS medium + 37.5µM BAP + 1µM NAA and highest number of shoots per explants was observed with MS + 13.32 µM BAP + 2.68µM NAA. Desiccation tolerance studies of the isolated shoot tips of *G. indica* showed 50% survival after 20 min. treatment with plant vitrification solution 2 (PVS2) using vitrification technique. Experiments are continued for developing protocol for shoot tip cryopreservation.

7.2.4 *In vitro* establishment and cryopreservation of *Colocasia esculenta*: Fresh cultures were re-established from field-grown plants of accession IC317585, which were earlier having endogenous

bacteria under *in vitro* storage. Aseptic cultures were established on MS + 2mg/l BAP + 0.1mg/l NAA, with 8-10 shoots/explants. Shoot-tips (2mm long) excised from mother cultures exhibited 20-30% post-thaw survival following treatment with PVS2 for 20 min. (Fig. 7.4).

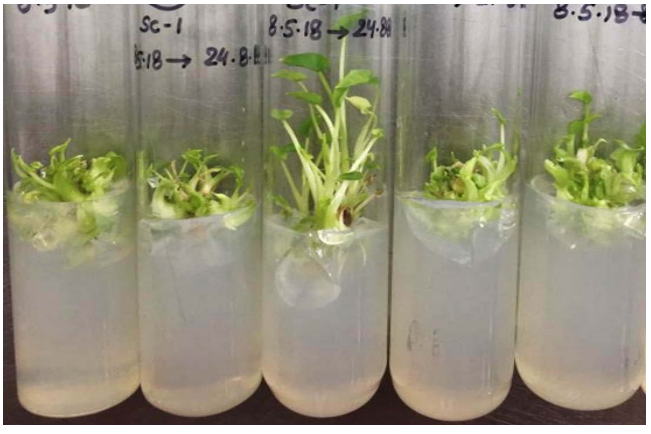


Fig. 7.4: Regrowth of shoot tips of *Colocasia esculenta* after cryopreservation

7.2.5 Cryopreservation of *Allium* spp.: Cryopreservation experiments continued in *A. albidum* (EC328484) to improve post-thaw regrowth using droplet-vitrification (DV) technique. Preconditioning of mother cultures and pregrowth of shoot tip explants was carried out at low temperature (5^{O}C) on shoot multiplication medium (SM10) comprising MS+0.1mg/l NAA+0.02mg/l 2iP +10% sucrose. Replacement of PVS2 with PVS3 led to improved post-thaw regrowth (20% and 40%, respectively).

Using vitrification technique, cryopreservation experiments were initiated in another species, *A. lineare* (EC328492). In non-frozen controls, shoot tips excised from mother cultures, maintained on shoot multiplication medium (SM) comprising MS+0.1mg/l NAA+0.02mg/l 2iP +3% sucrose and pre-grown on SM under culture room conditions, exhibited 71-16% survival following treatment with PVS2 from 10-50 min, with 57 and 28% regrowth at 10 and 20 mins PVS2. None of the explants survived LN freezing. Following pre-conditioning of mother cultures and pre-growth of explants on SM10 medium at 5^{0}C, there was 20% post-thaw regrowth.

In *A. fasciculatum* (IC623460), an underutilized *Allium* species procured from Arunachal Pradesh, cryopreservation experiments were initiated using DV technique. Shoot tips isolated from mother cultures, maintained on SM medium and pre-grown on SM10 under culture room conditions exhibited 10% post-thaw regrowth with 90 min PVS2 treatment (Fig. 7.5). There was swelling and proliferation of explants with PVS2 of less than 90 min (40-60 min).

Fig 7.5: (A) Post-thaw regrowth; (B) plantlet regeneration in *Allium fasciculatum*

Cryopreservation experiments carried out with shoot tip explants *A. chinense* [earlier identified as *A. macranthum* (IC623461) established in IVAG, NBPGR Annual Report 2017] using DV technique yielded 50% post-thaw regrowth with 60 min PVS2 treatment.

7.2.6 Cryopreservation in medicinal plants : Standardization /application of protocols for *in vitro* cryopreservation was continued in *B. monnieri, D. deltoidea, Gentiana kurroo* and *Rauvolfia serpentina* using encapsulation-dehydration, droplet vitrification and/or vitrification techniques. In *R. serpentina* (IC375975), 12 experiments using vitrification and/or encapsulation-dehydration (ED) technique, were carried out to determine optimal dehydration duration, pre- and post-culture conditions for successful post-thaw regeneration. Shoot tips, isolated from 6-month-old cultures, pre-grown on 0.5 M sucrose medium, exhibited 10% recovery using ED and vitrification techniques. Using vitrification protocol developed earlier, shoot tips of one new accession each of *B. monnieri* (IC353204) and *D. deltoidea* (IC527313) exhibited 20 and 30% post-thaw regrowth, respectively. Using vitrification technique in *G. kurroo* (IC554589) shoot tips, isolated from 8-week-old mother plants exhibited ~30% post-thaw recovery after ~30 min PVS2 dehydration at 0°C. In *B. monnieri* (IC375976), improved post thaw regrowth (40%) was obtained using DV technique compared with 20% using vitrification technique whereas 10% regrowth was obtained using ED technique.

7.2.7. Cryopreservation of *Dioscorea rotundata*: Cryopreservation experiments were initiated in accessions IC582606 and IC582607, using vitrification technique. Shoot tip and nodal explants excised from mother cultures were tested. Accession IC582606 exhibited 20% post-thaw regrowth following treatment with PVS2 for 90 min (Fig. 7.6).

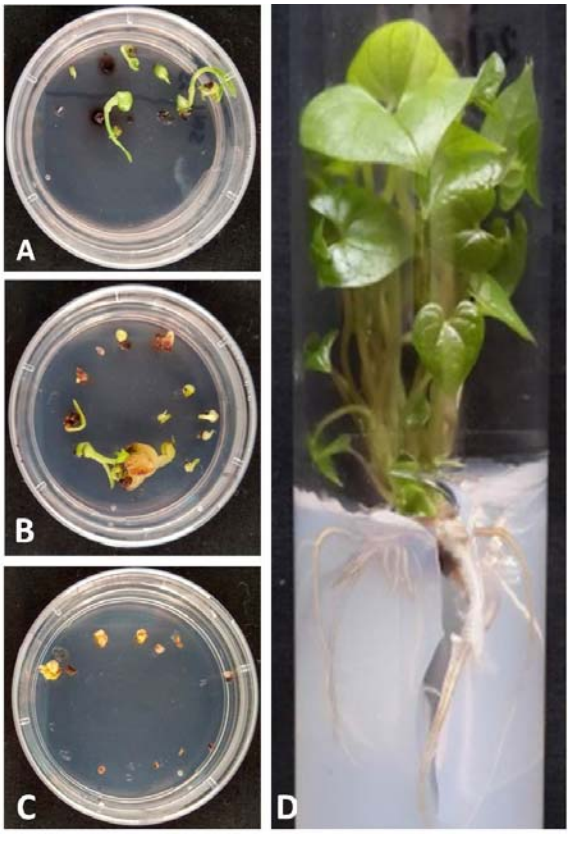


Fig. 7.6: Regrowth of nodal explants of *Dioscorea rotundata* after cryopreservation using vitrification technique; A: Control; B: Vitrification control; C: Cryopreserved Nodal Explants showing regrowth; D: fully grown plantlet from cryopreserved nodal explant

7.2.8 Cryopreservation of *Humulus lupulus*: Desiccation tolerance of shoot tips of *H. lupulus* (EC452691) encapsulated in 3% calcium alginate was studied. Osmotic dehydration in 0.75 M sucrose gave constant mc (~76%) after one day (Fig. 7.7A). Subsequent air dehydration of encapsulated explants reduced mc to 22% after 3-5 h (Fig. 7.7B). Optimum regeneration (50%) of encapsulated shoot tips occurred in explants subjected to 3 days of osmotic dehydration and 4 h of air dehydration, and cultured on MS medium supplemented with 0.45 µM BAP and 0.28 µM GA_3 (Fig. 7.7B). Cryopreservation of the aforementioned encapsulated-dehydrated shoot tips gave 40% post-thaw survival.

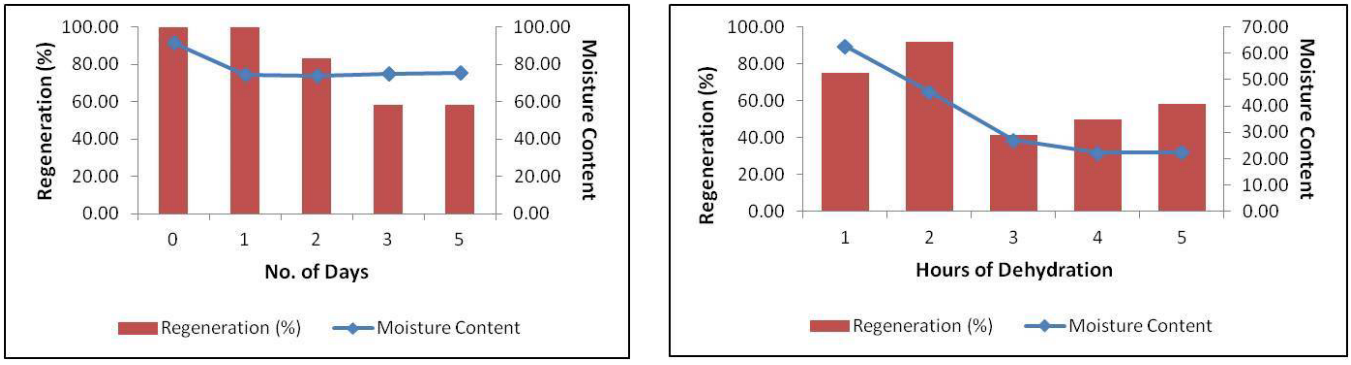


Fig. 7.7: A: Moisture content vs. survival rate after different days of osmotic dehydration; B: Moisture content vs. survival rate after different hours of air dehydration post osmotic dehydration of 24 h

7.2.10 Virus Indexing of *Rubus* spp.: Screening of *in vitro* conserved cultures of *Rubus* (27 accessions) against four associated viruses of economic importance was carried out in collaboration with DPQ, ICAR-NBPGR. The viruses tested were *Arabis mosaic virus* (ArMV), *Strawberry mild yellow edge virus* (SMYEV), *Raspberry bushy dwarf virus* (RBDV), *Tomato black ring virus* (TBRV). All the tested samples in the accessions were found free from the viruses, as determined by DAS enzyme-linked immunosorbent assay (ELISA).

7.2.11 Optimization of media for recovery of cryopreserved zygotic embryos of *Musa balbisiana* : Zygotic embryos from mature seeds of accession EC653579 were air desiccated to 8-10% MC prior to cryopreservation. Five media combinations were tested to increase recovery growth after LN treatment. Amongst the media tested, highest post-thaw regeneration (85±7%) was obtained on MS medium + TDZ (1 µM) + BAP (1 µM) (Fig. 7.8). This medium is being tested for post-thaw other wild relatives of banana.

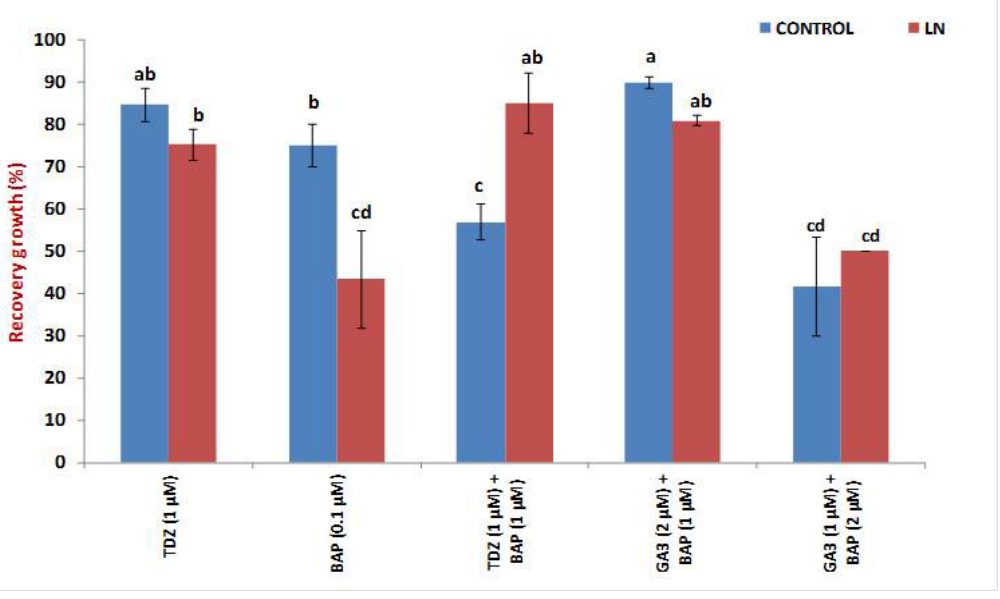


Fig. 7.8: Effect of five media combination on regrowth of cryopreserved zygotic embryos of *Musa balbisiana*

7.2.12 Genetic stability analysis of cryopreserved *Musa* germplasm: EST-SSR markers developed *in silico* were used for genetic stability analysis of plants of *Musa* accessions '*Musa* AAB cv Pisang Rajdah' (EC653551) and '*Musa* ABB cv Pelipita' (EC653545), regenerated post cryopreservation. Forty SSR primer pairs were used and similarity analysis and UPGMA clustering revealed no significant difference among the mother plant, the *in vitro*-cultured plants, and the cryopreserved materials, indicating no loss of genetic stability of the tested banana accessions post-cryopreservation. Fig. 7.9 shows the representative gel images of amplification of *Musa* accessions with EST-SSR Primer.

7.2.13 Genetic stability analysis of cryopreserved *Allium* germplasm: Genetic stability analysis of *Allium chinense* (2 accessions) and *A. tuberosum* (3 accessions) regenerated after cryopreservation was carried out using 30 ISSR primers. Fig. 7.10a shows the representative gel images of

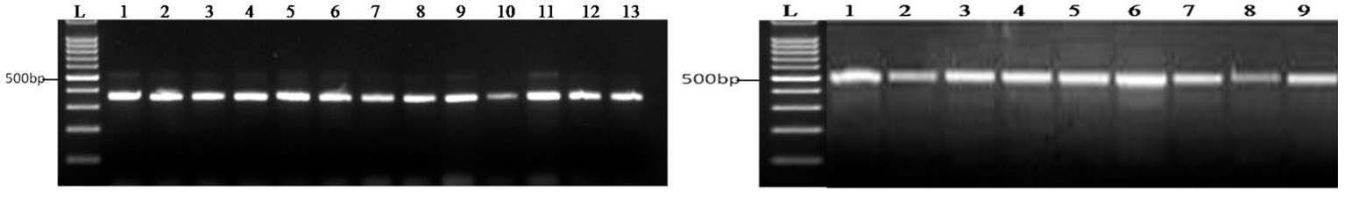


Fig. 7.9: Representative gel image showing amplification of *Musa* accessions with EST-SSR Primer E-P5: A: *Musa* AAB cv Pisang Rajdah: 1 – *In vitro*-raised single shoots; 2,3,4,5 non frozen PVS-2 controls; 6,7,8,9 –Samples cryopreserved by vitrification; 10,11,12,13 – Samples cryopreserved by droplet vitrification; B: *Musa* ABB cv Pelipita: 1 – *In vitro* raised single shoots; 2, 3 – Non-frozen PVS2 controls; 4,5,6 – Samples cryopreserved by vitrification; 7,8,9 – Samples cryopreserved by droplet vitrification

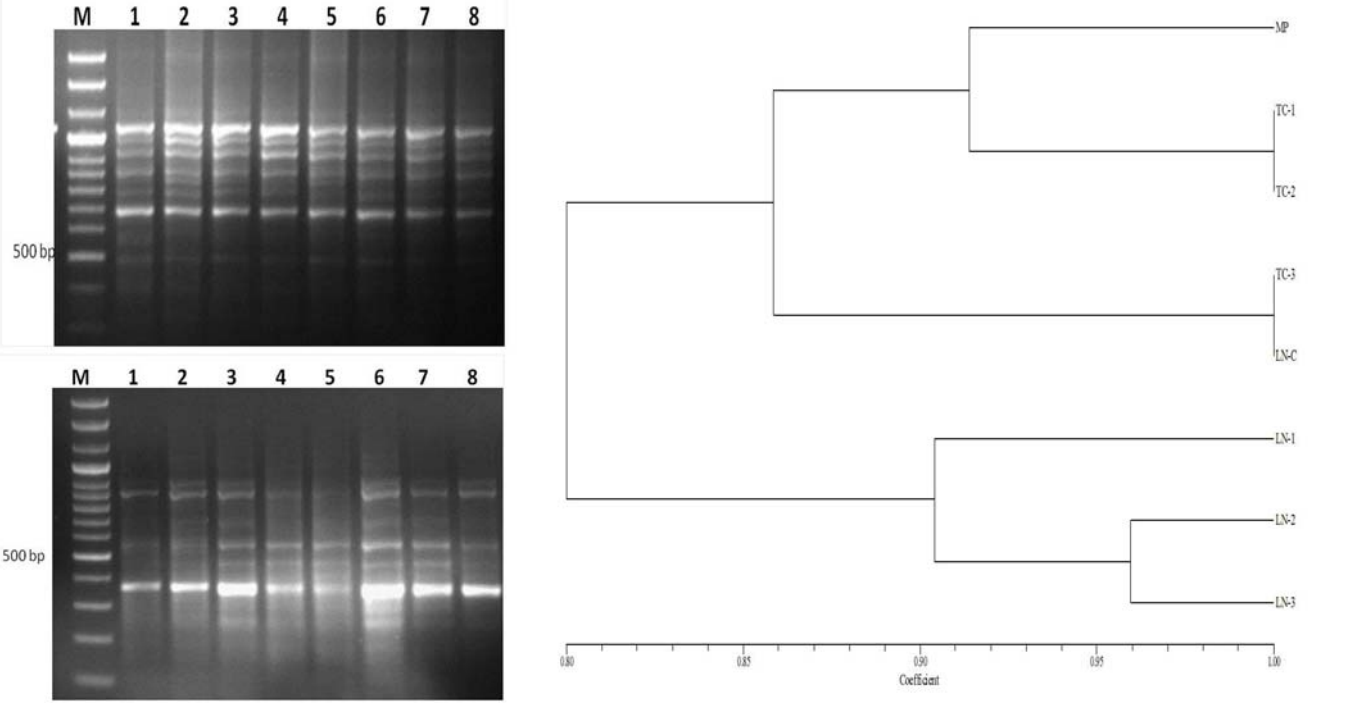


Fig. 7.10: A: Representative gel image showing amplification of *Allium chinense* (IC 623458) with ISSR Primer UBC 873 and *A. tuberosum* (IC 554562 with ISSR Primer IS6; M – Molecular weight marker, 1 - Mother Plant; 2,3,4 Tissue culture controls, 5 – LN control, 6,7,8 – cryopreserved samples); B: Dendrogram of *A. tuberosum* accession IC 554562

amplification of *Allium* accessions with ISSR primers. On similarity analysis, 70-88% similarity was observed between the mother plants; tissue cultured plants, LN controls and cryopreserved plants (Fig. 7.10 b).

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

7.2.1 Germplasm augmentation and cryostorage:

A total of 13,363 accessions comprising non-orthodox (intermediate and recalcitrant) and orthodox seed species were conserved in the Cryogenebank (Table 7.4; Fig. 7.11). A total of 479 accessions of diverse germplasm comprising fruits and nuts, industrial and underutilized crops, medicinal, vegetables, and wild species were received. Most of the germplasm were received from ICAR-NBPGR Headquarter and ICAR-IIOPR, Andhra Pradesh. A total of 428 accessions were cryostored as seeds, embryonic axes, pollen and genomic resources during this period at temperature between -160°C to -180°C in the cryobank. Cryostored accessions comprised fruits, industrial and underutilized crops, medicinal crops, including wild species and wild relatives of crop plants, belonging to 3+1+1 new species (three species of *Grewia*, *Muntingia calabura* and *Vangueria spinosa*). For attempting cryobanking of orchid species in collaboration with NRC Orchids,

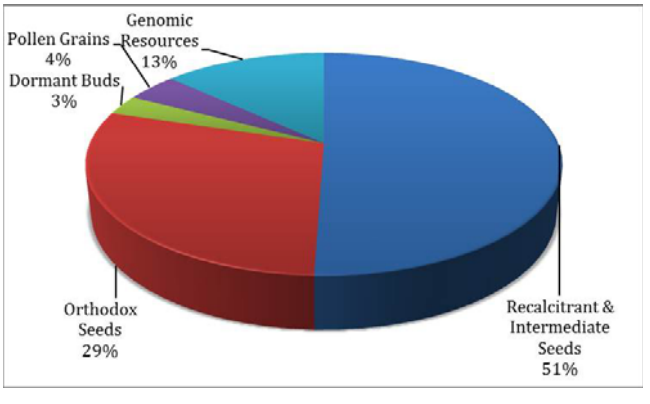


Fig. 7.11: Graphical representation of germplasm collections in the Cryogenebank (Dec. 31, 2018)

Table 7.4: Status of germplasm in Cryogenebank (as on Dec. 31, 2018)

Crop groups	Accessions (no.)*	Total
Recalcitrant & Intermediate		**6,754**
Fruits & nuts	3,519	
Spices & condiments	152	
Plantation crops	39	
Agroforestry & forestry sp.	1,645	
Industrial plants (Jatropha, Pongamia, Salvadora, Oil palm)	1,365	
Medicinal & aromatic plants, orchids	34	
Orthodox#		**3,902**
Cereals	289	
Millets and forages	293	
Pseudo-cereals	76	
Grain legumes	813	
Oilseeds	668	
Fibre crops	68	
Vegetables	581	
Medicinal & aromatic Plants	1,001	
Narcotics & dyes	35	
Miscellaneous sp.	78	
Dormant buds		**387**
Pollen grains		**556**
Genomic resources		**1764**
Total		**13,363**

*No. of species: 820;
#Rare & endangered plants: 99; varieties: 776; elite lines: 4; registered germplasm: 23, core collection: 323

fruit capsules were collected from NE states and seeds of *Coelogyne nitida, C. flaccida, Cymbidium mastersii, C. iridioides, C. erythreum*, *Paphiopedilum villosum, Phaius tankervilleae, Thunia alba,* were asymbiotically germinated and seed storage studies conducted.

7.2.2 Studies on desiccation and freezing sensitivity of seed germplasm: Seed storage behavior studies (seed viability, moisture content, desiccation and freezing sensitivity) were conducted on *Rubus* sp., *Pyracantha crenulata*, *Carissa carandus*, *Grewia villosa, G. tenax* and *G. serrulata*, *Muntingia calabura*, *Maclura cochinchinensis, Elaies guineensis, Garcinia indica, G. gummigutta, Syzygium cumini, Stixis suaveolens,* and *Canarium strictum*. Seeds of *Maclura cochinchinensis,* upon subjecting to desiccation to 7.69% MC showed 60% survival post-cryostorage (Fig. 7.12). Intermediate seed storage behavior was exhibited by *Carissa carandus* and *Elaies guineensis.* Seeds of *Garcinia* spp., *Syzygium cumini, Stixis suaveolens* and *Canarium strictum* showed recalcitrant seed behavior due to intolerance to desiccation and freezing, and hence could not be conserved in cryobank.

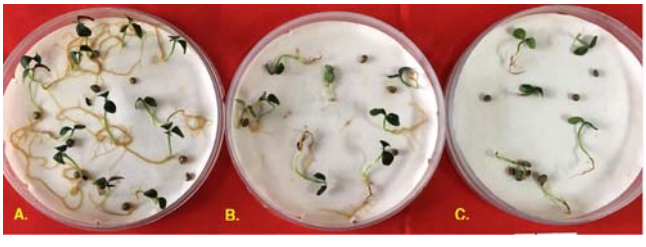


Fig. 7.12: Viability testing in *Maclura cochinechinensis* (IC629322); A: Germination of fresh seeds; B: Seeds germination after desiccation to 7.69% MC; C: Seeds germination after desiccation and LN storage for 24 h

7.2.3 Cryopreservation of dormant buds: Dormant buds of *Malus* (25) were cryopreserved by two-step freezing, and two accessions were sent for grafting at Srinagar to assess the viability of cryopreserved buds. Feasibility studies on *ex vitro* regeneration of cryopreserved dormant buds of almond (3) and walnut (2) through chip budding in field at ICAR-CITH, Srinagar were done. Protocol of cryopreservation, thawing and rehydration of dormant buds of *Prunus amygdalus* var. Shalimar (IC538535) and Drake collected from ICAR-CITH Srinagar and ICAR-NBPGR, RS, Shimla, respectively was refined. Nodal sections (9 cm long) containing 4-5 buds were desiccated (at -15^{0}C) until mc reached 25-28% followed by LN exposure. Subsequent to thawing, the buds showed good viability (80-90%, based on TTC test) and sprouting up to 75-80% after 14 days of rehydration in moist moss grass at 4^{0}C. Further experiments are underway.

7.2.4 Testing health status and regeneration of cryostored germplasm: For checking the health status of 82 accessions of diverse crops (both fresh and cryostored), seeds were sent to DPQ, ICAR-NBPGR, Delhi. Periodic viability testing was done for more than 45 accessions of orthodox and non-orthodox seeds and it revealed retention of original viability even after 15-26 years of cryostorage.

New Initiatives at TCCU

- A new DBT-funded project entitled 'Collection, evaluation, documentation and conservation of banana genetic resources from north eastern region' started from March 2018, for a period of 3 years.
- Development of protocol for *in vitro* pollen germination and cryostorage in *Abelmoschus moschatus* was initiated, with the objective to facilitate wide hybridization studies in okra.
- Thrust given to augment and conserve crop wild relatives from hotspots of diversity (Andaman and Nicobar Islands, Western Ghats, NER), in banana, tropical fruit trees (*Garcinia* spp.) and new forestry species (e.g. *Muntingia calabura, Vangueria spinosa).*
- Under collaborative projects, germplasm of wild *Musa* spp., orchids and oil palm were investigated in detail for their storage behavior and were suitably cryobanked.

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

Programme I- PGR/TCCU-BUR-01: *Ex situ* conservation of plant genetic resources of vegetatively propagated crops using *in vitro* and cryopreservation techniques **(Anuradha Agrawal)**

Research Projects (Code, Title, **PI**, CoPIs and *Associates***)**

PGR/TCCU-BUR-01.01 *In vitro* conservation of tuber crops with special reference to sweet potato, yams and taro (**Sangita Bansal**, Neelam Sharma till Mar 31, 2018; July 31, 2018), Vartika Srivastava and *DK Nerwal*)

PGR/TCCU-BUR-01.02 *In vitro* conservation of spices, plantation and new industrial crops [**Era Vaidya Malhotra** (PI w.e.f. Aug. 10, 2018)], Anuradha Agrawal [PI up to Aug 9, 2018, Co-PI w.e.f**.** Aug 10, 2018)]

PGR/TCCU-BUR-01.03 *In vitro* conservation of bulbous and ornamental crops (**Ruchira Pandey**, Neelam Sharma, Gowthami R)

PGR/TCCU-BUR-01.04 *In vitro* conservation of medicinal aromatic plants with special reference to rare and endangered species. (**Neelam Sharma**, Ruchira Pandey, Gowthami R)

PGR/TCCU-BUR-01.05 *In vitro* conservation of tropical fruit species (**Anuradha Agrawal**, Era Vaidya Malhotra and *DPS Meena*)

PGR/TCCU-BUR-01.06 *In vitro* conservation of temperate and minor tropical fruit crops. (**Sandhya Gupta,** Narender Negi)

PGR/TCCU-BUR-01.07 Studies on genetic integrity of conserved germplasm (**Era Vaidya Malhotra**, Sangita Bansal, Gowthami R, Vimala Devi and J Aravind)

Programme II- PGR/TCCU-BUR-02 *Ex situ* conservation of plant genetic resources of agricultural and horticultural crops using cryopreservation of seeds, dormant buds and pollen (**Rekha Chaudhury**)

Research Projects (Code, Title, **PI**, CoPIs and *Associates***)**

PGR/TCCU-BUR-02.01 Cryopreservation of non-orthodox and orthodox seed species in various forms using standard protocols. [**Rekha Chaudhury**, Sangita Bansal (w.e.f. Aug. 10, 2018) and *A.P. Singh*]

PGR/TCCU-BUR-02.02 Investigating desiccation and freezing tolerance in non-orthodox seed species, dormant buds and pollen for cryopreservation. [Vartika Srivastava (PI w.e.f. Aug 10, 2018) and Rekha Chaudhury (PI till Aug 09, 2018)]

Externally Funded Projects (PI)

1. Life cycle cryobiotechnology of orchids for bioresources conservation and sustainable development (**Rekha Chaudhury**)
2. Collection, taxonomy, molecular characterization and conservation of *Musa* germplasm from North-eastern Region (NER) of India (**Anuradha Agrawal**)
3. Improvement of banana for small holder farmers in the great lake regions of Africa Indian component – Breeding for improved bananas with fusarium wilt (*Fusarium oxysporum* fsp. *cubense*) resistance (**Anuradha Agrawal**)
4. Collection, evaluation, documentation and conservation of banana genetic resources from north eastern region (**Anuradha Agrawal**)
5. Molecular dissection of miRNA mediated regulation of phytohormone signalling cascade for including pod borer resistance in pigeonpea (**Era Vaidya Malhotra)**

PGR POLICY PLANNING UNIT 8

Summary: The PGR Policy Planning unit documents and collect literature on concurrent international and national developments concerning plant genetic unit resources and related fields, such as bio-safety, germplasm utilization, exchange, and quarantine and provides analytical inputs 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.

8.1 PGR management and related policy

8.1.1 International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA): Analyzed the agenda items and prepared for India's position for:

- VIII meeting of the Ad Hoc Open-ended Working Group to Enhance the Functioning of the Multilateral System (October 10-12, 2018)
- Preparation of the Third report on the state of the world's plant genetic resources for food and agriculture
- III Meeting of the Scientific Advisory Committee (SAC) on Article 17 of ITPGRFA (Fig. 8.1). SAC3 deliberated upon six agenda items proposed by the Co-Chairs. India as a co-chair of SAC (represented by Dr. Kuldeep Singh, Director, NBPGR) guided the deliberations keeping in view interests of developing countries in general and India in particular.
- 9th Session of Intergovernmental Technical Working Group on PGRFA held at Rome, Italy from July 25-27, 2018
- International workshop for Software Testing to Support DOI Implementation (Fig. 8.2). Objective of the program was to transfer the technical knowledge on DOI registration by using the DOI Toolkit developed in collaboration with IRRI and the ITPGRFA Secretariat. Meeting was held in Indonesia from April 22- May 1, 2018.
- Asian Regional Workshop on the Preparation of the National Reports on the Implementation of the International Treaty was hosted by ICAR-NBPGR, New Delhi, India from 11-13 December 2018 (Fig. 8.3). The workshop was attended by 29 participants from 12 countries. FAO office in India provided the logistic support. Mr Ashwani Kumar, Joint Secretary (Seeds) and national focal point of India for the International Treaty, gave opening remarks and Dr DK Yadava, Assistant Director General (Seed) presented welcome remarks. The main purpose of the meeting was to provide information on

Fig. 8.1: Dr Kuldeep Singh, Director, ICAR-NBPGR Co-Chair of Scientific Advisory Committee Meeting on Article 17 of ITPGRFA Meeting, Rome (June 21-22, 2018)

Fig. 8.2: Participants of the International Workshop for software testing

the Compliance Rules, the Standard Reporting Format for the elaboration of the national reports on the implementation of the International Treaty and the Online Reporting System and the mechanism for the official submission

8.1.2 Convention on Biological Diversity:

- Information compiled for submission of Sixth National Report on NBT-7.
- Analyzed the agenda items and prepared for India's position for CoP 14, CoP-MoP 3 and Nagoya Protocol on Access and benefit sharing.

8.1.3 National Biodiversity Authority (NBA)

- Comments/ inputs/ views were provided for the agenda under consideration by NBA for 47th, 48th,49th, 50th, 51st and 52nd Expert Committee Meetings on ABS held during 2018. Inputs on various agenda items related to access to biodiversity and IPRs; ABS agreements and capacity building activities for sensitizing different Stakeholders about the provisions of the Biological Diversity Act were provided.
- Inputs on experiences in implementation of Biological Diversity Act viz-a-viz ITPGRFA/ PPVFRA/Patents Act

8.1.4 National Advisory Committee on Management of Genetic Resources:

- First Meeting of the National Advisory Committee on Management of Genetic Resources was held on April 26, 2018. The agenda items discussed were : Expansion of the list of material of Annex I crops for designation under the International Treaty; Scope of safety duplication of cryopreserved germplasm and the designated accessions under MLS at Svalbard Global Seed Vault (SGSV) and cryopreserved germplasm; Expedited procedure for approval from NBA regarding access of material (GRFA) from ICAR Institutions to private entities falling under Section 3(2) of the Biological Diversity Act, 2002; Proposal for fixing handling/processing charges for the germplasm supplied to private entities; Regarding obtaining blanket permission for exploration and germplasm collecting from protected areas.

8.1.5 Inputs provided to ICAR/DARE/DAC/ MoAFW for:

- Indo-German bilateral cooperation on seed development to identify new areas of cooperation including export of seeds, planting materials and agricultural produce for the national interest, for inclusion in the next phase.

Fig. 8.3: Participants of the Asian Regional Workshop on Preparation of National Reports Implementation of ITPGRFA

- Developing India's position and Issues related to Digital Sequence Information (DSI) for SBSTTA22.
- Organized Brainstorming workshop on procedures related to seed movement and quarantine in collaboration with Alliance for Agri Innovation (AAI) on July 31, 2018.
- Organized the discussion meeting on the implementation of the collaborative research project on 'Evaluation of Stress tolerant orphan legumes for use in dryland farming systems across sub-Saharan Africa and India' during the visit of Dr. Edwin Southern, Chairman, Kirkhouse Trust, UK to India on October 3, 2018.
- The Plant Quarantine (Regulation of Import into India) Order 2003 was further analysed and sections where revision was needed were identified.
- In continuation of providing advisory in 2017, provided further policy inputs on *Fusarium* wilt disease (Panama lethal disease) caused by *Fusarium oxysporium* f.sp. *cubense* Tropical Race 4 (FocTR4) to ICAR to be taken up with Plant Protection Advisor (PPA) to the Government of India for its immediate containment and eradication.
- Comments given on the risk involved in import of several agricultural commodities, certain insect cultures, Spirulina blue-green microalgae and other biocontrol agents.
- Developed a proposal for India- ASEAN working group on "Training Course on Role of Sanitary and Phytosanitary Systems in Plant Quarantine" for 2 weeks with a budget outlay of USD 86,000/-.
- Inputs provided to ICAR on identification of export zones for producing export quality potatoes in Punjab, Madhya Pradesh and Gujarat during a stakeholders meet on April 21, 2018 at NASC Complex, New Delhi. The meeting was attended by officials from ICAR; ICAR-CPRI, Shimla; ICAR-NBPGR, New Delhi; DPPQ&S, Faridabad; APEDA, New Delhi; Directorate of Horticulture of Gujarat, Punjab, and Madhya Pradesh; Representatives from seed and processing industries; and exporters. Three presentations were made during the meeting on topics like (i) Sanitary and phytosanitary issues related to potato export, (ii) Identification of brown rot free areas for producing export quality potatoes, and (iii) Identification of potato tuber moth free areas for producing export quality potatoes. Recommendations and road map was prepared on the issues of potato export.

8.1.6 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). 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 strengthening national implementation of BWC.

8.1.7 Inputs to IPPC:

As member of the International Quarantine Forest Research Group Strategy Working Group under the International Plant Protection Convention (IPPC), provided scientific analysis on global phytosanitary issues, implications on trade etc. during meeting held through video conference on March 13, 2018. Thereafter, inputs were provided on the questionnaire developed for National Plant Protection Organizations (NPPOs) for gathering information from all IPPC member countries and the analysis submitted to IPPC for further International Standards for Phytosanitary Measures (ISPM) development.

8.1.8 Inputs provided to MoEF&CC:

- Submitted information on invasive alien species (IAS) in response to the invitation of CBD to parties after the 22nd meeting of Subsidiary Body on Scientific Technical And Technological Advice, held in Montreal, Canada during 2-7 July 2018.
  - (a) Addressing the risk associated with the trade in wildlife, IAS sold via e-commerce and IAS moving with sea containers
  - (b) Risk analysis on biological control agents
  - (c) Decision support tools for management of invasive alien species
  - (d) The progress on the achievement of Aichi Biodiversity Target 9
- Also, provided inputs to MoEF&CC regarding Aichi Target 9: By 2020, IAS and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their spread.
- Provided inputs on National Report on the implementation of the Cartagena Protocol on Biosafety, which was presented in the Meeting of Parties of the CBD.

8.1.9 Inputs to MoF:

Provided risk based-technical inputs to the Ministry of Finance, Department of Revenue on import of opium poppy seeds for trial cultivation of poppy crop production of concentrated poppy straw and extraction of alkaloids therefrom. Requests from firms were received in response to the GoI's call for expression of interest to set-up production units for concentrated poppy straw (CPS) from opium poppy (*Papaver somnifera*) crop and further extraction of alkaloids from such CPS.

8.1.10 Pest Risk Analysis:

Undertook country-wise, pathway-based generic PRA for following crops facilitating import of these crops for the first time as provided in table 8.1.

Table 8.1: List of crop species imported first time through pathway-based generic PRA.

Plant Species	Category of plant material	Country
Hing (*Ferula asafoetida*)	Seeds	Iran
Buckwheat (*Fagopyrum esculentum*)	Seeds	USA
Methi (*Trigonella* spp.)	Seeds	USA
Rice (*Oryza sativa*)	Lyophilized leaf	Philippines
Sesame (*Sesamum indicum*)	Seeds	Turkey
Maize (*Zea mays*)	Lyophilized leaf tissue powder	USA
Chia (*Salvia hispanica*)	Seed	Japan & Malaysia
Yacon (*Smallanthus sonchifolius*)	Rhizome	Japan & New Zealand
Jack fruit (*Artocarpus heterophyllus*)	Rooted plant	Nepal
Fenugreek (*Trigonella* spp.)	Seed	Germany

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

PGR/PPU–BUR-DEL-01-1.00: PGR management policy and back up research (Pratibha Brahmi)

Research Projects (Code, Title, **PI,** CoPI's and *Associates*)

PGR/PPU–BUR-DEL-01-01: 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/PPU – BUR-DEL-01-02: Policy issues related to biosecurity. (**SC Dubey,** Kavita Gupta, Pratibha Brahmi, Gurinder Jit Randhawa)

AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT 9

Summary: Agricultural Knowledge Management Unit (AKMU) at NBPGR is the center of PGR Informatics activities. AKMU has evolved from a mere service providing cell (as ARIS) to a unit where PGR databases and web-based applications are developed and maintained. The unit facilitates easy access to PGR information to enhance PGR utilization. The PGR Portal, NBPGR's principal web-based information portal, was accessed from many countries with an average number of >3,500 views per month in 2018. An online application, Cryobase was developed replete with infographics and structured back-end for up-to-date management. The Cryobase was launched on NBPGR Foundation Day 2018. AKMU collaborated with NHCP to develop an online application creating a virtual herbarium with taxonomic information and 7,000 images.

9.1 PGR Informatics

9.1.1 PGR Portal: Maintenance, updating and access management of PGR applications: PGR Portal has been providing the single window to access information on the plant genetic resources conserved in the Indian genebank (Fig. 9.1). The application has been running non-stop for six years since its inception in 2012 and is well maintained for a trouble-free operation. Further stability improvements were incorporated and additional reports were made available in the Passport Information Management System. Legacy data of more than 5,000 accessions related to passport, genebank storage and characterization were updated (correction/completion) and ported to the PGR databases.

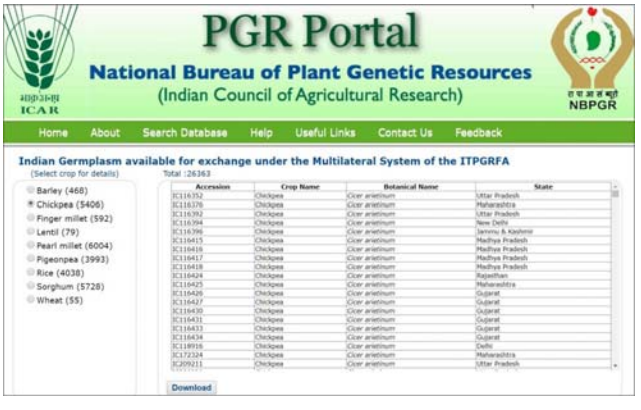


Fig. 9.1: PGR Portal hosts details of Indian germplasm available for exchange under MLS of the ITPGRFA

During 2018, PGR Portal witnessed as many as 42,296 page views indicating >100 per day. It was observed that PGR Portal has become popular among the researchers around the world since 41% users reached PGR Portal directly without any search engines. Every hit captured the attention of the users with an average session time being 5 min. The PGR Portal was accessed on mobile devices by 19% users.

9.1.2 New databases and applications: Cryobanking started at NBPGR in 1987. Currently NBPGR cryobank is the 3rd largest in the world with more than 13,000 samples (Fig. 9.2). This is a multi-crop repository unlike many crop-specific cryobanks in the world. In order to document the

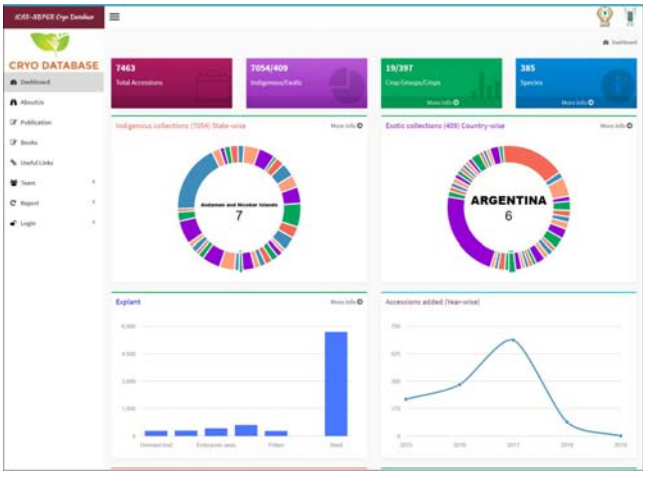


Fig. 9.2: Cryobase: web-based application to access cryobank data

status and details of cryobank, an online application Cryobase was developed replete with infographics and structured back-end for up-to-date management. The application also has information on related protocols developed and published as peer reviewed papers and books. It is expected that researchers around the world will benefit from the information. Cryobase was launched on the NBPGR Foundation Day, 2018.

9.1.3 Virtual Herbarium of the National Herbarium of Crop Plants: National Herbarium of Crop Plants (NHCP), established in 1985 at NBPGR, has 23,665 specimens representing 267 families, 1,521 genera and 4,271 species. In order to make students and researchers across the world to access the invaluable information by the click of a button, AKMU collaborated with NHCP to develop an online application creating a virtual herbarium with over 3,500 species of crop genepools complete with taxonomic information and about 7,000 images (Fig. 9.3).

Fig. 9.3: User interface of the virtual herbarium: National Herbarium of Crop Plants

9.2 PGR documentation and maintenance activities

Maintenance activities

(a) The unit managed and maintained NBPGR's webserver, database server (Table 9.1 and 9.2), security firewall, and LAN in three series with ~400 nodes connecting computers, printers and servers at NBPGR headquarters. Antivirus software licenses (console-based with 150 users) were maintained to ensure data security and safety.

(b) A new server has been commissioned in AKMU. About 25 new licenses of MS Office Professional 2016 were procured and got installed on systems of various users.

(c) Regular maintenance back-up of databases, NBPGR website and applications was carried out as per standard practices.

(d) NBPGR website was regularly updated by addition of advertisement (33), annual reports (3); application forms (3); books/manuals/ bulletins (13); circulars (41); corrigendum (6); events (6); e-publications (4); newsletter (9); purchase / rate contract (4); tender (83); training (5); news (61) and photo gallery (513)

(e) Aadhaar Enabled Biometric Attendance System (AEBAS) configured with UIDAI-RD Service was

Table 9.1: PGR data status (as on Dec 31, 2018)

Information	Activity	Additions during 2018(No. of Accessions)	Status as on 31-12-2018 (No. of Accessions)
Indigenous collections	IC number allotment	3,686	6,28,578
Exotic collections	EC number allotment	37,291	9,71,989
Genebank information	Data addition	1,922	4,39,717
Characterization data (*CRP-AB*)	Data porting	180	1,60,641
Cryobase	New database	1,139	7,382
Plant germplasm registration	Data addition	46	1,423

Table 9.2: PGR Informatics portfolio of NBPGR (Open access)

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	www.nbpgr.ernet.in:8080/climate/
Registered Crop Germplasm	www.nbpgr.ernet.in/registration/
Multi-location Evaluation Database	www.nbpgr.ernet.in/tsgi/index.htm
Digital Library of Bruchids	202.141.12.150/bruchid-library/
Network of GMO Testing Laboratories of India	gmolabs.nbpgr.ernet.in:9090/
National Genomic Resource Repository	www.nbpgr.ernet.in:8080/NGRR
Cryogene Bank	www.nbpgr.ernet.in:8080/cryobank/

initiated at NBPGR headquarters. Five new AEBAS wall-mount devices got procured and installed successfully in the office.

(f) As an additional responsibility RTI Quarterly Returns were also uploaded.

(g) A new website for "Network of GMO Testing Laboratories of India" was designed, developed and commissioned on NBPGR webserver through a third party.

NBPGR on social media

NBPGR maintains a strong presence on the social media via the official twitter account @INbpgr. During 2018, NBPGR tweeted 383 information bits which attracted as many as 80,763 impressions with an engagement rate of 5.6, total 988 link clicks, 142 retweets, 699 likes and 73 replies (Fig. 9.4). Additionally, new apps for handy and easy to use for mobile applications were also available (Fig. 9.5).

Fig. 9.4: Screenshot of the @INbpgr twitter account

Fig. 9.5: Screenshot of mobile apps genebank app and PGRMap app

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

PGR/AKMU-BUR-DEL-01.01: PGR Informatics (**S Archak**, Madhu Bala Priyadarshi (on study leave) *Rajeev Gambhir*, DP Semwal, MC Singh, J. Radhamani)

Externally Funded Projects

098-ICAR-AKMU-SA-014 (ICAR National Fellowship funded): Development and implementation of Novel Algorithms and Software Modules for PGR Informatics (**S Archak**)

REGIONAL STATION, AKOLA 10

Summary : Two explorations were undertaken during the year from Madhya Pradesh and a total of 164 accessions of medicinal, field and vegetables crops were collected. A total of 1951 accessions (132 accessions during *Rabi* 2017-18 and 1819 accessions during *Kharif 2018*) were characterized and evaluated. Crop-wise accessions characterized were safflower (68), and chickpea (64) during *Rabi* 2017-18 and little millet (1819) during *Kharif* 2018. Supplied a total of 1,325 accessions of various crop species for research purposes to 24 stakeholders within India. Multiplied and regenerated 2164 germplasm accessions of different crops. A total of 20,488 accessions of various crops/species germplasm comprising oilseeds (10,002), pulses (4,884), vegetables (1,876), potential crops (1,399), millets (1,433), wild relatives of crop plants (890) and others (4) are being maintained under medium term storage.

10.1 Exploration and collection of germplasm

First exploration programme for the collection of Madhunashni (*Gymnema sylvestre*) was undertaken from Betul, Seoni, Balaghat and Chhindwara districts of Madhya Pradesh in collaboration with ICAR-Directorate of Medicinal & Aromatic Plants Research, Anand, Gujarat during 17 - 25 February, 2018. The areas explored is situated between 21° 47'- 22° 23' latitude and 77° 34'–79° 54' longitude. A total of 27 accessions were collected from 16 collection sites in the four districts. In total, 27 accessions belonging to 09 genera and 09 species were collected. These includes 17 of Madhunashni (*Gymnema sylvestre*), *Mucuna pruriens* (01), *Hemidesmus indicus* (3), *Withania somnifera* (1), *Rauvolfia serpentina* (1), *Psorolea corylifolia* (1), *Asparagus racemosus* (1), *Datura metel* (1) and *Abrus precatorius* (1). The district-wise accessions collected includes Betul (15), Chhindwara (06), Seoni (05) and from Balaghat (01). During the exploration, out of the 17 accessions of Madhunashni (*Gymnema sylvestre*), six accessions were collected from farmer's field which were not under cultivation. One from farmer's house, two accessions from private nursery and eight accessions from natural wild forest habitat. High variability in plant types was observed. Pandervani jungle (Seoni) near Bahamn Dehi was the best hot spot for collection of natural wild species of *G. sylvestre.* (Fig. 10.1).

Second exploration programme was also undertaken from Madhya Pradesh during November 25 – December 3, 2018 for the collection of *Vigna*, cucurbits, cucumis and their wild spp., chilli and maize from Betul, Chhindwara and Hosangabad districts. A total of 139 accessions were collected from 16 collection sites in the three districts. In total, 139 accessions belonging to 09 genera were collected. These include *Zea mays* (32), *Benincasa hispida* (01), *Capsicum annum* (10), *Cucurbita maxima* (16), *Cucumis sativus* (02),

Fig. 10.1: Madhunashini (*Gymnema sylvestre*) collection A: Plant at farmers home; B: Madhunashini pods, C: Seed dehiscence from pods

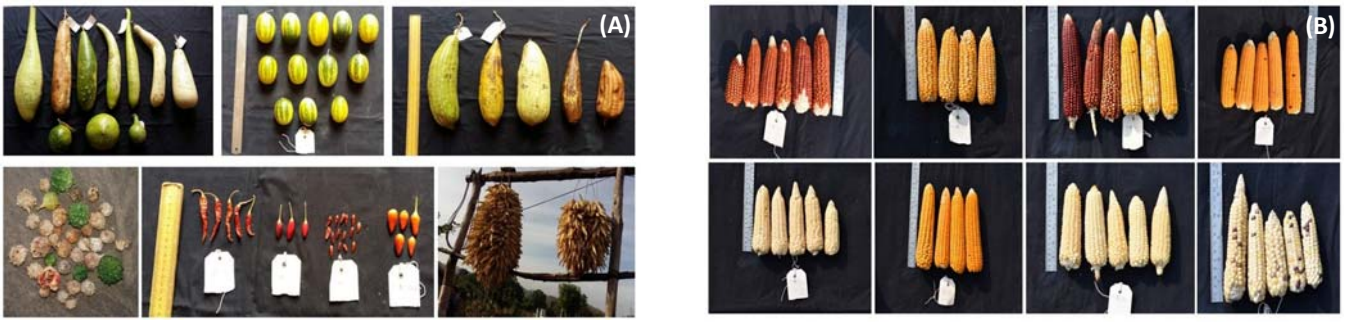


Fig. 10.2: Variability collected from Madhya Pradesh A: Various crops; B: Maize landraces

Cucumis melo spp. *agrestis* (02), *Cucumis hardwickki* (01), *Vigna mungo* (12), *V. radiata* (05), *V. unguiculata* (14), *Lagenaria siceraria* (16), *Luffa cylindrica (14), Luffa acutangula* (01), *Momordica charantia* (04), *Lablab purpureus* (07) and *Phaseolus vulgaris* (02). In total, 139 accessions were collected from 33 villages, from 10 tehsils of three districts i.e. Betul (34 accs), Chhindwara (87 accns) and Hosangabad (18 accs). High variability was observed for cob shape and kernel colour in *Zea mays*. In *Lagenaria siceraria* and *Luffa* spp. variability was observed for fruit size and shape. In *capsicum annuum*, ornamental types differing in colour, and with high pungency were collected from Tamia district. (Fig. 10.2).

10.2 Characterization and evaluation of germplasm

A total of 1951 accessions comprising 132 accessions during *Rabi* 2017-18 and 1819 accessions during *Kharif 2018* were characterized and evaluated. Crop-wise accessions characterized were safflower (64) and chickpea (68) during *Rabi* 2017-18 and little millet (1819) in *Kharif* 2018. 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).

10.2.1 *Rabi* 2017-18

Chickpea: A total of 60 accessions of chickpea were characterized and evaluated along with four checks (Vijay, PG-12, Saki and Warangal) in Augmented Block Design (ABD). Eight qualitative and seven quantitative traits were recorded. High variability was observed for days to 50% flowering, plant height, pods per plant and 100 seed weight (g). Among the qualitative traits, plant pigmentation, plant pubescence, seed shape, seed surface and seed colour exhibited high variation. Accessions ICC 506 (45 days), ICC 9586 (49 days) and ICC 1422 (52 days) revealed earliness in 50% flowering. Highest plant height was recorded in ICC 4463 (53.0 cm) and ICC 1083 (50.4 cm). For number of pods per plant ICC5434 (122.4), ICC 9002 (117.8) and ICC4495 (92.2) were promising. Seed yield per plant was highest in ICC 4948 (19.59g) followed by ICC14402 (19.21g). Promising genotypes identified for 100 seed weight were EC441747 (21.46g), ICC4918 (21.17g) and ICC 14402 (19.10g). (Fig. 10.3).

Safflower: Safflower germplasm collected from Marathwada region of Maharashtra were evaluated in *Rabi* 2017-18. A total of 64 genotypes and four checks (A1, Bhima, JLA 152, AKS 207) were evaluated in randomized block design (RBD) with two replications. Ten qualitative and seven quantitative traits were recorded. Promising accessions identified were for days to 50 % flowering: NMDC04 (38 days), NMDC19, NMDC38 and NMDC39 (48 days); number of capitula per plant: NMDC58 (85.6), NMDC57 (82.2) and NMDC28 (79.2); plant height: Bhima (102.80cm), NMDC60 (98.90cm) and AKS207 (97.20cm); number of seeds per capitula: NMDC61 (41.0), Bhima (39.0)

Fig. 10.3: Chickpea characterization-field view

Fig. 10.4: Safflower characterization-field view

and JLA152 (38.0); seed yield per plant: NMDC26 (13.48g), NMDC44 (13.28g) and NMDC46 (13.13g); for 100 seed weight: NMDC09 (3.84g), NMDC06 (3.36g) and NMDC04 (3.32g). (Fig. 10.4).

10.2.2 *Kharif* 2018

Little millet: A total of 1816 accessions of little millet received under CRP on Agro-biodiversity were raised in Augmented Block Design (ABD) with three checks (BL6, JK-8 and OLM 203) in 20 blocks. Excellent variability was recorded for days to 50% flowering, plant height, tiller number, panicle shape, panicle length and various morphological traits. The superior genotypes identified for days to 50% flowering were IC0405001 (40 days), IC0268171, IC0268172 (42 days) and for plant height: IC0482970, IC0482983, IC0280833, IC0320450, IC0404908 and IC0283293. Post-harvest observations are being recorded for all the accessions (Fig. 10.5).

10.3 Regeneration and multiplication of germplasm

A total of 2,643 accessions of different crops, *i.e.* grain amaranth (1,281), sesame (248), horse gram (193), okra (213), green gram (200), Kodo millet (105), niger (100), *Lathyrus* (126) and (177) chickpea were sown for regeneration during *kharif* and *Rabi* 2018-19. (Fig. 10.6 & Fig. 10.7)

10.4 Germplasm supply

Supplied 1,335 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 okra (416), sesame (70), foxtail millet (153), horse gram (40), winged bean (318), amaranthus (255) and pigeon pea (10). A total of 73 chickpea mini core germplasm were sent to ICAR-NBPGR, New Delhi for conservation.

10.5 Germplasm receipt

Received 2162 accessions/varieties of germplasm comprising two accessions of soybean from ICAR-NBPGR, Regional Station, Thrissur, 1816 accession of little millet from ICAR-NBPGR, New Delhi, 15 check varieties of six millets crops from PC, AICRP on Small Millets, Bengaluru and two accessions of winged bean from Indira Gandhi Agriculture University, College of Agriculture & Research Centre, Ambikapur. *Amaranthus* (104) was received from ICAR-NBPGR, RS, Bhowali and 223 accessions of linseed from ICAR-NBPGR, New Delhi.

10.6 Medium term storage of germplasm

A total of 20488 accessions of various crops/species germplasm comprising oilseeds (10002), pulses (4884), vegetables (1876), potential crops

Fig. 10.5: A: Variability in panicle shape in little millet germplasm; B: Little millet tall accession-IC0482971; C: Superior littlet millet accession IC0483405

Fig. 10.6: Horsegram regeneration-field view

Fig. 10.7: Lathyrus regeneration-Field View

(1399), millets (1433), wild relatives of crop plants (890) and others (4) are being maintained under controlled conditions in the medium term storage of the station at 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** (*w.e.f.* 01.07.2018) **N. Dikshit** (till 30.06.2018).

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,** N. Dikshit (till 30th June, 2018) 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** (*w.e.f.* 1st July, 2018), Dinesh Chand and N. Dikshit (till 30th June, 2018).

REGIONAL STATION, BHOWALI

11

Summary: Characterization/evaluation of about 330 unique landraces of various *Rabi* crops *viz.,* wheat (50), barley (50), mustard (61), lentil (100), fenugreek (18), pea (17) of Uttarakhand state was undertaken, besides characterization/ evaluation/multiplication of 1045 accessions of various *Kharif* crops. Sixty three landraces/farmers' varieties including paddy (35), finger millet (8), barnyard millet (7), foxtail millet (2), black-seeded soybean (7), horse gram (3) and linseed (1) were documented and seeds collected from parts of Pithoragarh, Bageshwar and Almora districts of Kumaon region of Uttarakhand. A total of 109 accessions of 15 crops comprising wheat, barley, coriander, fenugreek, cumin, brassica, horsegram, barnyard millet, amaranths, buckwheat, soybean, French bean, fennel, chilli and prosomillet were collected and 107 collections of WEUP (27) and fruits (80) were made including *Allium* spp, Rubus, Prunus, Ribes, Malus, Walnut etc. from the high altitude regions of district Chamoli, Uttarakhand. A total of 10 accessions of *Costus speciosus*, 01 accession of *C. pictus*, 02 accessions of *Rubus* spp., 03 accessions of *Allium roylei*, 03 accessions of *Allium conseguanum*, 03 accessions of *Plumbago zeylanica* and 02 accession of *Punica granatum* were collected from Jammu and lower hills of Himachal Pradesh region. A total of 11,266 accessions in MTS and 1,251 accessions in field gene banks are being maintained and a total of 854 accessions of various crops were supplied to different indenters. A Farmers' Field Day for paddy and an **"Awareness Camp-cum-Biodiversity Fair"** were organized. A sum of Rs. 1,26,821/- was generated from sale of planting material and other farm produce.

11.1 Exploration and germplasm collection

Four explorations were carried out during the year and 289 collections of various field and horticultural crops were made. An exploration trip was undertaken in parts of Pithoragarh, Bageshwar and Almora districts of Kumaon region of Uttarakhand under the DST funded project "Mainstreaming farmers' varieties in Himachal and Uttarakhand" from March 3-8, 2018. A total of 63 landraces/farmers' varieties including paddy (35), finger millet (8), barnyard millet (7), foxtail millet (2), black-seeded soybean (7), horse gram (3) and linseed (1) were documented and seeds collected. These accessions will be grown and characterized in on-station trails at the regional station, Bhowali to validate their uniqueness and facilitating their subsequent registration with PPV&FRA on behalf of respective farming communities. Another exploration trip was conducted in the high altitude regions of district Chamoli, Uttarakhand from May 16-27, 2018 in collaboration with ICAR-NRCSS, Ajmer. A total of 109 accessions of 15 crops comprising wheat, barley, coriander, fenugreek, cumin, brassica, horsegram, barnyard millet, amaranths, buckwheat, soybean, French bean, fennel, chilli and prosomillet were collected. Second exploration was conducted to high altitude regions of Niti Valley of district Chamoli in Uttarakhand in collaboration with ICAR-CITH Mukteshwar and 107 collections of WEUP (27) and fruits (80) were made including *Allium* spp, Rubus, Prunus, Ribes, Malus, Walnut etc. Exploration in areas of Nainital district was also conducted and collections of *Malus baccata* (08), *Chaenomeles speciosa* (02) and *Juglans regia* (04) were made. Fourth exploration was carried out at Jammu and lower hills of Himachal Pradesh region and 10 accessions of *Costus speciosus*, 01 accession of *C. pictus*, 02 accessions of *Rubus* spp., 03 accessions of *Allium roylei*, 03 accessions of *Allium conseguanum*, 03 accessions of *Plumbago zeylanica* and 02 accession of *Punica granatum* were collected. A pre-exploration survey was conducted for collection of local banana type from Pithoragarh and adjoining areas of Uttarakhand from December 3-7, 2018. During survey Bageshwar, Pithoragarh and Champawat districts were covered and total 15 accessions of fruit crops

germplasm (11 accessions of banana and 04 accessions of citrus) were collected.

11.2 Germplasm characterization and evaluation

Germplasm of *Rabi and Kharif* crops collected from various parts of Uttarakhand were characterized for different qualitative traits (Table 11.1). Also, evaluation of native lentil accessions belonging to Uttarakhand was undertaken and various qualitative and quantitative traits were documented.

11.2.1 Wheat: Fifty accessions of wheat, mostly indigenous landraces (from Uttarakhand) were characterized for various qualitative and quantitative traits. Moderate variations were recorded for most of the quantitative characters studied, maximum variations recorded for traits grain yield /plant and no. of effective tillers/plant whereas least variations were recorded for days to flowering and maturity (Table 11.2). While substantial diversity was recorded for some of the qualitative characters *viz.* Awn type, awn color and grain color (Fig. 11.1). For growth class, most of the landraces were either facultative or spring types; either erect or semi-spreading in growth habit, and predominantly with white glume colour. Better adaptation to various biotic/abiotic stresses, chapatti making quality and consumption characteristics were the important features of traditional landraces rather than yield alone.

11.2.2 Barley: Fifty accessions of barley particularly land races from Uttarakhand were characterized for various qualitative and quantitative traits. Significant diversity in barley landraces was observed. Six-rowed, four-rowed and two-rowed barley were all represented and diversity for spike shape, grain type (hulled and hulless) and grain colour have been observed (Fig. 11.2). Maximum variation was found for no. of grains per spike followed by 100 grain weight, whereas minimum was found for days to 80% maturity (Table 11.3). Barley is being consumed as human food, animal feed and also for brewing purposes. Six-rowed naked barley types are still popular among ***Bhotia*** communities of Uttarakhand hills as breakfast food in form of ***Sattu***, considered as an excellent source of complex carbohydrates

Table 11.1: Characterization and evaluation of crop accessions

S.No.	Crop	No of accessions	Characterization /evaluation
Rabi 2017-18			
1.	Wheat	50	Characterization
2.	Barley	50	Characterization
3.	Lentil	100	Evaluation & Characterization
4.	Mustard	61	Characterization
5.	Fenugreek	18	Characterization
6.	Pea	17	Characterization
Total		296	
Kharif 2018			
1.	Paddy	127	Characterization
2.	Amaranth	329	Characterization
3.	Soybean	165	Characterization and seed multiplication
4.	Maize	14	Characterization and seed multiplication
5.	Minor millets	51	Characterization and seed multiplication
6.	Perilla	34	Characterization and seed multiplication
7.	Buckwheat	9	Characterization and seed multiplication
8.	Sesame	6	Characterization and seed multiplication
9.	Horsegram	14	Characterization and seed multiplication
10.	Blackgram	7	Characterization and seed multiplication
11.	Cowpea	9	Characterization and seed multiplication
Total		765	

Fig. 11.1: Panicle and seed diversity among wheat accessions

Table 11.2: Range of variation in major quantitative traits among wheat germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Grain yield per plant	8.76	86.92	37.90	39.49
Effective tillers per plant	3.4	12.8	6.18	28.15
Days to 75% spike emergence	82	133	100.92	11.75
Days to 80% maturity	60	168	159.39	9.84
100 grain weight	2.26	9.79	4.24	24.16

Table 11.3: Range of variation in major quantitative traits among barley germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Plant height	65.6	137.4	105.82	14.53
Spike length	5.94	11.1	8.222963	14.87
No. of grains per spike	22.2	98	58.35	24.66
Days to 80% maturity	141	152	145.7	1.58
100 grain weight	1.15	5.52	3.88	20.96
Grain yield per plant	18.99	93.34	57.15558	35.8

that helps lower cholesterol levels and the risk of type-2 diabetes. The 2-rowed naked barley types are mostly used for brewing purposes.

11.2.3 Lentil: One hundred accessions including 79 pertaining to Uttarakhand were selected for analysis of quantitative traits along with nutritional parameters, and 21 landraces collected during explorations were grown for characterization. Maximum variation was found for yield traits namely grain yield per plant and 100-grain weight (Table 11.4). Seed coat colour varied from black, brown, pink, green to yellow. Nutritional analysis like iron and zinc content will be done to further shortlist the best genotypes from this area.

11.2.4 Paddy: 127 accessions of paddy, all landraces from different parts of Uttarakhand were grown for characterization and initial seed increase. The accessions included both rainfed as well as irrigated types. Considerable diversity was observed for various characters *viz.,* plant height, leaf length, no of effective tillers per plant and days to maturity (Table 11.5). Variability for hulled grain colour was also observed with range varying from yellow, brown, red, black etc (Fig. 11.3).

Fig. 11.2: Spike and seed diversity among barley accessions

Fig 11.3: Panicle and seed diversity among paddy accessions

Table 11.4: Range of variation in major quantitative traits among lentil germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Spike length	4.72	18.42	9.41	24.77
No. of grains per spike	34	66.8	47.88	15.93
Days to 80% maturity	146	158	151.66	2.18
100 grain weight	2.26	9.79	4.24	24.16
Seed yield per plant	8.76	86.92	37.90	39.49

Table 11.5: Range of variation in major quantitative traits among paddy germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Plant height (cm)	57.24	172.22	129.4	18.3
Leaf length (cm)	16.8	55.3	29.3	21.5
Leaf width (cm)	1.1	2.54	1.7	18.8
No of effective tillers	4	76.3	13.3	54.4
Days to 80% maturity	134	168	148.8	4.3
100 grain weight (g)	1	3.79	2.43	21.3
No of seeds per panicle	30.2	156.6	77.6	27.5

11.2.5 Horticultural and MA&P crops: A total 190 accessions were regenerated in field for replacement of old MTS seed material i.e. *Abelmoschus* spp. (105) and MA&P (85) and also evaluated total 120 accessions of horticultural and medicinal crops viz., Brazilian Malta (12), walnut (30), *Rubus* spp. (08), Persimmon (06) *Allium* spp. (42) and oregano (33). During exploration of Niti valley, identified two accessions of walnut with cluster bearing (>6 fruit in cluster) and intermediate lateral bearing trait. During the exploration also collected unique germplasm i.e., Pahari Jammun

(*Prunus cornuta*) and Kirol (*Prunus mira*) and all accessions are maintained at RS, Bhowali.

11.3 Germplasm conservation

11.3.1. Germplasm conservation in MTS: A total of 11,266 accessions including cereals (3345), pseudocereals (568), millets (552), pulses and legumes (3782), oilseeds (540), vegetables (1563), spices and condiments (716), medicinal and aromatic plants (180) and ornamentals (20) have been maintained in MTS module of the station (Table 11.6).

Table 11.6: Germplasm maintained in MTS facility

Crop group	Major crops	Accessions
Cereals	Wheat, barley, maize, rice	3345
Pseudocereals	Amaranths, buckwheat	568
Pulses and legumes	Lentil, common bean, soybean, rice bean, horse gram, black gram, pea	3782
Millets	Finger millet, barnyard millet, foxtail millet, proso millet	552
Oilseeds	*Brassica,* groundnut, linseed, sesame	540
Chillies	-	1203
Vegetables	Cucurbitaceous, leafy greens, okra, others	360
Spices & condiments	Coriander, fenugreek, *Perilla,* others	716
M & AP	*Ocimum*, *Datura*, lavender, others	180
Ornamentals	Tagetes	20
	Total	**11,266**

11.3.2 Germplasm conservation at Field Gene Bank: A total of 1251 accessions of different crops *viz.* fruit crops (314), flowering perennials (109), *Allium* spp. (156), arborescent plant species (178), M&AP (445), bamboosetum (38), temperate forage grasses (10) and *Hordeum bulbosum* (1) are being maintained in field gene bank of the station (Table 11.7).

Table 11.7: Germplasm maintained at FGB

Crop groups	Crop (s)	Accessions
Fruit crops	Kiwi, lemon, citrus, strawberry, apricot, pear, plum, peach, raspberry, walnut, apple, others	314
Flowering perennials	Dahlia, *Gladiolus*, *Tagetes*, others	109
Alliums spp.	-	156
Arborescent plant spp.	Indian butter tree, fig, maiden hair tree, olive, pine, pecan nut, cinnamon, others	178
M & AP	*Achillea, Artimisia, Asparagus, Calendula, Coleus*, turmeric, lemon grass, datura, lavender, lemon balm, mint, *Ocimum, Geranium*, rosemary, sage, valerian, violet digitalis, chamomile, poppy, *Aloe vera, Thyme*, Indian ginseng, others	445
Bamboosetum	Bamboos and others	38
Temperate forage grasses	-	10
Hordeum bulbosum	-	1
	Total	**1251**

11.4 Germplasm supply

A total of 2103 germplasm accessions including soybean (590), *Artemisia annua* (4), barley (15), cucumber (61), chilli (150), ricebean (18), *Centella asiatica* (1), strawberry (49), *Oreganum* (2), *Anacyclus purethrum* (1), *Saussurea costus* (2), *Gloriosa superba* (1), wheat (36), *Allium* spp (33) and amaranth (1140) were supplied based on indents received.

A total of 16,737 live plants/rooted plant/grafted plant were supplied viz., kiwi (977), strawberry (13,292), malta (956), kagazi nimboo (540), rosemerry (190), other MA&P (620), passion fruit (97) loquat (50) and ornamental plant (165) to different indentors or local farmers.

A total 36 accessions comprising of 01 accessions of *Sitairia grosvenorii*, 07 accessions of wild *Allium* species and 28 accessions of Pomegranate have been received from germplasm exchange unit, NBPGR, New Delhi and 01 accession of naked barley, 06 accessions of wild *Allium* species has been received from Division of Germplasm exploration and collection, NBPGR, New Delhi. Similarly 100 accessions of exotic soybean have been received for multiplication. However, due to severe infection of powdery mildew, the seed setting was not proper. We have also collected 14 accessions of peach, 08 accessions of nectarine and 03 accessions of walnut from NBPGR, RS, Shimla and 03 accessions each of peach and of nectarine from CITH, Srinagar. Thus, the FGB was enriched with 74 accessions of different horticultural and medicinal crops.

11.5 Main- streaming agrobiodiversity

11.5.1 "Chemotyping and molecular profiling of bioactive metabolites in *Hemidesmus indicus* and *Costus speciosus*, adapted to different phytogeographical zones & identification of candidate genes related to metabolic pathways": In *C. speciosus* standardizing propagation protocol and seed propagation is best (90-100 % germination) in comparison to rhizome cutting (60-70%) and in case of *Hemidesmus indicus* soft wood cuttings (70-85% rooting) was found best method for propagation. All collected germplasm from different geographical regions were planted in Bhowali region for further assessment of rhizome maturity, harvesting time, phyto-chemicals content (Diosgenin), rhizome production and standardization of cultivation techniques of elite genotypes.

11.5.2 "Mainstreaming farmers' varieties in Himachal and Uttarakhand": Registration proposal of total 39 landraces of different crops *viz.,* paddy (10), barnyard millet (2), fingermillet (7), foxtail millet (1), wheat (3), barley (3), lentil (2), soybean (2), blackgram (1), yellow sarson (1), horsegram (1), sesame (2), fenugreek (1) and amaranth (1) has been sent to PPVFRA for registration and is under process. Similarly 24 landraces of 6 crops *viz.,* paddy (11), wheat (4), lentil (3), Fingermillet (3), barnyard millet (2) and barley (1) are being sent for registration.

11.5.3 "Mainstreaming Agricultural Biodiversity Conservation and Utilisation in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability": Baseline survey of 45 households from Niti Valley, 51 households from Someshwar valley and 50 households from Suri-Garsyari of Tarikhet block has been completed. Different crop landraces of rainfed paddy (54), fingermillet (18), black seeded soybean (8) and horsegram (8) were sown at village Suri during *Kharif*-2018 for demonstration and seed multiplication and its subsequent distribution to interested farmers. Similarly landraces of irrigated paddy (25) were sown at Jhupulchaura village of Someshwar (Almora). FGDs for all the three sites have been conducted. Apart from that regular interaction with the farmers at the target sites is made to understand the gaps and to motivate them for cultivating their old landraces. In line with this one Farmers' Field Day on Paddy was organized at Someshwar site.

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

PGR/PGC-BHO-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of the Northern Himalayas and Adjoining Plains I.S. Bisht, (till June 30, 2018)/ Mamta Arya, (w.e.f. 01.07.2018).

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

PGR/PGC-BHO-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of field crops with emphasis on ethno botanical aspects (**Mamta Arya** (w.e.f. July 1, 2018; I S Bisht (till June 30, 2018); *P.S. Mehta* and *R. Joshi* (till Nov. 30, 2018).

PGR/PGC-BHO-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of temperate horticultural crops (**K.M. Rai**).

PGR/PGC-BHO-01.03: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species (**K.M. Rai** and Mamta Arya; A. Raina).

PGR/PGC-BHO-01.04: Strengthening benefit enhancing options of native crop diversity for sustainable food, nutrition and livelihood security of farmer households: a case study from Uttarakhand Himalayas (**I S Bisht** (till 30-06-2018), Mamta Arya; *P.S. Mehta* (Project completed).

Externally Funded Project

"Chemotyping and molecular profiling of bioactive metabolites in *Hemidesmus indicus* and *Costus speciosus*, adopted to different phytogeographical zones". **(K.M. Rai)**.

"Mainstreaming farmer's varieties in Himachal and Uttarakhand". **I.S. Bisht** (till June 30, 2018)/ **Mamta Arya** (since July 1, 2018) (for Uttarakhand).

"Mainstreaming agricultural biodiversity conservation and utilisation in agricultural sector to ensure ecosystem services and reduce vulnerability" under UNEP-GEF and Bioversity International. **I.S. Bisht** (till June 30, 2018)/**Mamta Arya** (since July 1, 2018).

BASE CENTRE, CUTTACK 12

SUMMARY: Two explorations were undertaken and 204 accessions comprising cultivated rice, *Cucumis*, *Luffa*, *Sesamum*, *Hibiscus*, *Abelmoschus,* chilli, leafy vegetable, other crops and their wild relatives were collected from Assam and Odisha. Significant germplasm collections include flood tolerant type rice viz. *Dhepa, Sonanjali*, *Harinkajali*, *Narikelbaji* and *Panisali*; sticky, scented, small slender grained and black kernel rice, hot/pungent chilli (*Futjhala*), wild *Solanum* spp, white seeded *Luffa aegyptica* etc. A total of 3596 accessions comprising cultivated rice, wild rice, *Hibiscus sabdariffa*, *Ocimum* spp, *Cucumis* spp, *Abelmoschus* spp were grown for seed multiplication and preliminary characterization and 430 accessions comprising cultivated rice (276), wild *Oryza* species (93), *Ocimum* spp. (43), *Hibiscus sabdariffa* (18) was characterized and promising genotypes were identified for different agro-morphological traits. A set of 216 accessions of cultivated rice was evaluated for salinity tolerance in controlled screening facility at ICAR-NRRI with tolerant and susceptible checks and promising genotypes were identified based on multiple scoring system. Phytochemical evaluation of *Mucuna pruriens* for L-Dopa per cent was undertaken and one black seeded accession was identified with L-Dopa content of 7.09 %. A total of 3596 accessions were grown/ vegetatively propagated for multiplication/ characterization/ evaluation. In all, 85 accessions were supplied to two ICAR institutes and 1935 accessions of cultivated rice were received from ICAR-NBPGR, New Delhi. Ethno-botanical information and indigenous traditional knowledge on different plant genetic resources were documented and 1,300 herbarium specimens were maintained.

12.1 Exploration and germplasm collection

During 2018, two explorations were undertaken for germplasm collection of multicrops including landraces of rice, sesame and sorghum, *Cucurbits, Abelmoschus*, *Vigna* including their wild relatives from Assam and parts of Odisha. A total of 204 germplasm accessions were collected. The exploration details are given in Table 12.1.

12.1.1 Exploration for germplasm collection of multi crop including other crop and wild rice: The exploration mission was undertaken for collection of multi crop including landraces of other crops and wild relatives of rice from Barpeta and Chirang districts of Assam in collaboration with ICAR-National Rice Research Institute, Cuttack, and ICAR-NBPGR, New Delhi during November 12-22, 2018. A total of 95 accessions comprising *Oryza sativa* (42), *Capsicum annum* (12), *Luffa* spp. (9),

Table 12.1: Details of exploration and germplasm collection during 2018

Crops/Species	Areas	Collaboration	Period of collection	Collection sites	No. of spp.	No. of acc
Multi crop including landraces of other crops and wild relatives of rice	Barpeta and Chirang (Assam)	ICAR-NRRI, Cuttack & ICAR-NBPGR, New Delhi	12th -22nd Nov., 2018	46	25	95
Cucurbits, *Abelmoschus*, *Vigna* including their wild relatives, sesame and sorghum	Malkangiri district (Odisha)	ICAR-IIVR, Varanasi & ICAR-IIHR, Bengaluru	5th – 14th December, 2018	67	23	109
			TOTAL	**113**	**48**	**204**

Vigna mungo (5), *Solanum* spp. (5), *Sesamum indicum* (3), *Ocimum gratissimum*(2), *Brassica rapa* (2), *Vigna unguiculata* (2) and six accessions comprising one acc each from *Oryza rufipogon*, *Ocimum sanctum*, *Coriandrum sativum*, *Hibiscus sabdariffa*, *Lens culinaris*, *Costus speciosus, Lablab purpureus* and leafy vegetable (07) were collected from Barpeta, Bongaigaon and Chirang districts of Assam. The district wise distribution of the germplasm collection was 61 accessions from Barpeta, 30 accessions from Chirang and 4 accessions from Bongaigaon. Wide range of variability for various morpho-agronomic traits such as grain type, panicle type, plant type, duration, height and adaptability was recorded among collected rice landraces. Significant germplasm collections include flood tolerant type, sticky rice, scented rice, small and slender grained rice, black rice, hot/pungent chilli (*Futjhala*- DP/DPS/BCM-2534), wild *Solanum* spp, white seeded *Luffa aegyptica* (DP/DPS/BCM-2482) etc (Fig. 12.1).

12.1.2 Trait specific germplasm collected: Five rice genotypes viz.,*Dhepa* (DP/DPS/BCM-2450), *Sonanjali* (DP/DPS/BCM-2503), *Harinkajali* (DP/DPS/BCM-2503), *Narikelbaji* (DP/DPS/BCM-2503), *Panisali* (DP/DPS/BCM-2503) collected from water logging areas were identified as donors for varietal improvement for deep water ecosystem.

12.1.3 Exploration and germplasm collection of *Cucurbits, Abelmoschus, Vigna* and their wild relatives, sesame and sorghum: The second exploration mission was undertaken for collection of Cucurbits, *Abelmoschus*, *Vigna* and their wild relatives, sesame and sorghum from tribal dominated Malkangiri district of Odisha during December 5-14, 2018 in collaboration with ICAR-IIVR, Varanasi and ICAR-IIHR, Bengaluru (Fig. 12.2). A total of 109 acc comprising of *Cucumis* spp. (40), *Luffa* spp.(14), *Trichosanthes* spp. (2), *Coccinea grandis* (2), *Diplocyclos palmatus* (3), *Abelmoschus tetraphyllus* var. *tetraphyllus* (1), *Vigna* spp. (21), *Sesamum indicum* (16), *Sorghum vulgare* (2), *Echinochloa frumentacea* (2), *Hibiscus sabdariffa* (3), and M&AP (3) such as *Zingiber zerumbet* (1), *Mucuna monosperma* (1), *Ocimum gratissimum* (1) were collected (Fig. 12.3). The major biodiversity hotspots like tribal dominated regions of Upper Bonda hills, Podia and Balimela reservoir catchment region were explored covering parts of Eastern Ghats of Odisha. A good range of variability for fruit shape, size, skin colour, stripes and spines in *Cucumis* germplasm found in different landscapes was recorded during the exploration. A wide range of variability for fruit shape and size and seed colour such as white, red, brown, grey, from in *Vigna unguiculata* and *Luffa aegyptiaca* was observed. Interactions were made with tribal inhabitants and farmers and information on traditional uses of wild *Abelmoschus, Cucumis* spp., *Coccinea grandis, Luffa aegyptiaca, Trichosanthes* spp. and *Diplocyclos palmatus* etc. used as vegetables and other utilities were collected. Thirty plant specimens were collected and preserved as herbarium materials for future research/ reference.

Fig. 12.1: Variability collected from Assam, A: Panicle type of rice; B: Grain type of rice; C: Chilli germplasm

Fig. 12.2: A: Collecting Cucumis sativus var. hardwickii from Pandripani; B: Seed variability in *Vigna unguiculata*; C: *Cucumis callosus*

12.2 Supportive research

Mangrove forest of Bhitarkanika in Odisha constitutes a specialized eco-geographical region quite distinct from inland forests. They inhabit a unique but vulnerable ecosystem harboring very rich floristic composition and occupy the second most important mangrove habitat in respect of species diversity. Therefore, an exploration conducted in Bhitarkanika during 2013 and subsequent visits the status of vegetation and land use types with dominant species composition, crown density and spatial coverage has been assessed based on the image characteristics of remote sensing satellite data (Fig. 12.4). The Indian Remote Sensing Satellite data were referred and information was updated with respect to floristic composition, canopy cover and species dominance in each category through exploration and ground truth. The multispectral imagery

Fig. 12.3: A: *Abelmoschus tetraphyllus* var. *tetraphyllus*, a wild okra, collected from Potrelu village, Malkangiri; B: A tribal Gadaba woman collects cowpea from field at Nuaguda, Malkangiri, Odisha

exhibited that the mangrove forest of Bhitarkanika have been subjected to rapid destruction and degradation due to mass encroachment for human in habitation and conversion of mangroves to scrubs, agriculture lands, aquaculture sites, mud/ tidal flats etc. In view of the importance and uniqueness of the ecosystem, a strategy has been developed for conservation and management of mangroves integrating the resource information generated from satellite data, Survey of India topographical maps and supplementary data. Five different zones each with distinct objectives, activity and management plan have been proposed. Realizing the immense economic potentiality and genetic diversity of wild gene pool such as *Oryza coarctata, Canavalia maritima, Phoenix paludosa, Vigna trilobata, Hibiscus tiliaceus, Mucuna gigantea, Cerbera odollam* etc at species and ecosystem level, the establishment of a mangrove genetic resource centre has been prioritized to act as mangrove heritage site in Eastern India.

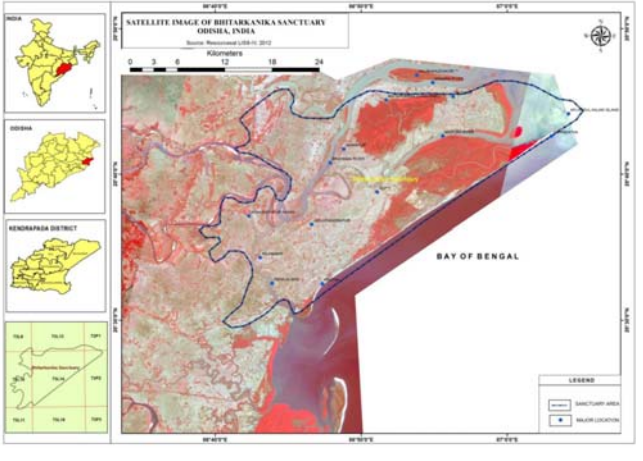


Fig.12.4: Satellite image of Bhitarkanika wildlife sanctuary

12.3 Germplasm characterization

A set of 3471 accessions comprising cultivated rice (3260), wild rice (95), *Hibiscus sabdariffa* (18), *Ocimum* spp (50), *Cucumis* spp. (28), *Abelmoschus* spp. (20) were transplanted in the experimental plot for seed multiplication and preliminary characterization. Out of these, a set of 432 accessions comprising cultivated rice (276), wild *Oryza* species (95), *Ocimum* spp. (43), *Hibiscus sabdariffa* (18) were characterized for different morpho-agronomic traits.

12.3.1 Cultivated rice: A set of 293 acc of cultivated rice germplasm was characterized for 28 agro-morphological traits in augmented block design along with six checks (*Kalajira, Panidhan, Tulsi, Ketakijoha, Jyoti, Geetanjali*). Each accession was grown in a plot size of 2.4m^2 with three rows in a spacing of 20 X 20 cm between rows and plants. The range of variability for both qualitative and quantitative traits was recorded (Table 12.2 and 12.3).

12.3.2 Wild *Oryza* species: A total of 190 accessions of wild rice germplasm received from Germplasm Conservation Division, NBPGR, New Delhi was grown for seed multiplication and 93 accessions were characterised in RBD with two replications for 20 agro-morphological traits. Each accession was maintained in three rows in a plot size of 4.05m^2 following spacing of 45x45cm between lines and plants. The range of variation for various quantitative traits is given in Table 12.4.

12.3.3 *Ocimum* germplasm: Forty-three acc of *Ocimum* spp. comprising *O. americanum* (8), *O. tenuiflorum* (9), *O. basilicum* (8), *O. citriodorum* (8), *O. gratissimum* (8) and O. *kilimandscharicum* (2) 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 genotypes are mentioned in Table 12.5.

12.3.4 *Hibiscus sabdariffa:* Eighteen accessions of *Hibiscus sabdariffa* were characterized for 33 agro-morphological and economic traits in RBD with two replications. The promising genotypes such as IC610800 for different traits viz. leaf length, leaf width, petiole length, number of fruits/plant;

Table 12.2: Range of variation in quantitative traits among cultivated rice germplasm (*276 acc*)

Traits	Range		Best check	Promising lines
	Minimum	Maximum		
Plant height (cm)	43.20 (IC847086)	157.45 (IC847222)	Kalajira (133.35)	IC847222, 847085, 847174
EBT	2.0 (IC847186)	13.5 (IC-814290)	Tulsi (9.5)	IC814290, 806969, 847237
Leaf length (cm)	20.7 (IC850077)	70.35 (IC847178)	Tulsi (57.9)	IC847178, 847226, 847086
Leaf width(cm)	0.4 (IC847096)	1.5 (IC847225)	Ketakijoha (1.10)	IC847225, 847205, 847057
Panicle length (cm)	12.0 (IC847224)	30.65 (IC847158)	Tulsi (28.8)	IC847158, 847225, 847086
Ligule length (cm)	0.35 (IC847122)	2.9 (IC847079)	Tulsi (2.65)	IC847079
Panicle wt. (g)	0.88 (EC847116)	4.92 (IC519962)	Panidhan (4.56)	IC519962
100 seed wt. (g)	1.69 (EC847087)	3.73 (EC847187)	Jyoti (2.98)	ICEC 847187, 847123

Table 12.3: Variability and frequency distribution among qualitative traits in cultivated rice germplasm (293 acc)

Traits	Descriptor states	Frequency/ (%)	Descriptor states	Frequency/(%)
Basal leaf color	Green Light P.P.	289 (98.63) 3 (1.02)	P.P. lines	1 (0.34)
Blade color	Pale green Dark green	13 (4.54) 11 (3.75)	Green	269 (91.81)
Ligule color	White	293 (100)		
Collar color	Green	293(100)		
Auricle color	Pale green	293(100)		
Internode color	Green	292 (99.66)	Light gold	1 (0.34)
Panicle type	Compact Open	31 (10.58) 2 (0.68)	Intermediate	260 (88.74)
Awning	Short & partly Absent	6 (2.05) 284 (96.93)	Long & partly	3 (1.02)
Awn color	Straw	9 (3.07)		
Apiculus color	White Straw	1 (0.34) 287 (97.95)	Purple Brown	3 (1.02) 2 (0.68)
Stigma color	White	285 (97.27)	Purple	8 (2.73)
Lemma palea color	Straw PP. furrow	281 (95.90) 4 (1.37)	Brown spot Brown	1 (0.34) 7 (2.39)
Seed coat color	White Purple	285 (97.27) 1 (0.34)	Light brown Brown	3 (1.02) 4 (1.37)

Table 12.4: Range of variation among wild rice germplasm (*Oryza nivara*)

Traits	Range	
	Min.	Max.
Plant height (cm)	47.2(W-1034)	170.78(W-983)
EBT	2.33(W-1024)	12.0(W-988)
Leaf length (cm)	22.8(W-1034)	61.5(W-998)
Leaf width(cm)	0.43(W-1024)	1.54(W-1003)
Ligule length(cm)	0.43(W-1023)	3.20(W-1014)
Panicle length (cm)	12.6(W-1040)	32.10(W-984)

IC610799 for plant height and number of leaf lobes; IC610682 for number of leaves harvest/ plant and fresh leaves yield/ plant; IC619334 for fresh calyx yield/ plant and IC610747 for 100 seed weight were identified (Table 12.6).

12.4 Germplasm evaluation

12.4.1 Evaluation of cultivated rice germplasm for salinity tolerance: A set of 216 acc of cultivated rice germplasm received from ICAR-NBPGR, New Delhi was evaluated for salinity tolerance with four checks viz. Pokkali, FL-476 (tolerant) and Pusa-44, IR-29 (susceptible) in controlled screening facility at ICAR-NRRI, Cuttack. Based on two tier scoring system, superior genotypes were identified and will be further evaluated for confirmation of the trait during *Kharif,* 2019.

12.4.2 Evaluation of L-Dopa (%) of seed samples of *Mucuna* spp.: Superior genotypes of *Mucuna pruriens* (5) collected from wild habitats of different agro-ecological zones of Odisha and grown under similar environmental conditions were analyzed for estimation of L-Dopa (%). Black coloured seeds *M. pruriens* var. *pruriens* (IC599290) showed highest L-dopa content (7.09 %) after chemical evaluation and validation of superior genotypes for four consecutive years.

12.5 Seed multiplication

A total of 3596 acc comprising cultivated rice (3260), wild *Oryza* species (190), *Ocimum* spp. (50), *Hibiscus sabdariffa* (18), *Abelmoschus* spp. (20), *Cucumis* spp. (28), *Dioscorea* spp. (18), *Costus speciosus* (4), *Hedychium* spp. (3), *Mucuna pruriens* var. *pruriens* (1), *M. pruriens* var. *utilis* (1), *Solanum lycopersicum* var. *cerasiforme* (1), *S. viarum* (1), *S. sisymbrifolium* (1), were regenerated/ vegetative propagated for seed multiplication.

12.6 Germplasm supply

A set of 85 acc of wild relatives of *Cucumis* (65) and *Abelmoschus* (20) were supplied to ICAR-IIVR, Varanasi for research purpose. Besides, seed samples of *Mucuna pruriens* (5), rhizome samples of *Costus speciosus* (4), *Hedychium* spp. (3); essential oil samples of *Ocimum* spp. (34) and

Table 12.5: Herbage yield and essential oil content of promising genotypes in *Ocimum* species

Sl.No.	Species	Highest estimation of herbage yield/plant (g)	Highest estimation of essential oil yield/ plant(ml)
1.	*Ocimum tenuiflorum*	585.07 (IC624512)	1.9 (IC624512, 599368)
2.	*O. gratissimum*	694.01 (IC599334)	2.7 (IC599334, 589184)
3.	*O. basilicum*	549.9 (IC599326)	1.8 (IC599326, 599337)
4.	*O. americanum*	495.3 (IC599329)	1.4 (IC599329, 599362)
5.	*O. kilimandscharicum*	478.9 (IC599299)	2.7 (IC599299)
6.	*O. citriodorum*	416.7 (IC624514)	2.3 (IC624514,599357)

Table 12.6: Range of variation in morpho-agronomic traits of *Hibiscus sabdariffa*

Traits	Range	
	Min.	Max.
Primary branches/plant	9.9 (IC614090)	16.0 (IC614078)
Leaf length (cm)	10.22 (IC614078)	15.03 (IC610800)
Leaf width (cm)	10.44 (IC614078)	15.86 (IC610800)
Petiole length (cm)	4.71 (IC619334)	6.67 (IC610800)
No. of leaf lobes	3.0 (IC614089)	5.0 (IC610799, IC610800)
Plant height (cm)	136.49 (IC614090)	211.22 (IC610799)
No. of leaves harvest/ plant	122.6 (IC614090)	624.2 (IC610682)
Fresh leaves yield/ plant (g)	46.82 (IC614090)	358.9 (IC610682)
Epicalyxes segment no.	9.4 (IC617967)	11.0 (IC610747)
Calyx length (cm)	2.71 (IC610800)	4.48 (IC617963)
Calyx width(cm)	1.68 (IC610799)	2.28 (IC617966)
Fresh calyx yield/plant (g)	99.2 (IC614090)	272.12(IC619334)
No. of fruits/plant	73.0 (IC624364)	172.4 (IC610800)
Seed yield/ plant	31.61(IC614090)	96.60 (IC617967)
100 dry seed weight (g)	1.48 (IC610800)	2.67 (IC610747)

powder samples of leaf and calyx of *Hibiscus sabdariffa* (17) were sent for research purpose. A total of 1935 accessions of cultivated rice were received from ICAR-NBPGR, New Delhi.

12.7 Germplasm conservation

A total of 1568 accessions comprising cultivated rice (1387), wild rice (84), *Cucumis* spp. (65), *Abelmoschus* spp. (20), *Ocimum kilimandscharicum* (2), *Ocimum gratissimum* (2), *Mucuna pruriens* var *utilis* (1), *Hibiscus panduriformis* (1), *Solanum viarum* (1), *Solanum esculentum* var. *cerasiforme* (1), *Mallotus philippensis* (2), *Abelmoschus ficulneus* (1) and *Ocimum citriodorum* (1) were deposited for long term conservation in National Gene Bank, ICAR-NBPGR, New Delhi. *Hedychium coronarium* (1), a vulnerable medicinal plant was deposited for *in-vitro* conservation.

12.8 Germplasm maintenance

A total of 591 accessions under 228 species comprising medicinal and aromatic plants (240), horticultural crops (6), tuber/aroid crops (45), *Ocimum* spp. (50), *Mucuna* spp. (2), *Hibiscus sabdariffa* (18), wild *Oryza* species (169), wild relatives of crops such as wild *Abelmoschus* (20), *Hibiscus* spp. (3), *Cucumis* spp. (28) *Solanum* spp. (3), *Costus speciosus* (4), *Hedychium* spp. (3) are being maintained in the FGB/experimental plots of the centre.

12.8.1 Maintenance of medicinal and aromatic plants: A total of 228 species of medicinal and aromatic plants comprising important plant species viz. *Zingiber zerumbet, Abelmoschus moschatus, Hedychium coronarium, H. coccineum, H. flavescens, Mucuna pruriens, M. monosperma, M. nigricans, Ocimum basilicum, O. citriodorum,*

Ocimum kilimandscharicum, O. americanum, O. tenuiflorum, O. gratissimum, Nicandra physalodes, Solanum viarum, *Argyreia nervosa, Asparagus racemosus, Bacopa monnieri, Saraca asoca, Celastrus paniculata, Centella asiatica, Corchorus capsularis, Gardenia gummifera, Hibiscus panduriformis, Hemidesmus indicus, Litsea glutinosa, Mallotus philippensis, Nyctanthes arbortristis, Oroxylum indicum, Piper longum, Plumbago rosea, Pterocarpus santalinus, Rauvolfia erpentine, Scindapsus officinalis, Stevea rebaudiana, Strychnos potatorum, Solanum sisymbrifolium, Tinospora cordifolia, Watakaka volubilis* etc have been conserved in the field gene bank of the centre.

12.8.2 Herbarium preservation: The herbarium of the centre is harbored with about 1400 voucher specimens belonging to wild relatives of crops, rare/ endangered and high valued M&AP and other economically useful plants collected from parts of Odisha, Bihar, West Bengal, Mizoram, Tripura and Manipur. The important specimens such as *Abelmoschus tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus*, *Abelmoschus crinitus*, *Abelmoschus tetraphyllus* var. *tetraphyllus, Mucuna pruriens* var. *utilis, Hedychium coronarium, Zingiber zerumbet, Hibiscus cannabinus*, *Solanum esculentum* var. *cerasiforme* etc were augmented to the herbarium.

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

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

Research Project (Code, Title, **PI,** CoPIs & *Associates***)**

PGR/EXP-BUR-CUT- 01.01- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural and horticultural crops in Odisha and adjoining regions. (**D.R. Pani**, R.C. Misra)

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

REGIONAL STATION, HYDERABAD 13

SUMMARY: A total of 51278 samples comprising of 44159 import and 7119 export samples were processed for quarantine clearance. Sixty-five phytosanitary certificates were issued. Import samples (11491) infested/infected with pests/pathogens were salvaged and released (29499) to consignees. In exports, 115 samples consisting of 12 pearlmillet (bacteria gram –ve, *Bipolaris* sp and *Fusarium* sp), 9 sorghum, 64 chickpea (Bacteria gram- ve), 24 pigeonpea (Bacteria gram –ve, *Rhizoctonia* sp. and insect infestation) and 6 groundnut (Bacteria gram- ve) were not found suitable for export, hence detained. Okra germplasm (172 accessions) was evaluated against *Okra yellow vein mosaic virus* (OYVMV) and *Okra enation leafcurl virus* (OELCV). Quarantine services were extended to 39 organizations in South India. Post-entry quarantine inspection was conducted for 6671 samples of different crops grown at PEQIA of ICRISAT (3485), AVRDC (104), private industries (2470), NBPGR field (395) and NBPGR greenhouse (217). Three collaborative explorations were undertaken and 263 accessions of various crop groups were collected. A total of 1020 accs. of different agri-horticultural crops were sown/ characterized/ evaluated during the reporting period. A total of 672 accessions of germplasm were evaluated during *Kharif* and *Rabi* 2018-2019. In addition, exploration and other vouchers of sorghum, blackgram, greengram, horsegram, pigeon pea, kenaf, okra, roselle, *Setaria glauca* and cowpea were sown for multiplication. In addition, 15 accessions of finger millet including four checks were evaluated for moisture stress tolerance during *Kharif* 2018. Under the AICRN-PC project accessions of Pillipesara (30 accs) and Amaranths (15 varieties) were characterised and evaluated during *Kharif* 2018 and *Rabi* 2018-2019 respectively. Under RKVY Project 180 accessions of various cereals, millets, pulses in both *Kharif* 2018 and *Rabi* 2018-2019. Total of 106 exploration voucher samples including cowpea, blackgram, greengram, horsegram, chillies, paddy, okra, sesame, maize and *Vigna trilobata* were multiplied and sent for long-term conservation in NGB. In addition 1061 germplasm accessions were provided to 20 SAUs/ICAR institutes against 31 indents. Resource Generated: Quarantine Services 3756860/-; Seed Health testing: 403560/-

13.1 Germplasm quarantine

A total of 51278 samples comprising 44159 import samples and 7119 export samples were received for quarantine processing. Quarantine services were extended to four international organizations, 35 public organizations (ICAR/CSIR institutes, universities/state govt. organizations) and 52 private organizations.

13.1.1 Import quarantine: A total of 44159 samples including paddy (12964); maize (23853); wheat (101), barley (218), sorghum (4248); pearl millet (142); fingermillet (696); soybean (42); sunflower (395); groundnut (405); pigeonpea (14); chickpea (226); cowpea (4); chilli (173); tomato (136); brinjal (7); bittergourd (446); cucumber (10); amaranth (7); watermelon (8); okra (61); mustard (2) and *Solanum scabrum* (1) were imported from different countries.

Interceptions

During quarantine processing, the following major pathogens were intercepted.

Maize: *Stenocarpella maydis* from South Africa, *Drechslera maydis* from Thailand; Sorghum: *Stemphylium* sp. was found from Egypt; **Bittergourd:** *Drechslera sacchari, D. setariae, Myrothecium roridum*, *Colletotrichum dematium* and *Lasiodiplodia* sp. were found from Thailand (Fig. 13.1 and 13.2).

Insect Interceptions

Pearlmillet: *Stegobium paniceum* from Kenya; **Maize:** *Sitophilus zeamais* from Thailand; **Paddy:** *Rhyzopertha* sp.; **Sorghum:** *Trogoderma granarius*

Nematode interceptions

Paddy : *Aphelenchoides besseyi* from the Philippines.

Fig. 13.1: *Colletotrichum dematium* on Bittergourd seed from Thailand

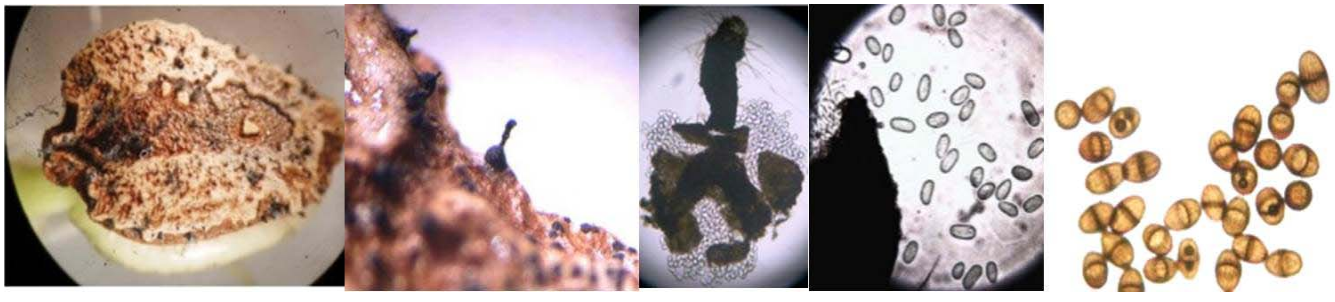


Fig. 13.2: *Lasiodiplodia* sp. on Bittergourd seed from Thailand

13.1.2 Imports processed and released: Seed samples (29,499) including paddy-12,232, maize-9,523; wheat-101, barley-218, sorghum-4250; pearl millet-176; fingermillet-696; sunflower-998; groundnut-405; pigeonpea-14; chickpea-226; cowpea-4; chilli-73; tomato-194; brinjal-7; bittergourd-285; cucumber-6; amaranth -7; squash-12; watermelon-8; okra-61; mustard-2 and *Solanum scabrum*-1 were imported from different countries after necessary mandatory treatments.

TSOP treatment

The mandatory trisodium orthophosphate treatment (10% sol) was given to the germplasm of tomato (129) and chilli (173), imported from USA, before release to the consignees.

Salvaging of imported germplasm

Total number of samples infected/infested: **11472**

Fungi: 11472; (Pathogenic-8764; saprophytes-2708); Bacteria: 09; Viruses: Nil; Nematodes: 08; Insects: 05; Weeds: Nil

Number of samples salvaged: 11472

Number of samples detained: 0

Number of samples rejected: 0

13.1.3 Export Quarantine

***Exports processed*:** Crop germplasm samples (7119) consisting of maize (4613), sorghum (878),

Table 13.1: Details of export samples received for quarantine

Exports (ICRISAT)	Number of samples		
Crop	Received	Rejected	Released
Sorghum	878	9	869
Pearl millet	334	12	322
Foxtail millet	39	0	39
Proso millet	109	0	109
Chickpea	628	64	564
Pigeonpea	222	24	198
Groundnut	296	6	290
Exports (CIMMYT)			
Maize	4613	0	4613
Grand total	7119	115	7004

pearlmillet (334), foxtail millet (39), proso millet (109), pigeonpea (222), chickpea (628) and groundnut (296) were processed for export to different countries by CIMMYT and ICRISAT, respectively. However, 115 samples consisting of 12 pearlmillet, 9 sorghum, 64 chickpea, 24 pigeonpea and 6 groundnut were not found suitable for export, hence detained (Table 13.1). In all, 65 Phytosanitary certificates were issued.

13.1.4 Post-entry Quarantine inspection: PEQ inspection of 3485 samples consisting of sorghum (906- Niger, 31-Japan, 691- Kenya); pearlmillet (1650-Niger); chickpea (202-Australia); pigeonpea (5-Niger), were conducted at PEQIA of ICRISAT.

Crop germplasm (104 samples) consisting of bittergourd (30-Thailand); Amaranthus (02-Tanzania); mustard (02- Tanzania); brinjal (03-Tanzania); tomato (55-Taiwan, 6- Tanzania) and chilli (06 -Tanzania) meant for AVRDC, grown at PEQIA of ICRISAT, was inspected. One wilt affected tomato plant was uprooted and incinerated. *Ascochyta pinodes*, *Phoma* sp., *Periconia byssoides*, *Myrothecium* sp. and *Cercospora* sp were observed on testing the tomato leaf samples, by conducting blotter test.

Groundnut samples (277- Niger) grown in the greenhouses of ICRISAT were also observed. Incidence of bacterial wilt (*Ralstonia solanacearum*) was noticed in few accessions. Harvested seed was tested against *R. solanacearum*, using ELISA and healthy seed was released.

In all, 217 samples consisting of squash (12-Egypt), bittergourd (5- Thailand) and soybean (200- USA) received from NBPGR New Delhi, grown in QGH, were inspected at different intervals and found free from pathogens and released to the consignee. However, 19 accessions of soybean did not produce any seed, hence 181 accessions only could be released.

Sunflower accessions (395) from USA, grown for PEQ growing at NBPGR RS, Hyderabad field are being inspected at regular intervals (Fig. 13.3). ELISA testing of samples suspected with *Tobacco streak virus* was completed and found that all the 42 tested samples were found infected with the virus.

Fig. 13.3: Tobacco streak virus infection in sunflower accessions from USA (Left); Enlarged view of severely infected plant (Right)

Post entry quarantine inspection of 2470 accessions consisting of maize (2155; Fig. 13.4-13.6) from South Africa (410), Zimbabwe (104), USA (568), Philippines (287), Indonesia (85), Mexico(11), Thailand (609) and Brazil (81); okra from Taiwan (65); brinjal from Thailand (49); bittergourd from Thailand (128); tomato from Vietnam (25); paddy from the Philippines (39); chilli from Taiwan (09) were inspected.

In addition, post entry quarantine supervision of proficiency testing of a consignment of paddy (3 accns.), imported from Italy, was done at the seed processing lab of M/S Bayer Bio Sciences, Hyderabad and another inspection was conducted during destruction of samples after recording observations (Table 13.2).

13.1.5 Seed health testing services: Seed health testing of 407 samples consisting of paddy-304, cauliflower-6, cabbage-1, okra-6 and maize-90, meant for export to different countries was conducted. Of these, 164 samples were rejected, the details of which are given hereunder: In paddy,

Fig. 13.4: Downy mildew affected maize plant observed during PEQ inspection of maize from South Africa in Bengaluru. Left: Tuft of oospore masses on the lower surface; Right: Chlorotic streaks on the upper surface

Fig. 13.5: Fall Army worm (*Spodoptera furgiperda*) damage on maize plant from South Africa

Fig. 13.6: Northern leaf blight (*Helminthosporium turcicum*) incidence on maize from South Africa observed during PEQ inspection

Cochliobolus geniculatus-13, *Cochliobolus carbonum*-22, *Pseudomonas syringae*-90, *Curvularia clavata*-04, *Aphelenchoides besseyi*-07, *Epicoccum nigrum*-07, *Alternaria longissima*-01and *Alternaria padwickii*-01; In maize, *Acremonium strictum*-14 and *Acremonium maydis*-02; In okra, *Fusarium oxysporum*-01 and *Cochliobolus geniculatus*-01.

Table 13.2: Post-entry quarantine inspection details

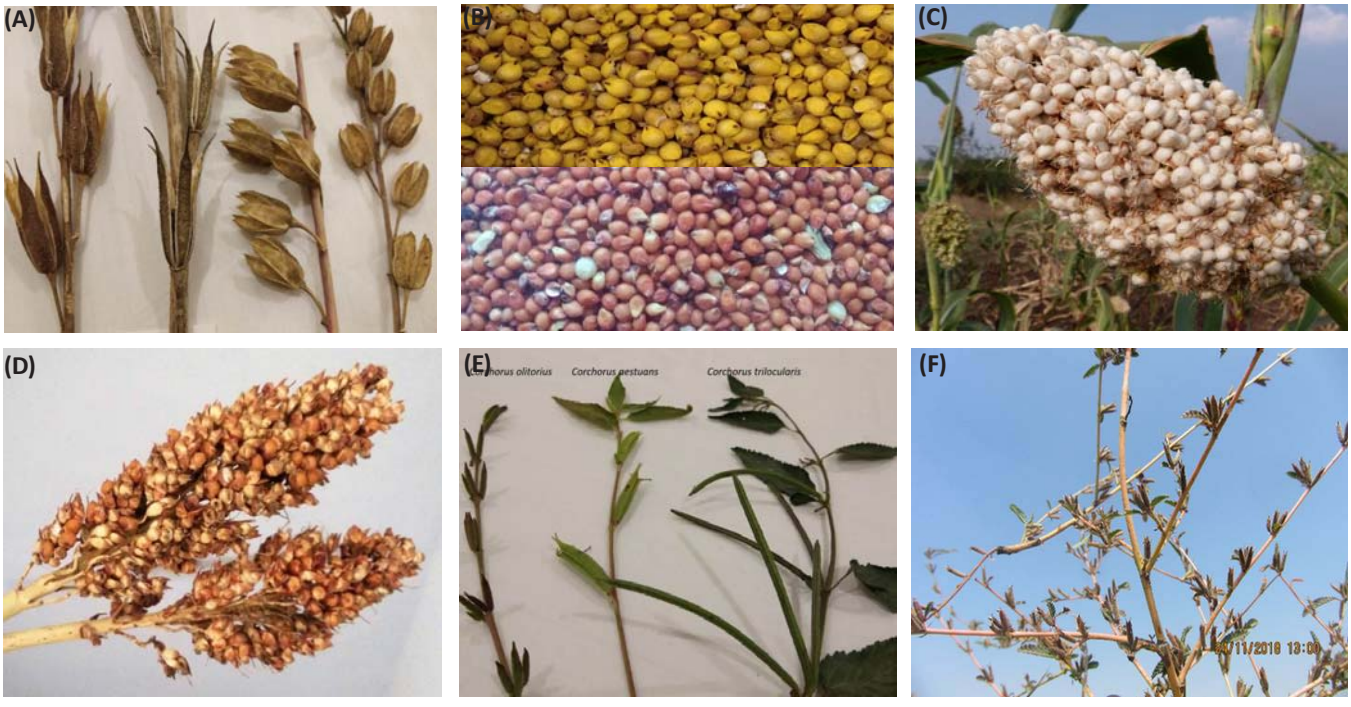
Crop	Country	Observations	Action taken
Maize	South Africa	Incidence of Fall armyworm (*Spodoptera frugiperda*), stem borer (*Chilo partellus*), downy mildew, northern leaf blight (*Helminthosporium turcicum*) was observed.	Plant samples showing rotting; plants suspected with *Maize streak virus* incidence and downy mildew affected plants were uprooted and incinerated.
	USA	*Drechslera turcicum* and *D. maydis; Phoma* sp.	Plants exhibiting rotting symptoms were uprooted and incinerated.
	Thailand	Plants suspected with *Maize streak virus* symptoms; leaf blight and downy mildew incidence	6 plants were uprooted and destroyed due to downy mildew incidence and two accessions were uprooted and destroyed due to *Drechslera maydis* incidence.
Okra	Taiwan	*Okra yellow vein mosaic virus*	Infected plants from four accessions (EC930804; 930814; 930831 and 930850) were uprooted and incinerated.

Crop	Country	Observations	Action taken
		Alternaria crassa, Colletotrichum dematium, Cercospora sp., *Myrothecium roridum; Phoma* sp., *Periconia byssoides, Stemphylium* sp. Etc	Advised fungicidal spray to the plants in two accessions (EC930821-EC930823)
Bittergourd	Thailand	42 samples showed symptoms of mosaic, mottling, crinkling, yellow spotting and narrowed leaf laminae, suspected with virus infection. ELISA tested against *Cucumber mosaic virus* (CMV), *Papaya ringspot virus* (PRSV), *Cucumber green mottle mosaic virus* (CGMMV), *Watermelon silver mottle virus* (WSMoV) and *Zucchini yellow mosaic virus* (ZYMV)	Three samples (EC939508 (AVBG1638) and EC939464 and 2 plants of THMC-35 (EC939487) were found positive to WSMoV. Infected plants were uprooted and incinerated. AVBG1308 revealed the presence of *Alternaria cucumerina.*
Chilli	Taiwan	Accession (EC929764), exhibiting leaf spots with yellow halo revealed the presence of Gram-ve non-pathogenic bacterium. Cercospora leaf spot infection noticed.	*Colletotrichum lindemuthianum* was intercepted in one chilli accession (EC929763).
Tomato	Vietnam	16 accessions showed severe leaf curl symptoms. Leaf spots *Cercospora* sp.	Advised to uproot the severely infected plants to avoid spread of the virus. *Alternaria solani, Stemphylium solani* and

13.2 Germplasm Exploration and Collection

13.2.1 Two explorations were undertaken as Lead Centre: In first one, Maize was collected from parts of Telangana (Bhadradri-Kothagudem Jayashankar-Bhoopalapally) in collaboration with Maize Research Centre, PJTSAU, Hyderabad. A total of 37 collections were made including maize (37 accs.), Oriental pickling melon (1 accn.) and *Trichosanthes cucumerina* (1 accn.). Konda reddy, Koya and Nethakan are the Tribal groups associated with the patronage of the local landraces of Maize. The landrace diversity collected in Maize include mainly *Chinna makka* and *Nakka mokkajonna.*Variability was mainly observed in plant height, stem thickness, cob shape/ size, husk character, kernel rows (no.), kernels/ row (no.), kernel colour and kernel type etc. The local landraces are generally medium statured with early maturity, mostly free from pests and diseases, resistant to moisture stress with high seed weight and good taste. The tribal groups are still cultivating these landraces because of the above reasons. In some pockets in Aswaraopeta of Bhadradri-Kothagudem district, cobs with purple kernels and some with xenia effect are also observed and collected. In the surveyed region, Cheepuruchelaka, Chennapuram and Nadimi Reddigudem are the most diversity rich pockets for Maize genetic resources.

In second exploration, Crop wild relatives and landraces of *Corchorus*, *Sorghum* and *Abelmoschus* were collected from from parts of Telangana (Medak, Nizamabad) and Maharashtra (Hingoli, Nanded) in collaboration with ICAR-CRIJAF, Kolkata and ICAR-IIMR, Hyderabad. Collections made comprised 176 samples (Fig. 13.7) including *Corchorus olitorius* (36), *C. trilocularis* (17), *C.*



13.7: A: Variation in *Abelmoschus* species from Medak; B: Pivli Jowar and Lal Jowar from Nanded; C: Dagdi sorghum from Basmat, Hingoli; D: Bhendi Jowar from Vai, Hingoli; E: E: *Corchorus* species diversity in Medak and Nizamabad; F: *Corchorus aestuans* from Medak

fascicularis (8), *C. aestuans* (23) ; *Sorghum bicolor* (23); *Abelmoschus ficulneus (17)*; *A. esculentus* (9); *A.* tetraphyllus (5); *A. manihot* (3); *Hibiscus cannabinus* (9); *H. sabdariffa* (14); *Eleusine coracana* (4); *E. indicum* (1) *Echinochloa colona* (4); *E. crus-galli* (1); *Panicum sumatrense* (1) and *Crotalaria verrucosa* (1). Sorghum landraces collected: *Mudda Jonna, Gaddi Jonna, Gali Jonna, Erra Jonna, Nalla Jonna, Letha Jonna, Vayunowka Jonna, Pivli jowar, Bhendi jowar, Pili jowar, Talki jowar, Hruda jowar, Dagdi jowar and Dukri jowar.*

13.2.2 One Exploration undertaken in collaboration with IIHR: Participated in an exploration survey of Mahaboobnagar and Adilabad districts of Telangana for the collection of Tamarind germplasm in collaboration with ICAR-IIHR Bangalore. Collected 48 accessions of Tamarind germplasm, both pods and scions, from diversity rich villages from both the districts.

13.3 Germplasm Characterization and Evaluation

A total of 1,020 accs. of different Agri-horticultural crops were sown/ characterized/ evaluated during the reporting period. A total of 672 accessions of germplasm including sesame (56), horsegram (43), blackgram (48), Italian millet (55), maize (115), brown top millet (43), field bean (48), chillies (164), brinjal (30), dolichos bean (40) and tomato (30) along with appropriate check varieties during *kharif* and*rabi* 2018-2019. In addition, exploration and other vouchers of sorghum (27 accs.), blackgram (25), greengram (9), horsegram (11), Pigeon pea (1), Kenaf (3), Okra (6), Roselle (6), *Setaria glauca* (1) and cowpea (34) were sown for multiplication. In addition, 15 accessions of finger millet including four checks were evaluated for moisture stress tolerance during *Kharif* 2018. Under the AICRN-PC project accessions of Pillipesara (30 accs) and

Fig. 13.8: Accession showing profuse pods in IC553555 and IC553524

Fig. 13.9: Promising accessions for pod and seed weight (IC249526) and seed weight (IC261257)

Amaranths (15 varieties) were characterised and evaluated during *Kharif 2018* and *Rabi* 2018-2019 respectively. Promising accessions were identified for different crops for various traits as follows:

13.3.1 Pillipesara: Clusters/plant IC550540(37.8), IC550529 (24.3); pod length (IC553594(5.2), IC553555, IC553526 IC550531(5.1); pods/plant: IC553494 (57.4), IC553524 (51.7), IC550537 (51.0); pods/cluster: IC553524 (6.8; Fig. 13.8), IC550524 (6.7); 100 seed wt IC550537 (1.07g) IC553524 (1.01g)

13.3.2 Field Bean: Pod length: IC249526 (14.0cm), IC261014 (12.6cm), IC446556 (12.4cm); 10 fresh pod weight: IC261014 (80.5g,) IC261257 (80.1g), IC249536 (78.5g); seeds/ pod: IC249536 (5.2), IC446556 (5.2): 100 seed weight: IC261257 (52.0g; Fig. 13.9), IC249526 (48.4g), IC446556 (47.8g), IC261014 (44.5g).

13.3.3 Greengram: IC598470 (*Balintapesalu*) was identified as a promising landrace for nutritional traits. *Balinta pesalu* is well known and traditionally highly popular for lactating mothers. This accession IC598470 (*Balintapesalu*), collected from Adilabad was characterized and evaluated for 26 morpho-agronomic traits and 19 biochemical parameters as per standard procedures along with three released varieties K-851, LGG-460 and ML-267. The identified accession IC598470 had significantly higher content of fat (109%), dietary fibre (130%), carbohydrates (108%), soluble sugars (132%), phenols (324%), antioxidants (119%), magnesium

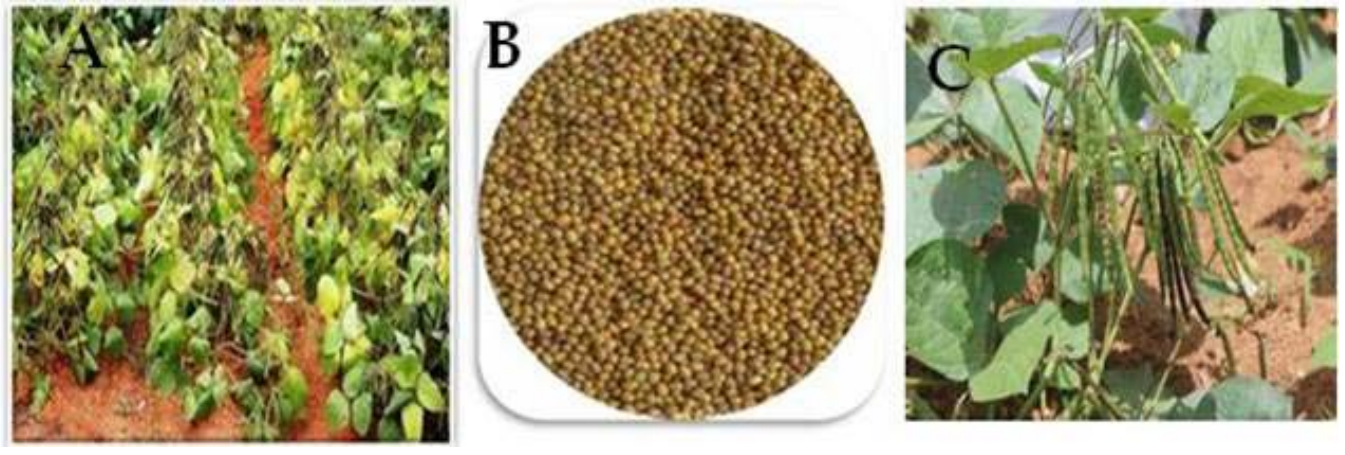


Fig. 13.10: Promising green gram (*Vigna radiata* L. Wilczek) accessions. A and B: Plant and seeds of IC598470 rich in nutritional traits with typical attractive yellow seed colour; C: Accession IC614797 promising for pod length and 100-seed weight

(104%), calcium (127%), sodium (115%), iron (160%) and copper (103%) compared to the mean of the three released varieties or even the absolute values for most of the parameters (Fig. 13.10A and B). The antioxidant activity showed 1.2 times higher than that of the released varieties. High levels of iron and calcium along with high soluble sugars validate the belief that it increases the milk production and provides the much needed energy and strength to support lactation. High levels of phenolic compounds also play a major role as an antioxidant. Further, as it had low phytate, it facilitates increased bioavailability of iron and calcium that are available in this genotype. *Balintapesalu* has highest amount of total soluble sugars (19.2%) and carbohydrates (50.7%) which make it easy to cook, impart high swell index and provide sweetness. It also has high amounts of iron (11.8 mg/ 100g) which will help in restoring sufficient quantities of blood and haemoglobin content. Another interesting observation is the presence of high amounts of phenols (109 mg/ 100g) and antioxidants (273mg/ 100 g) which after delivery impart the much needed immunity, resistance and scavenging of free radicals in the system. This accession of Green gram (IC598470) assumes significance as parental material in crop improvement programmes to enhance utilization

Fig. 13.11: Sesame germplasm showing variability for capsule length

Fig. 13.12: Brinjal fruit diversity

for developing varieties with superior nutritional traits. In addition to this promising accession for quality, another accession IC614797 was identified to be promising for pod length and 100 seed weight (Fig. 13.10C).

13.3.4 Sesame: Days to 50% flowering: IC004981 (35.3) IC014082 (35.3) IC131607 (35.3) IC132167 (35.3) IC081563 (35.3); capsules per plant: IC013878 (115.6) IC132167 (111.6) IC131936 (99.6); capsule length: IC110221 (3.92; Fig. 13.11) IC073518 (3.82)

13.3.5 Brinjal: Plant height: IC112341 (92.0) IC112741 (82.0), IC136258 (86.0); plant spread: IC112315 (119.00cm), IC136309 (111.00cm): primary branches: IC136268 (8.0), IC136308 (8.0); fruit diversity (Fig. 13.12): fruit length: IC136177 (16.3cm), IC112741(16.0cm), IC136251 (15.3cm); fruit breadth: IC136366 (8.0cm).

13.3.6 Pigeonpea: Under RKVY Project 180 accessions of various cereals, millets, pulses especially pigeonpea (Fig. 13.13) in both *Kharif* 2018 and *Rabi* 2018-2019 are under characterization and evaluation.

Fig. 13.13: Seed variability in pigeonpea

13.3.7 Brown top millet: Plant height: IC617956 (111.7 cm), IC613558 (110.0); basal tillers: IC613546 (13.0), IC617955 (13.0), IC617958 (12.70; inflor. length (cm): IC613549 (17.8), IC613546 (17.7), IC617953 (17.7); seed yield/ plant (g): IC617952 (39.2), IC613555 (36.7), IC613559 (34.5).

13.3.8 Italian Millet: Plant height: IC308936 (196.7cm), IC438725 (185.3cm), IC308934 (176.7cm); panicle length: IC308936 (38.3cm), IC308939 (32.0cm); seed yield/ plant: IC436863 (63.4g); days to flowering: IC308861 (49.0), IC283688 (51.0).

13.3.9 Maize: Ear length IC336412 (17.6cm); Days to silking IC332069 (42.0), IC332070-1 (42.0); Days to tasselling: IC332069 (37.0), IC332070-1 (38.0)

13.3.10 Chillies: Plant height: IC362013 (72.7cm), IC561736 (70.7cm), IC561661 (69.0cm), IC561737 (69.0cm); fruit length: IC561653 (12.6cm), IC561736 (11.6cm), IC561730 (11.5cm), IC561714 (11.0cm); 25 dry fruit weight: IC561686 (39.0g), IC561613 (37.8g), IC561736 (37.5g), IC561615 (36.3g); days to flowering: IC561688 (62.0), IC561632 (63.0), IC561670 (66.0), IC344650 (66.0).

13.3.11 Evaluation of okra germplasm against biotic stresses: Okra germplasm (172 accessions) was evaluated for the second season against *Okra yellow vein mosaic virus* (OYVMV) and *Okra enation leafcurl virus* (OELCV). Final scoring was taken for all the accessions, sown at two different dates of sowing, and percent disease index was calculated. Promising accessions against YVMV: 5 (<10.0 PDI), promising accessions against OELCV: 11 (0 PDI); 38 (<10.0 PDI). Additionally, screening for root-knot nematode (*Meloidogyne incognita*) resistance in okra (81) comprising cultivated *A. esculentus* (24) and inter-specific derivatives obtained from wild *Abelmoschus* spp. (42) was done under pot culture conditions. All the accessions were found susceptible. Five accessions C2741gr-5, C2741gr-6, C2741gr-19, C2741mizo-8 and C2106mizo-20 found resistant in a preliminary screening are under advanced screening to confirm the resistance.

13.4 Germplasm conservation

13.4.1 Germplasm sent to NGB: A total of 106 exploration voucher samples including cowpea (12), blackgram (12), greengram (7), horsegram (2), chillies (31), paddy (13), Okra (1), Sesame (21) and Maize (7 accn.) and *Vigna trilobata* (4) were multiplied and sent for long-term conservation in NGB.

13.4.2 Germplasm shared with NAGS: Germplasm shared with NAGS: Maize germplasm (37) collected during a collaborative exploration survey with two sets were shared with ICAR-IIMR and ANGRAU, Hyderabad. In addition, shared multiplied germplasm (112 accessions) of sorghum, finger millet, pearl millet, little millet, barnyard millet, pigeonpea with RKVY project partners.

13.4.3 Medium Term Module: Germplasm (450) comprising voucher samples from explorations (278), and multiplied germplasm of pillipesara (30), brown top millet (37), and pulses (107) were added to the MTM at the station. Germination and seedling vigour was tested in 800 accessions comprising blackgram, greengram, horsegram, stored in the medium term storage module for over 10 years.

13.5 Germplasm supply

Germplasm accessions (1,061) were provided to various SAUs/ICAR institutes including of pillipesara (30), sesame (39), chillies (213), blackgram (230), brinjal (50), tomato (270), dolichos bean (48), greengram (175 accs), finger millet (3), Italian millet (3). In addition, shared multiplied germplasm (112 accessions) of sorghum, finger millet, pearl millet, little millet, barnyard millet, pigeonpea with RKVY project partners. In addition 32 samples of seed diversity in various millets and pulses were sent to ICAR NBPGR, New Delhi for display during the Krishi Unnati Mela, IARI March 2018.

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**)

Research Project (Code, Title, **PI,** CoPIs & *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, SK Chakrabarty, N Sivaraj, Prasanna Holajjer and *Babu Abraham*)

PGR/PQR-BUR-HYD-01.02: Post-entry quarantine processing of imported germplasm (**SK Chakrabarty**, K Anitha, B Sarath Babu, Prasanna Holajjer 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)**

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 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*)

Externally Funded Projects

- Agri-biodiversity of Telangana: Inventorization and documentation for posterity and sustainable management of crop genetic resources. (**SR Pandravada**, N Sivaraj, Kamala Venkateswaran, B Sarath Babu).
- In - situ Management of Indigenous Crop Diversity through Community Managed Seed Systems for Value Addition and Improved Market Access for Climate Resilience in Rainfed High Altitude Tribal Areas (**B Sarath Babu, N Sivaraj**, SR Pandravada, Kamala Venkateswaran, K Anitha, SK Chakrabarty, P Pranusha**).**
- Genetic resource assessment, *in-situ on-farm* conservation and impact of banana waste as a feed for animals in North-East region of India (**N Sivaraj**).

REGIONAL STATION, JODHPUR

14

SUMMARY: Two explorations were conducted during the year 2018. In first exploration, a total of 133 accessions of *Vigna* species (21), cucurbits (33), sesame (08), clusterbean (23), pearlmillet (24), sorghum (02), cotton (02) and crop wild relatives (10) of cucurbits and cotton were collected. In second exploration 42 accessions representing significant diversity in *Chlorophytum* spp. (25), *Aloevera* (8), *Gymnema sylvestre* (3), *Cymbopogon flexuosus* (2), *Asparagus racemosus* (1), *Vetiver zizanoides* (1) and two unique landraces of *Eleusine coracana* were collected. In *Chlorophytum,* three species were collected representing significant diversity *viz. C. borivilianum* (21), *C. tuberosum* (3) and *C. comosum*. During *Kharif* 2018, 360 accessions of different crops including cluster bean (100 acc.), mungbean (80 acc.), mothbean (110 acc.) and Cowpea (70 acc.) were evaluated. Grain yield of early maturing (50 days) bold seeded genotype IC39289-P4 of mungbean has further been verified as 14 q/ha in first picking of pods and 13 q/ha in second picking of pods. An early maturing (53 days) mothbean accession IC 120963-$P_{2,}$ identified earlier was reconfirmed this year also. The performance of guar accession IC47564-P7 has been further verified that yielded 27.85 q/ha of grain in a large plot size of 12m^2 at line to line and plant to plant distances of 20 and 10 cm, respectively. Another vegetable type guar accession IC432117-P7 had also been verified that yielded 22% higher green pods yield than best check Pusa Navbahar. Three accessions of methi i) early maturing (93 days), ii) having huge foliage and iii) having small seed with high aroma, identified earlier, were reconfirmed for the traits. Accession of mothbean IC16218 was verified for its genetic resistance to *Cercospora* leaf spot disease. Accession of cowpea (C-720) re-verified for insect resistance. Two different accessions of ber i.e. stoneless ber and another one for fruit fly resistance identified earlier was reconfirmed. Accession of cowpea with early maturity (45 days) developed following single plant selection was verified. The 776 accessions of germplasm of horticultural plants are being maintained as live plants in the fields. The 38600 accessions of agri-horticultural crops are being conserved at the station either being maintained as live plants in the field gene bank or seeds being conserved in the MTS facility.

14.1 Exploration and germplasm collection

In collaboration with ICAR-DMAPR, Anand, an exploration for collection of landraces of Safed musli and *Aloe vera* from Dang forest of Gujarat and Maharashtra (Fig. 14.1A) were undertaken from July 16-25, 2018 after first rainfall in the region. A total of 42 accessions representing significant genetic diversity in *Chlorophytum* spp. (25 acc.), *Aloe vera* (8 acc.), *Gymnema sylvestre* (3 acc.), *Cymbopogon flexuosus* (2 acc.), *Asparagus racemosus* (1acc.), *Vetiver zizanoides* (1 acc.) and two unique landraces of *Eleusine coracana* were collected. In *Chlorophytum* three species were collected (Fig. 14.1B) representing significant diversity *viz., C. borivilianum* (21), *C. tuberosum* (3) and *C. comosum* (1). The collected 25 accessions of Safed musli represent the diverse landraces having peculiar geographical and other economic advantage to the local farmers.

Fig. 14.1: A: Germplasm collection sites in Gujarat & Maharastra; B: *Chlorophytum* collection

Second exploration was carried out for collection of *Vigna* species, cucurbits and millets from western Rajasthan including Barmer, Jalore and Jaisalmer districts from October 5-13, 2018 at the time of harvesting of *Kharif* season crops in the interior rural parts of desert areas. A total of 133 accessions [(*Vigna* species (21), cucurbits (33),

sesame (08), cluster bean (23), pearl millet (24), sorghum (02), cotton (02) and crop wild relatives (10)] representing significant diversity were collected by method of random sampling of plants, pods, fruits from farmer's field or bulk from farmer's seed storage units. Crop wild relatives and crop progenitors belonging to diverse crops *viz., Momordica balsamina, Abelmoschus tuberculatus, Trichosanthus cucumerina, Cucumis maderaspatanus*, wild *Cyamopsis tetragonoloba*, wild *Vigna* were also collected (Fig. 14.2).

14.2 Evaluation of germplasm during *Kharif*

During *Kharif* 2018, the accessions of cluster bean (100), mungbean (80), mothbean (110) and cowpea (70) were evaluated following Augmented Block Design in most cases and RCBD in some cases. Promising accessions were identified for different traits.

14.2.1 Evaluation of guar (*Cyamopsis tetragonoloba*) germplasm: Hundred accessions of guar (100) were evaluated for the traits of agronomical importance and disease resistance. Some of the accessions were identified to be superior in terms of yield, number of clusters per plant and number of pods per cluster. Performance of guar accession IC47564-P7 has been further verified that yielded 27.85 q/ha of grain in a large plot size of 12 m^2 at line to line and plant to plant distances of 20 and 10 cm, respectively. Another vegetable type guar accession IC432117-P7 was also verified that yielded 22% higher green pods yield than best check Pusa Navbahar.

14.2.2 Evaluation of mothbean (*Vigna acconitifolia):* Mothbean (110 acc.) were evaluated during *Kharif* 2018 for traits of agronomic importance. Some of the accessions have been identified to be higher yielding having large seed size. Early maturing accession IC120963-P_2 (53 days) identified during previous with high yield potential was confirmed. Two accessions of mothbean IC36786 and IC37822 were reconfirmed for their inbuilt resistance to crinkle virus disease under field conditions. Accession of mothbean IC 16218 was verified for its genetic resistance to cercospora leaf spot disease

14.2.3 Evaluation of mungbean (*Vigna radiata*) and cowpea germplasm: Eighty accessions each of mungbean (80) and cowpea were evaluated for agronomical traits in augmented block design. Bold seeded accession with high yield potential of mungbean and cowpea were identified. Early maturing accession IC39289-P_4 of mungbean (50 days) with 14 q/ha bold seed (6 to 6.5 gm/ 100 seed weight) was identified. After first picking at 50 days, it flowered again and in next 20 days it further yielded 13 q/ha of grain yield. It had huge biomass also. A cowpea accession developed through single plant selection that matures in 45 days, has further been verified.

14.2.4 Evaluation of ber (*Ziziphus mauritiana*) germplasm: Ber germplasm were evaluated during

Fig. 14.2: Collections from Rajasthan. A: Collection of *Cucumis maderaspatnum,* wild species of cucurbits; B: Variability of cucurbits collected from western Rajasthan; C: Collection of *Momordica balsamina*; wild relative of *Momordica*

four consecutive *Rabi* seasons from 2014 to 2017, specially targetting traits of agronomical and genetical importance in fruits. A promising ber genotype IC0625849 was observed with a unique trait *i.e.,* the stone part of the fruit was absent and small, soft and shriveled edible seeds were present, therefore this landrace was named as stoneless ber (Fig. 14.3). In all other accessions the large sized stone was present. It was observed that 97-99 % part of the fruit of the IC0625849 was made up of edible fleshy pulp. While in other accessions only 10 to 40 % part of the fruit was made up of edible pulp and rest of the part (60-90 %) of the fruit is made up of stone that is inedible. The highest pulp:stone ratio was noted in IC0625849 and it was recorded as high as 100 per cent, while the least pulp: stone ratio was recorded in IC0625848 among the studied germplasm. Complete absence of stone in stoneless ber could be useful in breeding programme for development of ber fruit cultivars with stoneless fruits.

14.3 Germplasm conservation

The 38235 accessions of agri-horticultural crops are being conserved at the station, either being maintained as live plants in the field gene bank or seeds being conserved in the MTS facilities.

In MTS, seeds of a total of 36410 accessions of cereals & millets (14964), legumes (14221), plants of economic importance (1027), medicinal plants (583), horticultural crops (2916), fiber and fodder plants (514), and other crop species 2183 are being maintained in MTS.

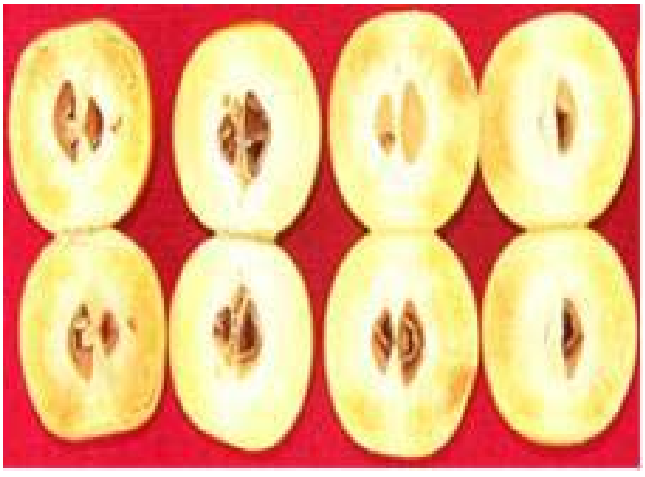


Fig. 14.3: Split stoneless fruit of accession IC625849

14.4 Germplasm supplied

A total of 1036 accessions of various crop species *viz*., mothbean (307), mungbean (15), pearlmillet (55), guar (448), cowpea (245), sesame (11) and chickpea (5) were supplied to indenters under MTA.

Table 14.1: Germplasm of different crop species being maintained in the field gene bank

S. No.	Crop/ taxa group	Number	
		Crop/ taxa	Accession
1.	Fruits	26	263
2.	Ornamentals	10	53
3.	Oil yielding plants	06	212
4.	Medicinal & Aromatic plants	39	148
5.	Multipurpose trees	17	44
6.	Fiber yielding plants	01	08
7.	Forage grasses	05	14
8.	Others	09	10
	Total	**113**	**752**

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

PGR/GEV-BUR-JOD-01.00- Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in arid and semi arid regions. (**Om Vir Singh**)

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

PGR/GEV-BUR-JOD-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of field crops in arid and semi-arid regions. (**Om Vir Singh**, Kartar Singh and Neelam Shekhawat).

PGR/GEV-BUR-JOD-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of horticultural crops in arid and semi-arid regions. (**Om Vir Singh**, Neelam Shekhawat and Kartar Singh)

REGIONAL STATION, RANCHI 15

SUMMARY: One exploration programme was undertaken during 2018 from Banka, Jamui and Gaya districts of Bihar to collect vegetable genetic resources. A total of 239 accessions of vegetable crops collected from the region. During the period, accessions of jackfruit and bael were characterized for agro-morphological attributes to identify superior accessions. Preliminary evaluation of tamarind accessions revealed significant diversity for fruit yield attributing traits. Horticultural crops (617) and medicinal plant (300) are being conserved in field gene bank. During the period under report, *Macrotyloma uniflorum* (157) and *Phaseolus vulgaris* (609) are multiplied for LTS. Two PGR awareness workshops cum biodiversity fair were organized in Simdega and Khunti districts of Jharkhand. A germplasm field day for horsegram (*Macrotyloma uniflorum* L.) and a one day workshop on "Utilization of Plant Genetic Resources (PGRs) Towards Doubling Farmers' Income" was organized.

15.1 Exploration and germplasm collection

15.1.1 Exploration for vegetable crops: An exploration to collect vegetable germplasm was undertaken from 18-27 December, 2018 in collaboration with ICAR-IIVR, Varanasi. During the exploration, a total of 239 accessions was collected from three districts of Bihar namely Banka, Jamui and Gaya. These germplasm belonging to family *Cucurbitaceae*, *Fabaceae*, *Solanaceae*, *Malvaceae*, *Amaranthaceae*, *Apiaceae* and *Beassicaceae* (Fig. 15.1A). Major collections were: *Luffa* (75), *Benincasa* (11), *Cucurbita* (19), *Lagenaria* (33), *Momordica* (26) and others. Maximum diversity was found for pumpkin fruit size in the region (Fig. 15.1B).

15.2 Gemplasm evaluation, characterization and multiplication

15.2.1 Maize evaluation: A total of 43 Maize accessions collected from Chhatisgarh in 2017 were evaluated for grain yield attributing trait and performance were geo-referenced to identify trait specific hot spots in the explored region (Fig. 15.2A).

15.2.2 Horticultural crop evaluation: A total of 134 bael accessions were evaluated for 8 economically important attributes and the population found most diverse for fruit weight followed by pulp weight. Out of 246 accessions of jackfruit conserved in field gene bank at the station, fruits developed in a total of 168 accessions during

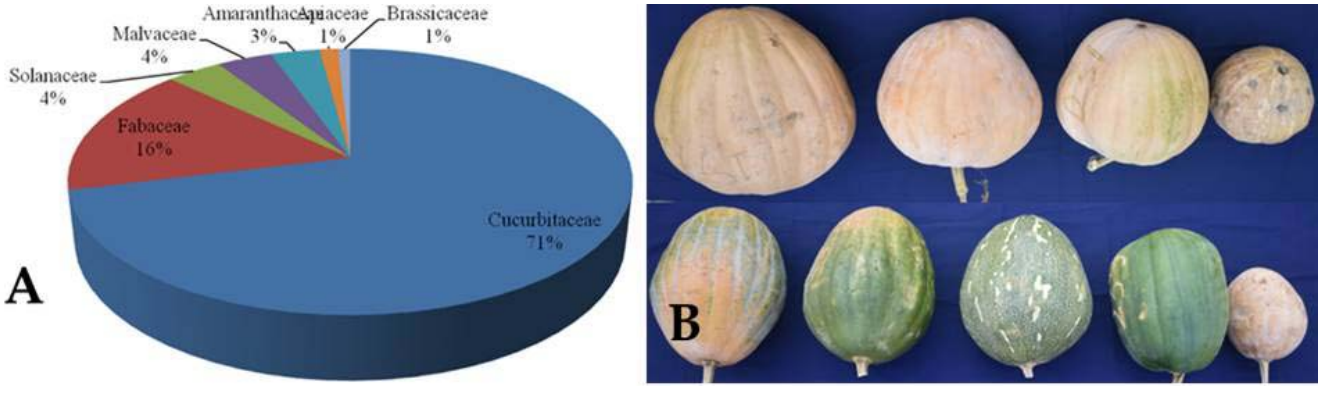


Fig. 15.1: A: Family-wise distribution of collected accessions from Bihar; B: Fruit diversity from the collected pumpkin accessions

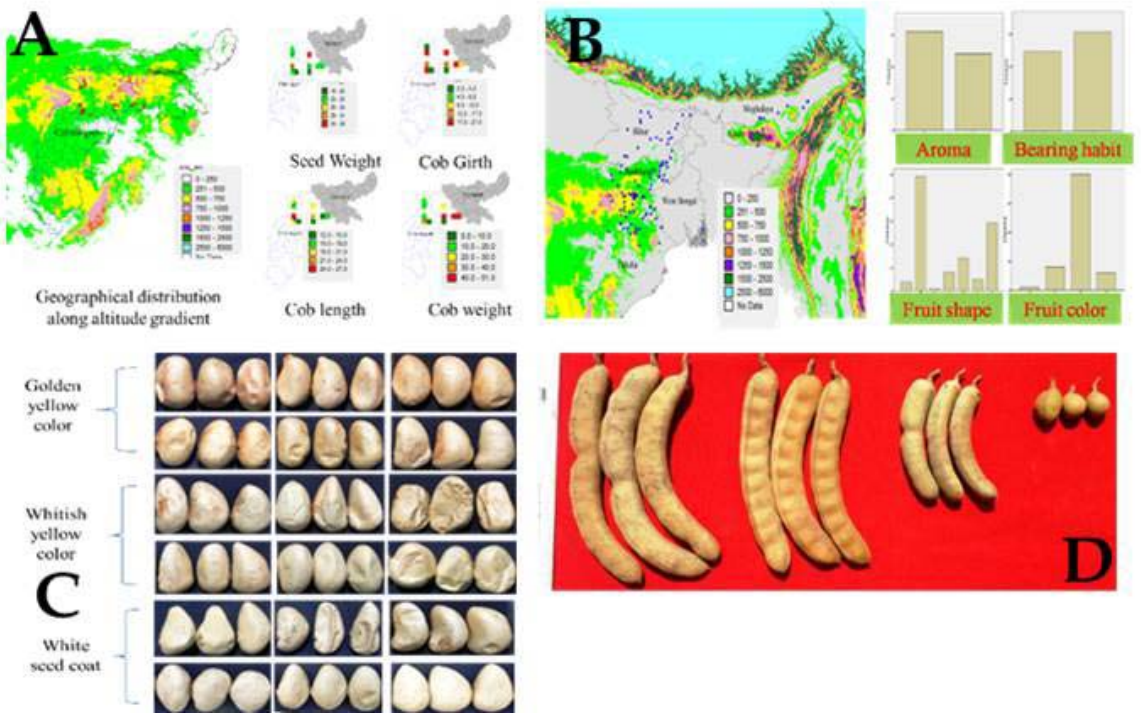


Fig. 15.2: A: Geo-reference of maize accessions for grain yield; B: Evaluation of jackfruit for agro-morphological traits; C: Diversity of seed morphology in jackfruit; D: Fruit diversity in tamarind

summer. These accessions were characterized for agro-morphological attributes that revealed significant diversity for fruit yield and quality attributes (Fig. 15.2B & C). During 2018 a total of 72 accessions of tamarind out of 102 accessions conserved in field gene bank found bearing fruit significantly. Preliminary evaluation of these accessions revealed broad spectrum diversity for fruit length, fruit girth and number of seed per fruit. Particularly, accessions IC209896 (13) and IC594356 (1) identified unique as having maximum and minimum seed per fruit, respectively (Fig. 15.2D). Thus both the accessions are stable in their uniqueness.

15.2.3 Germplasm multiplication and maintenance: A total of 617 acc. of fruit/ vegetable/ natural dye yielding plants are being conserved in field gene bank of the station (Table 15.1). 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 157 accessions of *Macrotyloma uniflorum* and 609 accessions of *Phaseolus vulgaris* are being multiplied at the station for LTS.

Table 15.1: 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

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. (**SK Bishnoi** till July 7, 2018, **SB Choudhary** w.e.f July 8, 2018)

Research Projects (Project Code, Title**, PI**, CoPIs and *Associates***)**

Project-1 (PGR/PGC-BUR-RAN-01.01): Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agriculture crops, their wild relatives and economic species including medicinal plants (**SK Bishnoi** till July 7, 2018, **SB Choudhary** w.e.f July 8, 2018; SB Choudhary till July 7, 2018 and AK Gupta)

Project-2 (PGR/PGC-BUR-RAN-01.02): Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of horticultural crops and perennial medicinal plants (**SB Choudhary**; SK Bishnoi (till July 7, 2018) and AK Gupta).

REGIONAL STATION, SHILLONG 16

SUMMARY: Two exploration trips were conducted in Khasi Hills and Garo Hills of Meghalaya in which 92 accessions of different crops were collected. A total of 1427 accessions of agri-horticultural crop germplasm comprising maize (690), rice (414), *Coix* (65), buckwheat (60), black gram (11), chilli (115) and mustard (72) are maintained. In addition to these crops, in field gene bank (FGB) banana (45), ginger & turmeric (450), *Colocasia* (77), *Dioscorea* (30), and fruit crops like *citrus* (10) and guava (7), and M&APs are also being maintained. A total of 101 accessions of various crops including rice (30), *Flemingia procumbens* (27), maize (33), *Coix* (06), buckwheat (3), *Alpinia galanga* (1), and *Trichosanthes* (1) were supplied to indenters as per MTA. The Regional Station participated in two workshops organised by NBPGR New Delhi in Assam and Meghalaya. The station also conducted two farmers training in Ri-Bhoi (Meghalaya) and Dima Hasao (Assam).

16.1 Germplasm exploration

An exploration was undertaken covering three districts of Meghalaya i.e East Khasi Hills, East Garo Hills and West Khasi Hills during March 16-20, 2018 in collaboration with ICAR-Research Complex for NEH Region. A total of fifteen diverse wild *Musa* germplasm was collected belonging to the species *Musa acuminata* (11) and *Musa balbisiana* (4). Among the three districts, East Khasi Hills was observed to be more diverse for *Musa* germplasm (Fig. 16.1).

Another exploration was conducted in South Garo Hills district and adjoining areas in West Garo Hills of Meghalaya from Nov. 21-30, 2018, covering South Garo Hills and West Garo Hills districts. A total of 77 germplasm samples of field and horticultural crops were collected. The collected crops included rice (28), maize (9), pseudo-cereals and minor millets (6) *viz. Coix* (2), foxtail-millet (2), sorghum (1) and small-millet (1), vegetables (9) *viz.* chilli (4), okra (1), brinjal (2), *Luffa* sp. (2), pulses /grain legumes (3) *viz*. soybean (1), pigeon pea (1) and rice bean (1), tuber/bulbs, rhizomatous (6) such as *Colocasia* (1), *Alocasia* (1), *Allium tuberosum* (1), turmeric (1) and ginger (2), *Citrus* spp. (11) and other crops (5) like sesame, leafy mustard, *Gossypium arboreum* and *Corchorus*. Additionally, two local visits to Dima Hasao (Assam) and Tuensang (Nagaland) were made and small sized cucurbit pumpkin was collected from Dima Hasao (Fig. 16.2A, B). From Tuensang (Nagaland), female tubers, fruits and seed samples of *Momordica subangulata* subsp. *subangulata* were collected (Fig. 16.2C, D). This species was first reported from India during 2015 by NBPGR which has great potential as vegetable crop.

Fig. 16.1: *Musa* germplasm collection. A: Wild diploid *Musa* sp. collected from East Khasi Hills; B: Seed dispersal of *Musa puspanjaliea*; C: Collected seeds of *Musa puspanjaliea* (L) and *Ensete glaucum* (R)

Fig. 16.2: Collections from Assam and Nagaland. A and B: Small sized Pumpkin collected from Haflong, Dima Hasao (Assam); C and D: Fruits and seeds of *Momordica subangulata* subsp. *Subangulata* collected from Tuensang (Nagaland)

16.2 Germplasm characterization

16.2.1 Characterization of ginger germplasm

Sixty ginger accessions conserved in Field Gene Bank were evaluated in ABD for various agro-morphological traits (Fig. 16.3A). Accessions SR9028, SR9033 and SR9031 recorded highest for traits like number-of-suckers (25), cormel-weight (1000g) and mother-rhizome-weight (90g), respectively.

16.2.2 Characterization of *Flemingia procumbens* (sohphlang) germplasm

Twenty-seven accessions of *Flemingia procumbens* collected during November, 2017 were multiplied and evaluated (Fig. 16.3B). Superior accession were identified for various traits plant-cover (IC0627406, 59 cm), 50%-flowering (IC0627421, 140 days), tuber-length (IC0627414, IC0627425, 12.5 cm), tuber-width (IC0627418, IC0627419, 3cm) and single-tuber-weight (IC0627401, IC0627415, 30g).

16.2.3 Characterization of buckwheat germplasm

Sixty accessions of buckwheat were evaluated for different agro-morphological traits (Fig. 16.4A). Accession IC107216 recorded highest for plant height (123cm), similarly IC13145 for number-of-primary-branches (9), IC37306 for 1000-seed-weight (33.2g). Buckwheat germplasm were also assessed for some physiological parameters like high transpiration-rate stomatal-conductance and photosynthetic-rate, where IC37305 and IC37306 showed higher transpiration-rate while IC18225 and IC13411 showed high stomatal-conductance and photosynthetic-rate, respectively.

Fig. 16.3: A: Different species of *Zingiberaceae*; B: *Flemingia procumbens* in flowering stage

Fig. 16.4: Seed variability. A: Buckwheat; B: Ricebean

16.2.4 Characterization of rice bean germplasm

A total of 118 rice bean accessions was evaluated for different agro-morphological traits (Fig. 16.4B). Accessions RB90, RSR/NSP-18-67 and JPRH/15-004 recorded highest for number-of-primary-branches/plant (15), number-of-seeds/pod (12), and 100-seed-weight (20.74g), respectively.

16.3 Germplasm regeneration/maintenance and conservation

A total of 1427 accessions of agri-horticultural crop germplasm comprising maize (690), rice (414), *Coix* (65), buckwheat (60), black gram (11), chilli (115) and mustard (72) were maintained. In addition to these crops, in field gene bank (FGB) banana (45), ginger & turmeric (450), *Colocasia* (77), *Dioscorea* (30), and fruit crops crops like *Citrus* (10), guava (7) and M&APs are also being maintained (Fig. 16.5).

Fig. 16.5: Variability in *Dioscorea*.

16.4 Germplasm supply/receipt

A total of 101 accessions of various crops including rice (30), *Coix* (06), maize (33), buckwheat (03), *Alpinia* sp. (1) and *Flemingia procumbens* (27) were supplied to indenters as part of national supply. Twenty-seven herbarium samples of *Flemingia procumbens* were also deposited at NHCP, ICAR-NBPGR, New Delhi as reference collection for taxonomic studies and teaching. Three hundred and thirty-two accessions of different crops were received from various Institutes and Organizations either for regeneration and multiplication or allotment of IC numbers. One hundred and fifty accessions of different crops including rice, maize, *coix*, millet, amaranth, vegetable crops etc. which were collected during November, 2018 from Garo Hills District of Meghalaya were also received for regeneration and multiplication.

Ongoing projects

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** w.e.f. July 8, 2018, **AK Mishra** July 7, 2018)

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** w.e.f. July 8, 2018, **AK Mishra** till July 7, 2018 and S Hajong)

PGR/PGC-BUR-SHL-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of horticultural crops (chilli, ginger, turmeric, yams, taros, citrus, banana and passion fruit) and their wild relatives. (**S Hajong** and Harish GD, AK Mishra till July 7, 2018)

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 w.e.f. July 8, 2018, AK Mishra** till July 7, 2018 and S Hajong)

Externally Funded Projects

Study on nutraceutical properties, genetic variability analysis and agro-technique development of the edible Aroids from Borail Hill Range of Assam, India. (**Harish GD**)

Collection, Taxonomy, molecular characterization and conservation of *Musa* germplasm from North-Eastern Region (NER) of India. (**Harish GD** and S Hajong)**.**

REGIONAL STATION, SHIMLA 17

SUMMARY: Two explorations were undertaken to collect germplasm of different agri-horticultural crops from different parts of Himachal Pradesh and Jammu & Kashmir. A total of 192 accessions comprising of cereals (105), millets (6), pseudocereals (14), pulses (35), oilseeds (6), vegetables (18), spices (6) and other crops (2) were collected. During germplasm exploration and collection, diversity was recorded for various traits such as seed shape, size, colour and plant types. As far as germplasm introduction is concerned, 178 accessions of ricebean were introduced from gene bank of Genetic Resources Centre NARO, Japan. A total of 1,765 germplasm accessions was characterized and evaluated for elite traits of interest. Remarkable variability was observed for different agro-morphological traits. In grain amaranth, 24 promising accessions were identified for six important agronomic traits *viz*., IC38758 (early maturing, 120 days), IC38758, IC583640-1 (plant height, 112 cm and 150 cm), IC38378 (seed yield/plant, 216.6g). In buckwheat, IC202266, IC24300, NIC 8817 and EC125940 were found promising for no. of inflorescence/plant, days to maturity, seed yield/plant, and 1000-seed weight. In French bean, IC037168, EC755297 and Barrot2 showed high no. of seeds/pod and no. of pods/plant, respectively. While in pea, EC838139, EC838196, P2262, P2350, 6619/P3586, P3685, NC64085 and IC411719 showed superiority for days to maturity, pod length, no. of pods/plant, no. of clusters/plant, no. of seeds/pod, and field resistance to powdery mildew respectively. Likewise in horticultural crops, a total of 124 germplasm accessions comprising of apple (24), apricot (15), plum (10), peach (26) and walnut (49) were characterized and evaluated for various pomological traits.

17.1 Germplasm exploration and collection

17.1.1 Germplasm exploration: Two explorations were undertaken to collect germplasm of agri-horticultural crops from different parts of Himachal Pradesh and Jammu & Kashmir. A total of 192 accessions comprising of cereals (105), millets (6), pseudocereals (14), pulses (35), oilseed (6), vegetables (18), spices (6) and others (2) were explored from Lahaul & Spiti, Nyoma and Kishtwar regions (Fig. 17.1). A wide range of genetic diversity was observed in the collected germplasm accessions, such as variability in french bean collections with respect to grain size, shape and color.

Fig. 17.1: Germplasm collection from diversity rich sites of Nyoma region of J&K

17.1.2 Germplasm Introduction: A total of 178 accessions of ricebean were introduced from the gene bank of Genetic Resources Centre NARO, Japan.

17.2 Germplasm characterization and evaluation of field crops

17.2.1 Assessment of genetic variability of field crops: A total of 1765 accessions comprising french bean, adzuki bean, grain amaranth, buckwheat, chenopod, ricebean was sown during *Kharif* 2018 and pea in *Rabi* 2017-18, along with standard checks in Augmented Block Design (ABD) (Table 17.1). Observations were recorded as per the minimal descriptor developed by NBPGR for various agro-morphological traits and significant variability was observed among the germplasm

Table 17.1: Germplasm characterization and evaluation of field crops

Crop	Accessions	Checks
French bean	226	PLB-10-1, PLB-14-1, Triloki, Kailash, Baspa, Jawala
Grain amaranth	359	Durga, PRA-2, Annapurna, PRA-3
Buckwheat	286	PRB-1, Himpriya, VL-7, Shimla B-1
Chenopod	97	EC-507741, NIC-22503, PRC-9801, IC415477
Adzuki bean	42	Totru local, HPU-51
Ricebean	183	PRR1, PRR2, RBL1, RBL6, VRB3
Pea	572	Arkel, Azad Pea, DMR-11, DMR-7, HFP-4, IC279125, Super Linkon
Total accessions	**1,765**	

Table 17.2: Promising accessions identified for important agro-morphological traits

Character	Range	Mean±SE	CV%	Promising accessions
French bean				
Days to flowering	32-143	57.69±1.35	35.19	EC755305, JCR2108, EC755321, EC 755326
Pod length (cm)	4.4-21.1	12.51±0.16	18.98	EC894826, EC894828, IC010900, IC 037144
No. of pods/plant	2-26.5	14.77±0.36	36.83	Barrot2, EC755297, EC021752, EC 018896
No. of seeds/pod	3.3-8.5	5.62±0.07	17.53	IC037168, EC755297, EC 024598, EC 025502
100-seed wt (g)	4.14-178.42	28.79±1.11	58.18	EC755290 , EC894821, EC024947 , IC018179
Days to maturity	71-222	110.81±1.96	26.56	EC755378, EC755379, EC755305, IC037145
Seed yield/plt (g)	1.33-154.38	23.75±1.03	65.42	EC894821 , EC755290 , EC024947 , MS1
Grain Amaranth				
Days to flowering	44-112	89.19±0.69	14.60	IC38758, IC583640-1, IC38161, IC38149, IC38161
Stem thicknes (mm)	10.03-39.83	21.46±0.20	17.44	IC107118 , EC146541 , EC146537, EC150191
Plant height (cm)	120.1-298.5	226.62± 1.89	15.77	IC583629, EC150187, IC583009, IC38758, IC583640-1
Days to maturity	112-174	161±0.65	7.65	IC38758, EC150195, EC150190 , EC150194
Seed yield/plant (g)	6.71-216.67	54.89±1.34	46.15	IC38378, IC38166, IC38376, IC38232
1000-seed wt. (g)	0.4-1	0.72±0.01	14.07	IC38432, IC107509, EC12336, EC146533
Buckwheat				
Days to flowering	29-75	49.39±0.68	23.31	IC024300, IC202266, IC274430, IC280340
No. of primary branches/plant	1.3-8.8	3.73±0.09	41.60	NIC 8824, NIC 22584, IC36805, IC49670
No. of infl./plant	6-51.33	20.51±0.54	44.70	IC 202266, IC024300, IC26583, IC447693
Plant height (cm)	41.9-241.2	109.2±2.06	31.89	IC16556, IC582976, IC583594, IC423489
Days to maturity	80-144	112.71±0.81	12.16	IC 024300, IC26584, IC13140, IC26755
No. of seeds/infl.	1.3-13.6	4.82±0.14	49.2	IC024300, NIC8817, IC447694, IC540857

Character	Range	Mean±SE	CV%	Promising accessions
Seed yield/plant (g)	0.22-10.59	2.04±0.11	87.38	IC024300, NIC8817, IC447694, EC125940
1000-seed wt. (g)	11.7-38.5	19.27±0.22	19.39	EC125940, IC423485, NC 64051, NC58513, IC26600
Chenopod				
Days to flowering	41-130	83.11±1.59	18.89	IC 013420, IC258254, IC258253, NIC22496
Leaf length (cm)	1.5-21.4	12.89±0.27	20.82	IC599554, IC611820, IC582940, IC313278
Leaf width (cm)	0.8-20.5	10.19±0.33	31.75	IC599554, IC611820, NIC 22494, IC599552
Infl. length (cm)	26.8-71.4	39.99±0.83	20.56	IC599555, IC258253, NIC22491, IC258331
Plant height (cm)	115.5-299.7	230.87±5.39	23.00	IC031420, IC583623, NIC22502, IC341703
Days to maturity	98-179	140.01±1.79	12.60	NIC22506, NIC22489, IC013420, IC599555
Seed yield/plant (g)	4.38-47.52	22.41±0.97	42.72	IC108819, NIC22493, IC328877, IC109193
1000-seed wt. (g)	0.1-1.25	0.81±0.03	30.56	NIC22493, IC415477, IC341703
Rice bean				
Pod length (cm)	7.8-13.35	10.95±0.07	8.47	SKMRB 2, SKMRB1, LRB290, LRB306
No. of seeds/pod	6-9.66	7.65±0.05	8.74	LRB476, LRB 34, LRB40, IC524084
Days to maturity	148-216	168.99±0.75	6.03	PRR(NL) 2017-2, PRR2007-1, IC 528983, PS/JCR 2
Seed yield/plant (g)	3.3-56.3	35.31±0.50	19.29	IC563940, IC504070, SKMRB2, LRB476
100-seed weight (g)	5.14-12.46	7.60±0.08	14.34	SKMRB2, IC568980, IC 563940, SKMRB1
Adzuki bean				
No. of clusters/plant	10.5-29	17.01±0.80	29.44	EC340253, EC340251, EC 340267, EC340285
No. of pods/plant	27-67.5	42.49±1.51	22.16	EC340253, EC340254, EC 340267, EC340284
No. of seeds/pod	6-11	9.48±0.15	10.11	EC341939, EC340271, EC 000377, EC340253
Days to maturity	90-124	101.1±1.28	7.89	EC120460, EC36973-A, EC 080850, EC 057959
100-seed wt (g)	7.52-14.9	11.09±0.29	16.46	EC340271, EC340213, EC 340276, EC8707
Pea				
Days to flowering	56-150	96.27±0.70	17.29	P2140, P2279, P2266, P2122
No. of clusters/plant	2.0-30.3	13.96±0.28	48.11	6619/P3586, P3469, P3685, 6609/3577
Pod length (cm)	2.6-9.4	6.01±0.04	17.43	P2262, P3287, P2350, P3106
No. of pods/plant	3-51.6	22.33±0.47	50.46	6619/P3586, P3685, P3699, 6320/P3308
No. of seeds/pod	2.3-7.6	5.01±0.04	19.94	NC64085, IC382756, EC838168, P2381
Days to maturity	151-196	166.69±0.48	6.93	EC838139, EC838196, EC838198, IC413441
100-seed wt (g)	4.4-24.8	13.05±0.15	27.56	P2262, IC381541, NC60948, P3173

Fig. 17.2: Agri-horticultural crops evaluated. A: Amaranth accession IC583640-1 identified for plant height; B: Buckwheat accession IC24300 identified for early flowering & maturity; C: Ricebean accession PRR2007 NL-1 identified for early maturity.

accessions. Promising germplasm for various traits were identified for different traits were shown in Table 17.2 and Fig. 17.2.

17.2.2 Evaluation of F_5 derivatives in grain amaranth: 228 derivatives of F_5 cross of VL44 x PLP-1 were evaluated along with their parental cultivars for important traits. An average seed yield/plant varied among derivatives ranging from 13.10 to 137.11 g, Infl. length (42.1-72.1cm) and plant height (119.1-275.4 cm). Maturity time was also observed less in some of the derivatives as compare to their parents and other ruling check varieties. The overall performance revealed transgression for some of the important agro-morphological traits (Table 17.3).

17.2.3 Screening common bean germplasm against white mould & anthracnose: French bean (250) were screened against white mould (*Sclerotinia sclerotiorum*) and anthracnose (*Collectotricum lindemuthianum* race 87) under controlled conditions. Following accessions showed different disease reaction and grouped into various classes using rating scale. Out of 250 accessions, six accessions *viz*., IC280353, IC278744, IC278709, IC278734, EC271528, EC271554 and IC278704, IC210544, IC279989, IC278734, EC271576, EC286075, EC286080, EC286068, EC285583, EC285581, EC284246 found resistant against white mould and anthracnose respectively. Accession, IC-278734 conferred resistant against both the pathogens. These genotypes could be promising donors for the induction of resistance against the pathogen into susceptible French bean cultivars.

17.2.4 Assessment of genetic variability of horticultural crops: In horticultural crops, apple (24), apricot (15), plum (10), peach (26) and walnut (49) were characterized and evaluated for various pomological traits, which resulted into the identification of following accessions carrying important pomological traits (Table 17.4 and Fig. 17.3).

17.3 Germplasm conservation

17.3.1 Germplasm sent to LTS: A total of 741 accessions of various crops comprising of pea (252), lentil (148), amaranth (119), adzuki bean (30), rice bean (74), french bean (41), buckwheat (33),

Table 17.3: Agro-morphological evaluation of F_5 derivatives of grain amaranth

Character	Mean±SE			Range			CV %		
	P_1	P_2	F_5	P_1	P_2	F_5	P_1	P_2	F_5
Days to 50% flowering	84.1± 0.31	61.1± 0.35	58.50± 0.13	82-85	59-63	53-66	1.18	1.80	3.44
Stem thickness (mm)	25.48± 0.75	23.02± 0.69	21.55± 0.19	21.9-27.8	21.19-28.31	12.62-29.54	9.31	9.52	13.17
Plant height (cm)	252.1± 6.32	211.3± 4.39	202.0± 1.53	221.2-279.5	193.1-230.7	119.1-275.4	7.93	6.57	11.41
Infl. length (cm)	15.7± 1.38	11.08± 0.41	57.05± 0.41	10.4-24.5	9.2-12.4	42.1-72.1	27.80	11.79	10.78
Days to 80% maturity	150±0.21	143.4± 0.34	140.5± 0.33	149-151	141-145	131-177	0.44	0.75	3.54
Seed yield/ plant (g)	90.99±11.3	87.25±12.6	64.6±1.59	49.5-143	30.42-161	13.1-137.11	39.09	45.64	37.10
1000-seed wt. (g)	0.79±0.01	0.70±0.01	0.71±0.01	0.75-0.80	0.7-0 .75	0.1-0.9	1.99	2.24	11.42
10 ml seed wt.(g)	8.12±0.02	8.04±0.74	7.50±0.02	8.05-8.21	7.93-8.11	6.17-8.14	0.81	0.74	3.97
Seed yield (g /plot)	197.4± 19.4	227.8± 28.2	155.56± 4.5	123.31-315	82.61-332.21	22.14-365.11	31.11	39.09	43.21

Table 17.4: Promising accessions identified for important pomological characters

Crop	Character	Range	Mean ± SE	CV %	Promising accessions
Apple	Days to fruit harvest	98-137	116±1.95	8.22	EC43973, EC331125
	Fruit wt. (g)	44.29-168.07	96.32±6.42	32.66	EC115704, EC202706
	TSS %	7.50-17.00	11.29±0.51	22.38	EC311125, Cherry Gala
	Fruit firmness (lbs)	7.60-24.80	17.87±0.85	23.44	Golden 792, IC558073
	Total sugar	4.98-12.20	7.69±0.49	31.47	EC513662, EC28449
	Juiciness	High			EC513662, EC349921
Apricot	Days to fruit harvest	71-93	79.47±1.60	7.78	IC584510, EC539003
	Fruit length (mm)	29.75-54.68	79.47±2.05	18.29	EC552703, EC174901
	Fruit width (mm)	30.43-54.05	43.44±1.79	15.94	EC552703, EC174901
	Fruit weight (g)	22.20-86.82	50.41±5.37	41.28	EC539003, EC174901
	Stone length (mm)	11.33-21.46	16.76±0.64	14.98	IC584510, IC158065
	Stone width (mm)	4.39-14.25	11.25±0.60	20.71	IC22037, IC584510
	Stone weight (g)	0.80-3.80	2.43±0.22	35.19	A-3, EC174901
	TSS %	10.10-19.20	14.42± 0.65	17.51	Kaisha, A-3, EC39003
	Fruit-stone wt ratio	11.04-47.07	21.90±2.29	40.48	EC174901, IC558083

Crop	Character	Range	Mean ± SE	CV %	Promising accessions
Plum	Days to fruit harvest	72-111	90.62±3.27	13.00	EC34050, Frier
	Fruit length (mm)	27.20-49.43	35.20±1.97	20.17	IC566139, IC349972
	Fruit width (mm)	26.69-46.03	35.05±1.66	17.11	IC566139, IC349972
	Fruit wt. (g)	13.90-67.68	31.23±4.31	49.71	Frier, Kala Amritsari
	TSS %	12.40-19.40	14.44±0.54	13.52	IC349972, IC20085
	Stone weight (g)	0.60-2.62	1.18±0.17	51.33	IC566139, EC34050
	Fruit to stone ratio	16.11-59.85	31.96±3.60	40.66	IC566139, EC382626
	Total phenol content	52.25-228.94	143.78		IC55306, Kala Amritsari
Peach	Days to fruit harvest	74-140	98.19±4.71	19.20	EC468324, EC280769
	Fruit length (mm)	38.36-74.70	56.58±2.15	15.22	EC198817, EC552665
	Fruit width (mm)	44.18-65.13	56.11±1.31	9.32	EC198817, EC284453
	Fruit wt. (g)	72.49-172.60	105.94±6.86	25.90	EC198817, EC468324
	Stone length (mm)	23.08-44.12	33.72±1.57	18.67	EC552643, EC312408
	Stone width (mm)	19.10-30.70	23.77±0.82	13.77	EC552643, EC174084
	Stone wt. (g)	4.59-13.60	8.20±0.70	34.13	EC174084, IC439929
	Fruit-stone wt ratio	8.03-21.69	13.83±1.06	30.57	EC174084, EC198817
	TSS %	6.30-13.90	10.71±0.56	20.86	EC552640, EC468324,
Walnut	Days to nut harvest	135-161	145.00±0.97	4.66	IC20117, IC27442
	Nut length (mm)	26.66-45.48	32.53±0.57	12.19	IC14618, IC20070
	Nut width (mm)	22.74-33.22	28.16±0.31	7.77	IC19369, IC15379
	Nut wt. (g)	4.96-15.45	8.34±0.35	29.17	IC027482, IC20070
	Kernel wt. (g)	0.79-5.33	2.58±0.13	35.13	IC14618, EC24507

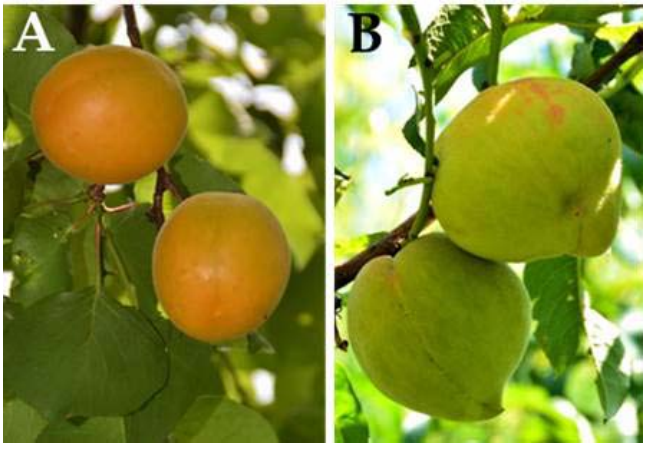


Fig. 17.3: Horticultural crop evaluation. A: Early type apricot accession (EC539003); B: Peach accession EC198817 early type.

chickpea (26) and chenopod (18) were sent to the National Gene Bank for long term storage.

17.3.2 Medium term storage: A total of 12,565 accessions of various seed crops are being conserved in MTS.

17.3.3 Field gene bank: A total of 1,023 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.

17.3.4 Establishment of community seed bank: One community seed bank (CSB) was established

Table 17.5: .Status of MTS at RS Shimla

Crop	No of acc.	Crop	No of acc.	Crop	No of acc.
French bean	4353	Foxtail millet	278	Soybean	144
Amaranth	3270	Chickpea	258	Paddy	108
Buckwheat	1000	Cowpea	228	Barnyard millet	71
Pea	705	Chenopod	199	Meetha karela	42
Wheat	642	Adzuki bean	169	Urdbean	30
Finger millet	410	Proso millet	160	*Cuphea*	16
Ricebean	332	Horse gram	150	**Total**	**12565**

Table 17.6: Status of FGB at RS Shimla

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

at Dhangyra, village in District Mandi of Himachal Pradesh under DST funded project. Seeds of pulses (French bean, pea, mash), amaranth and red rice were purchased from farmers of various villages and kept in the CSB (Fig. 17.4) at Dhangyra village, to strengthening the informal seed exchange system among the marginal farmers. Besides, about 22 local landraces were distributed among

Fig. 17.4: DST funded Community seed bank established at Dhangyra, HP

29 progressive farmers of different villages namely Baggi, Sathmala, Talaw and Haribehna of block Gopalpur and Sarkaghat of Mandi District of Himachal Pradesh.

17.4 Germplasm supply

Germplasm comprising 542 seed samples of agricultural crops and 410 scion wood of fruit crops were supplied to researchers/indenters across the country. **Seed crops**: chenopod (50), kidney bean (195), buckwheat (130), amaranth (52), pea (115); **Bud sticks/ scion woods:** apple (225), apricot (25), persimmon (50), grapes (110).

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

PGR/GEV/BUR/SHM-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of North Western Himalayan region (**Mohar Singh)**

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, Badal Singh on study leave w.e.f. 18/06/2018 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**, Badal Singh on study leave w.e.f 18/06/2018, Rahul and Narender Negi)

Externally funded projects:

Collection, mapping, evaluation and conservation for sustainable utilization of plant genetic resources of cold desert region of India. (**SM Sultan**, Mohar Singh)

Understanding the impact and response of glacier retreating on floristic diversity and societal livelihoods at naradu glacier in Kinnaur district of Himachal Pradesh. (**Mohar Singh**)

Mainstreaming of farmer varieties in Uttarakhand & Himachal Pradesh. (**Mohar Singh** and Rahul)

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. (Badal Singh upto June 18, 2018, Rahul and Narender Negi)

Integrated genomic strategy for accelerating domestication of rice bean (**Mohar Singh**)

REGIONAL STATION, SRINAGAR 18

SUMMARY: Three exploration and germplasm collection programmes were conducted in different areas of Jammu & Kashmir including first time explored far-flung and remote areas in Kishtwar district of Jammu province and Lolab valley in Kupwara district of Kashmir in collaboration with NBPGR-RS, Shimla and ICAR-NRC, SS Ajmer. A total of 151 valuable germplasm accessions of cultivated crops and crop wild relatives were collected during these programmes. 316 accessions comprising of wheat (209) and barley (107) were characterized for their agro-morphological traits as per the minimal descriptors during *rabi* 2017-18 under rain fed conditions and based on different traits promising genotypes were identified. Besides, 34 common bean genotypes were evaluated for resistance to fungal diseases during *kharif* 2018. 106 accessions of collected/multiplied multi-crop germplasm have been conserved in NGB under LTS. 108 germplasm accessions of different crops were supplied to different indenters for research purpose. Two "PGR/Farmer Rights Awareness Camp cum Biodiversity Fairs", one at village Kathalan Karewa Shadab, District Shopian, Kashmir and another at village Akchamal, District Kargil, Ladakh were organized under TSP programme during the period under report.

18.1 Exploration and germplasm collection

18.1.1 Exploration and germplasm collection of *Aegilops tauschii*: 14 diverse germplasm of *Aegilops tauschii* ssp. *tauschii* (Tausch's goatgrass or rough-spike hard grass), currently considered the most important CWR gene resource for wheat improvement were collected (Fig. 18.1) from different areas situated at an altitude of 1591-1842m in Srinagar and Budgam districts including Dachigam National Park and Chrar-e-Sharief. The accessions varied in spike length, color, spikelet number and length of rachis internodes.

18.1.2 Multi-crop collections including maize (early maturing and waxy types): 88 multi-crop germplasm accessions belonging to 22 taxa including CWR were collected during exploration undertaken in collaboration with ICAR-NBPGR RS Shimla from different areas, mostly remote of Kishtwar district of Jammu province of Jammu & Kashmir state including first time explored areas of Sarthal, Dachan, Nagini and upper regions of

Fig. 18.1: *Aegilops tauschii* ssp. *tauschii* growing under natural conditions in Budgam area and mature spikes with spikelets

Gulabgarh area of Padder valley like Massu and Narhal. Altitude of collection sites varied between 1498-2670m. The collected germplasm included that of cereals, pseudocereals, millets, grain legumes, vegetables, spices etc. Good variability was collected in French beans (23), maize (13), *Elymus semicostatus* (6) and rice (5). Interesting collections include primitive type of Foxtail millet (*Setaria italica*) locally called as 'Sallan', *Chenopodium album* locally called as 'Bajarbang', red rice locally called as 'Lal Dhan', maize, early white maize, cucumber and tobacco (Fig. 18.2).

18.1.3 Oilseeds & coriander and cumin: A total of 49 germplasm accessions were collected during exploration programme conducted in collaboration with ICAR-NRC SS Ajmer in Lolab valley of Kupwara district of Jammu & Kashmir. Altitude of collection sites varied between 1588-1633m. The germplasm collected included different species of *Brassica oleraceae*, *B. campestris*, *B. nigra*, *Raphanus sativus* besides fenugreek, coriander, cumin, some legumes and *Lipidium sativum*. Some interesting and unique germplasm accessions collected include small seeded greengram locally called as 'Keygam mung' and *Lipidium sativum* locally called as 'Halyun' (Fig. 18.3). *Lipidium sativum* collected from the wild is used as vegetable/condiment by the locals. According to locals it was used for promoting abortion in females during earlier times.

Fig. 18.2: A: Collection of primitive type of Foxtail millet from a small field in Padder area; B: Local cucumber collected D: from this farmer from Sarthal area; C: Maize collected from Chatroo area; D: Edible Creeping Cucumber (*Solena heterophylla*) growing wild in Nagni area of Bhonjwa Kishtwar.

Fig. 18.3: Collecting information about local PGR from an elderly lady in Lolab valley and seeds of *Lipidium sativum* locally called as 'Halyun'

18.2 Germplasm characterization

A total of 316 accessions of wheat and barley was characterized for agro-morphological traits as per the minimal descriptors during *rabi* 2017-18 under rain fed conditions and based on different traits promising genotypes were identified in both of these crops (Table 18.1). In wheat, a total of 209 germplasm accessions has been characterized in augmented block design using two national (GW-322 and PBW-343) and one local (HS-240) checks where as in barley, 107 germplasm accessions were characterized again in augmented block design using two national checks Jyoti and DL-36.

Besides, 34 common bean (*Phaseolus vulgaris*) genotypes collected earlier by the station were evaluated for resistance to fungal diseases during *kharif* 2018. Based on the detection of spores and the symptoms of the disease, five genotypes including IC0616433 and IC0625026 were found to be highly susceptible to angular leaf spot (ALS) disease while rest of the genotypes revealed no ALS infection. A recent collection (Kulgam rajma) revealed no infection of the *Alternaria* leaf spot fungus which seems to commonly affect common beans in the region.

18.3 Germplasm conservation

A total of 106 multi-crop accessions including 14 accessions of *Aegilops tauschii* ssp. *tauschii* have been conserved in NGB under LTS. Germplasm accessions of *Allium cepa* var. *proliferum* (pran) (09), *Allium sativum* (18), *Allium ampeloprasum* (02), strawberry (03), mint (01), *Iris* (1), *Dioscorea deltoidea* (25), *Bunium persicum* (6) and some temperate fruits/nuts are being maintained in the experimental field (Fig. 18.4).

18.4 Germplasm exchange

During the period under report a total of 108 germplasm accessions were supplied to different indenters for research purpose under MTA. The germplasm included colored barley (3), wheat (20), barley (70), and pea (15). 10 accessions comprising of pulses, cereals and spices were supplied to

Table 18.1: Promising accessions identified for some important traits in wheat and barley

Crop/Traits	Range	Mean	Best Check Value	Promising Accessions
Wheat				
Plant height (cms)	64.9-116.3	87.3	94.4 (PBW-343)	IC79013, IC79009, IC532310, IC533985
Flag leaf length (cms)	16.7-33.4	22.3	23.5 (GW-322)	IC532310, IC532803, IC78853, IC532772
Flag leaf width (cms)	1.1-2.1	1.5	1.5 (GW-322)	IC532198, IC532096, IC82209, IC68984
Days to 80% maturity	180-185	183	183 (GW-322)	IC532818, IC532945, IC534876, IC104655
Seed yield/plant (g)	6.332-60.133	20.157	24.408 (GW-322)	S/R-Gulistan, IC145972, IC78916, IC532442
100-seed weight (g)	2.0-5.0	3.475	3.225 (GW-322)	IC68984, IC532210, IC533985, SHEIKH/KP-710
Barley				
Plant height (cms)	64.8-105.6	83.3	84.5 (Jyoti)	EC667420, EC667448, EC667436, EC667435
Days to 80% maturity	178-184	181.6	180 (DL-36)	SHEIKH/KP-706, SHEIKH-634, EC667408, IC062189
Seed yield/plant (g)	13.0-53.5	30.966	33.049 (Jyoti)	EC667424, EC667439, EC667383, EC667421
100-seed weight (g)	3.1-6.2	4.308	4.65 (Jyoti)	EC667447, EC667448, EC667379, EC667414

Fig. 18.4: *Dioscorea deltoidea* and *Prunus tomentosa* maintained at the station

ICAR-NBPGR RS Thrissur, Kerala for exhibition purpose in Kisan Unnati Mela. 100 accessions each of early barley and wheat and one (01) accession (EC966538) of Hing/Heeng (*Ferula asafoetida*) has been received for characterization/evaluation at Srinagar station. One accession of fababean (HPFB-II) has been received under IVT/AVT trial.

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

PGR/PGC–BUR-SRI-01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of germplasm resources of various crops from Jammu & Kashmir region (**SM Sultan** and Susheel Kumar Raina)

Externally Funded Project

Collection, mapping, evaluation and conservation for sustainable utilization of plant genetic resources of cold desert region of India. (**SM Sultan** and Mohar Singh).

REGIONAL STATION, THRISSUR 19

SUMMARY: During 2018, 419 samples of germplasm were collected in three exploration trips, covering northern districts of Karnataka and Great Nicobar Biosphere Reserve. A total of 624 collections comprising 360 of rice, 23 of pulses, 11 of oriental pickling melon, 127 of bitter gourd, 80 of yard-long bean and 23 of catjang bean were characterized. Germplasm of 528 collections comprising 444 of various crops and 84 of crop wild relatives/ medicinal plants were sent for LTS. Thrissur has a germplasm holding of 8,306 accessions of various crops/ perennial horticultural plants and their wild relatives of which 6,493 are in the MTS and 1,813 are in the FGB. A total of 1,218 accessions in various species/taxa were supplied to 17 user agencies under MTA. Germplasm Field Day on Yard-long bean and two Diversity Appreciation Days were conducted. The station has facilitated visit of 466 students and 190 farmers. A training-cum demonstration on value addition in kokum was organized. Field assessment study of PGR loss due to the 2018 floods was undertaken. Two National Exhibitions had our participation, one in Kannur (Kerala Science Congress) and another in Thrissur (VAIGA -2018 cum ICAR-Krishi Unnati Mela).

19.1 Germplasm exploration and collection

19.1.1 Exploration at Great Nicobar Biosphere reserve: Three exploration and collection trips were undertaken amassing 419 collections. The first trip was undertaken in collaboration with NBPGR HQ and ICAR-CIARI, Port Blair to Great Nicobar Biosphere reserve (Fig. 19.1). Parts of South Andamans Rutland Island, Brooksabad forest and Chidiyatop Biological Park were also explored. For the first time, Little Nicobar Island was explored for CWR's and cultivated crops of Nicobari tribes. Plant diversity rich pockets like parts of Mt. Thullier, Koppenheat Rd., Afrabay and Nicobari tribal hamlets like *Macachua, Pilopunja* and *Pilobao* were explored. A total of 122 samples, mostly of crop wild relatives (CWR) like *Amomum, Amorphophallus, Cinamomum, Curcuma, Dioscorea, Garcinia, Mangifera, Musa, Piper, Vanilla, Vigna, Zingiber* and medicinal plants, besides a few cultivated crops of Nicobari tribes were collected. Phenological information, CWR species enumeration, locality details, herbarium

Fig. 19.1: A: Exploration and collection mission to Nicobar Islands; B: Variant of *Abelmoschus moschatus* from Great Nicobar; C: *Alocasia odora* from Great Nicobar; D: Regeneration of *Gossypium barbadense* var. *acuminatum* collected from Nicobar.

and photographic documentation for future fine grid explorations were made. Part of the germplasm was planted at ICAR-CIARI as a safe duplicate.

19.1.2 Exploration at Karnataka: Second exploration was undertaken at Northern districts of Karnataka (Belgaum and Bagalkot) in collaboration with ICAR-IIPR Regional Research Centre, Dharwad for the collection of urdbean, mungbean and grain cowpea germplasm (Fig. 19.2). In third exploration, Vijayapur, Kalaburgi, Koppal, Bellary and Raichur districts were covered; in collaboration with ICAR-IIHR Bengaluru for the collection of vegetables, urdbean, mungbean and cowpea germplasm. A total of 297 samples comprising mungbean (41), urdbean (29), grain cowpea (37), curry leaf (12), field bean (9), roselle (8), red gram (10), vegetable cowpea (9), horse gram (9), ridge gourd (9), pumpkin (7), melon (6) and drumstick were collected. Unique collections included two samples of black gram (NR/18-42 and NR/18-63) with glossy cowpea-like grains and black, dark green and light green *Vigna radiata* (green gram) samples. Other notable collections include two traditional landraces of rice (*Ramgalli* and *Doddiga*, the former having extended sterile glumes), a maize landrace with dark purple grains, germplasm of two farmer developed varieties, one in Brinjal with high single fruit weight - *Huliyal Zulappi Kari Badane* (HZKB-1) and another in durum wheat, *Huliyal Zulappi Godi* (HZG-30) and the germplasm of medical Garden Cress, *Lepidium sativum* (NR/18-91), Chilli (LSR/18-119) - *Bedagi-katti* – long slender, highly pungent fruits with brick red colour; melon (*Cucumis melo* var. *conomon* LSR/18-95) – *mikkikai* – a local vegetable available in field as weed and cultivated occasionally in homesteads; sponge gourd (LSR/18-104) – *thiprikkai*- another local vegetable used in *bajji* preparation; cluster bean (LSR/18-82) – a traditional primitive cultivar with short pods of 3-4 cm length; rice (LSR/18-36 & 72) – *kempuhakki* – a long duration landrace used as a weaning food. The area surveyed is a dry belt and farmers invariably cultivate all types of primitive cultivars of small millets. Progressive farmers reailizing the value of the wealth in diversity and variability, they conserve and maintain all types of traditional varieties of vegetables, pulses and small millets. Their younger generation are also keen in conservation of this heritage.

Fig. 19.2: Seed variability in cowpea collected from Karnataka

19.1.3 Collections within Kerala: Besides this, nine samples of Oriental Pickling Melon were collected from an innovative farmer conservator Shri Vivekanandan of Thrissur Dt. Field visits were also made to Jack fruit on-farm conservation plots in Kottayam district and eight elite table types jackfruit were identified and collected as bud-sticks and grafted to root stocks. One rice landrace (*Komban*; Fig. 19.3), *Solanum psuedocapsicum* and two landraces of finger millet (*karumkanni*, *chenkanni*) were collected from Chinnar Wildlife Sanctuary, Idukki dt., Kerala.

Fig. 19.3: A: Flood survived rice landraces collected from Wayanad & Kozhikode districts of Kerala; B: *Komban* – a special rice of tribes of Idukki district, Kerala

19.2 Germplasm characterisation

19.2.1 Taxonomic studies: Wild relatives collected from Nicobar Islands were studied. Seeds of *Myristica andamanica*, *Knema laurina*, *K. andamanica*, *Horsfieldia glabra*, *Raphaloblaste augustata*, *Amorphophallus hirsutus* (Fig. 19.4) and *Aglonema simplex* had 40-50 days gestation period. Morphological distinguishing *Myristica andamanica*, from related *Horsfieldia glabra* and *Knema andamanica* were developed. Based on morphological characterisation a new subspecies of sweet gourd, viz., *Momordica cochinchinensis* subsp. *andamanica* was described.

19.2.2 Rice: A total of 360 accessions of rice sown for regeneration were characterised for 23 traits comprising 11 qualitative and 12 quantitative characters. 29 accessions were found to be early with 90-100 days of maturity. Three accessions were found to be photo-sensitive.

19.2.3 Pulses (Mungbean, urdbean and moth bean): Preliminary characterisation and seed multiplication was done in 23 collections of pulses comprising urdbean (4), mungbean (9) and moth bean (10). Four quantitative and 9 qualitative characters were also recorded. Three black gram accessions (IC626197, IC626177 and IC626179)

Fig. 19.4: Wild *Amorphophallus* germplasm maintained in shade house

Fig. 19.5: Black gram seed multiplication for lines exhibiting tolerance to YMV disease under natural epiphytotic conditions

were found to be primitive cultivar type and were highly tolerant to YMV disease under natural epiphytotic conditions (Fig. 19.5). In green gram IC626183 and IC626187 were found to be field tolerant to YMV disease and high yielding compared to best check. LRM/13-35 was observed to be highly tolerant to YMV but was photosensitive and late flowering. Variation was insignificant in mothbean collections.

19.2.4 Oriental pickling melon (*Cucumis melo* var. *conomon*): Charactezisation and seed multiplication was done in 11 accessions of oriental pickling melon for eight quantitative and 15 qualitative characters. Seven accessions possessed globular shape and two had tapering stalk end. All the accessions were bitterless. Placental cavity was persistent in all the accessions.

19.2.5 Bitter gourd (*Momordica charantia*): One hundred and twenty seven accessions of bitter gourd were characterized for nine quantitative and 17 qualitative characters (Fig. 19.6).

19.2.6 Yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis*) & Catjang bean (*V. unguiculata* subsp. *sinensis*): A total of 103 accessions comprising 80 of yard-long bean (Fig. 19.7) and 23 of catjang bean collected from Kerala TN, MP and North – Eastern hill region were evaluated for 17 traits comprising 11 quantitative and six qualitative

Fig. 19.6: Fruit variability in bitter gourd conditions

characters for the second year. All accessions except IC622566 were tolerant to yellow mosaic disease under field conditions which confirms tolerance recorded last year. KERYLB-1252 was consistently superior for maximum pod length (56 cm). The accessions were grouped based on the consumer preference as assessed by the farmers during the diversity appreciation day. The general preferences were for long pods, purple coloured pods and dwarf types rather than non-viny. The accessions preferred by the farmers/ women for home gardens were given in Table 19.1.

Fig. 19.7: Yardlong bean. A: Field view of regeneration; B: Seed variability

Table 19.1: Yardlong bean accessions preferred for various traits as identified by farmers

Characters	Accessions
Long pods (> 40 cm)	IC622557 (TCR1), IC622565 (TCR10), IC622599 (TCR48), IC626138 (TCR54), IC626153 (TCR75), IC626162 (TCR93), IC626173 (TCR117), KERYLB1252 (TCR85)
Pods colour: full purple or with blotches of purple	KERYLB1287 (TCR101), IC622578 (TCR24), IC622591 (TCR40), IC622596 (TCR45), IC622600 (TCR49), IC622601 (TCR50), KERYLB1168 (TCR76), IC626155 (TCR80), IC626166 (TCR104), IC626172 (TCR116), IC626170 (TCR125)
Less or non fibrous pods for easy to chop	IC626172 (TCR116)
More No. of pods, prolonged pod yield and desirable cooking trait *i.e.*, on cooking the pods expand in contrast to shrinking of pods commonly observed and was found to be consistent.	IC622601 (TCR50)
Dwarf bushy type with more pods	IC20482

19.2.7 Biotic stress observations on crop wild relatives: *Artocarpus chama* was found susceptible to collar rot, *Macaranga nicobarica* to stem borer and *Musa indandamanensis* to rhizome weevil.

19.2.8 Distant hybridization: Hybridization involving *Abelmoschus esculentus* (Arka Anamika and Pusa Sawani) with *A. enbeepeegearensis*, *A. mizoramensis* sp. nov. and *A. moschatus* subsp. *biakensis* were made and fruits harvested.

19.2.9 Regeneration, multiplication and evaluation of okra: A total of 624 accessions of okra germplasm comprising 192 and 432 accessions from Division of Germplasm Evaluation (DGE) and Division of Germplasm Conservation (DGC), respectively, were sown for characterization and multiplication in Augmented Block Design, with 9 blocks and four checks viz., Pusa Sawani, Arka Anamika, Parbhani Kranti and VRO-6. Only 596 accessions germinated. Single row with 7 plants per accession were maintained. Row to row spacing of 1.50 m and plant to plant distance of 60 cm were given and all inter-cultural operations recommended by KAU were followed for raising a good crop. During Aug-2018, the crop faced 5-6 days of heavy and continuous rains, which severely affected the overall growth of the plants. However, out of the 624 accessions, seeds were regenerated and multiplied from 445 accessions and sent to NGB for LTS. Taxonomic correction for species identity was done. Thirteen accessions were identified as *Abelmoschus caillei*, two as *A. tetraphyllus* and the remaining as *A. esculentus*.

Fig. 19.8: Fruit variability among okra accessions

Wide variability was observed for fruit traits (Fig. 19.8). Single fruit weight ranged from 13.00 g (EC901938, IC510682, EC930127, IC089976 and IC93780) to 55.00 g (EC901979). Range of fruit length observed was 5.40 cm (EC 930104) to 20.20 cm (EC901979). Number of ridges on the fruit ranged from 3 to 11, and 10 accessions did not possess ridges on the fruit surface (round fruit surface). EC305689 had fruits with ridge development prolonged up to half length of the fruit. Three hundred and sixty eight accessions possessed yellowish green coloured fruits whereas 90 had green fruits. Accessions EC930102, IC24180 and IC20569 had red/purple coloured fruits.

19.3 Germplasm conservation

A total of 6493 accessions comprising cereals (3242), millets (74), pulses (721), vegetables (1550), medicinal plants (76) and crop wild relatives (830) were conserved in the MTS facility at the station. In the field gene bank, currently 1813 accessions are maintained including 200 of tropical fruits, 473 of spice crops, 283 of tuber crops, 14 of vegetables, 451 of medicinal plants, 312 of crop wild relatives (Fig. 19.9) and 80 of other economic plants.

Fig. 19.9: *Musa indanadamanensis*, collected from Nicobar, established in the FGB

For long term storage, 528 samples consisting of collected (158 voucher samples) and multiplied (370 samples) germplasm were deposited at NGB, which comprises ash gourd (5), black gram (27), bottle gourd (2), brinjal (5), chilli (1), cowpea (29), field bean (1), finger millet (3), fox-tail millet (3), green gram (38), horse gram (4), little millet (2), moth bean (12), okra (256), OP melon (5), rice (15), sponge gourd (1), yard-long bean (35) and species of *Abelmoschus* (6), *Amaranthus* (1), *Cajanus* (2), *Cucumis* (7), *Lycopersicon* (2), *Momordica* (9), *Ocimum* (5), *Oryza* (6), *Sesamum* (4), *Solanum* (7), *Trichosanthes* (3), *Vigna* (8) and others including medicinal plants (24).

19.4 Germplasm exchange

19.4.1 Supply to user agencies: Under Material Transfer Agreement (MTA), 1,218 accessions of germplasm of various crops/ species were supplied to 17 user agencies, comprising 3 ICAR institutes (111), 8 State Agricultural Universities (902) and 6 other agencies (205).

19.4.2 Germplasm receipt: Received 41 accessions comprising taro (40) from ICAR-NBPGR New Delhi and yard-long bean (1) from ICAR-NBPGR, RS Hyderabad.

19.5 New initiatives and success stories

19.5.1 Repository for RET crop wild relatives: Developed a simulated *in-situ* plot for RET, CWRs of Andaman and Nicobar origin at Thrissur for the benefit of researchers, where 36 perennial species are established.

19.5.2 Enrichment of germplasm with rare, unique and trait specific collections: Thirty collections of various *Abelmoschus* species comprising *A. moscahtus*, *A. tetraphyllus* var. *pungens,* various crop wild relatives species collected from North-Eastern region, Western Ghats and Great Nicobar Biosphere Reserve were

regenerated for taxonomic identification and preliminary seed multiplication. One collection each of *Momordica balsamina* and *Musa indandamanensis* was also regenerated. Regenerated and multiplied Nicobari tree cotton *Gossypium barbadense* var. *acuminatum* IC626380 (JPJ/18-66) successfully. As a follow up of survey and rescue collections from flood ravaged pockets in Kerala, 12 traditional landraces of rice such as *Chennellu, Chennelthondi, Chenthadi, Chitteni, Gandhakasala, H-4, Kalladiaryan, Mallikuruva, Orissa, Ramli, Thondi, Vedantham* and *Veliyan* were collected. The custodian farmers reported survival of these landraces even after submergence for 6-8 days at seedling stage.

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

PGR/GEV-BUR-THR-01.00: Augmentation, characterisation, evaluation, maintenance, regeneration, conservation, documentation and distribution of plant genetic resources in southern India including Goa and Andaman & Nicobar Islands (**Joseph John K**)

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

PGR/GEV-BUR-THR-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of field crops and their wild relatives (**M Latha**; M Abdul Nizar (till Nov. 30, 2018), A Suma (on study leave), *S Mani* and *A Indiradevi*)

PGR/GEV-BUR-THR-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of tropical vegetable, fruit and tuber crops and their wild relatives (**Joseph John K**; M Latha, M Abdul Nizar (till Nov. 30, 2018), A Suma (on study leave), *S Mani, R Asokan Nair* and *A Indiradevi*)

PGR/GEV-BUR-THR-01.03: Augmentation, characterisation, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of spices and their wild relatives, medicinal and other economic plants (**M Abdul Nizar** (till Nov. 30, 2018), **M Latha**, A Suma (on study leave), *S Mani, R Asokan Nair* and *A Indiradevi*)

TRAININGS AND CAPACITY BUILDING 20

20.1 Trainings organized in 2018

S. No.	Title of programme	Duration	Venue
1.	Learning workshop on 'Digitalization of PGR Management'	January 19, 2018	ICAR-NBPGR, New Delhi
2.	Workshop on 'Plant Genetic Resources Awareness and Diversity Fair'	February 17, 2018	Koruva, Chakarata, Dehradun, Uttarakhand
3.	One day learning workshop on 'Digital Field Book'	February 23, 2018	PDKV, Akola
4.	National Training Program on 'Management of Plant Genetic Resources'	March 6-19, 2018	ICAR-NBPGR, New Delhi
5.	National workshop along with WASSAN on 'Decentralized seed systems for climate resilient rain-fed agriculture'	March 8-9, 2018	ICAR-NBPGR RS-Hyderabad and MANAGE, Hyderabad,
6.	Emerging Plant Protection Technologies: Opportunities and Challenges	April 20, 2018	NIPHM, Hyderabad
7.	Review Workshop on 'CRP on Agrobiodiversity'	May 18-19, 2018	ICAR-NBPGR, New Delhi
8.	Digitalization of PGR management under CRP on Agrobiodiversity	May 19, 2018	ICAR-NBPGR, New Delhi
9.	Workshop *on 'Swachhta Hi Sewa* (SHS)'	September 19, 2018	ICAR-NBPGR, New Delhi
10.	Workshop on 'Plant Genetic Resources Conservation of Meghalaya'	September 20-21, 2018	Tura, Meghalaya
11.	A short orientation programme for awareness about 'Digital Field Book'	October 10, 2018	ICAR-NBPGR, Regional Station, Akola
12.	National training course on 'Contemporary Approaches to Plant Genetic Resources Management'	November 27-December 17, 2018	ICAR-NBPGR, New Delhi

20.1.1 National training program on 'Management of Plant Genetic Resources'

Dr Trilochan Mohapatra, Secretary, DARE & DG, ICAR, inaugurated the National Training Program on 'Management of Plant Genetic Resources', which was organized by ICAR-NBPGR, New Delhi, during March 6-19, 2018. Dr Kuldeep Singh, Director, ICAR-NBPGR was the Course Director, Drs S.K. Kaushik and Anuradha Agrawal were Course Conveners and Drs Sandeep Kumar and S. Rajkumar were Co-Conveners. The training was attended by 21 participants from 12 different institutes located in 12 states across India. Among these, 14 were from ICAR institutes and others from SAUs, CAU and CSIR institutes. The training program was conducted by experts from diverse disciplines through lectures (33) and practicals/demonstration (7). In all, 55 resource persons imparted training, comprising 12 from ICAR, IARI, PPVFRA, TAAS and Bioversity International, New Delhi, IIHR, Bengaluru and IIMR, Hyderabad, and remaining

Fig. 20.1. National training program on 'Management of Plant Genetic Resources'

from NBPGR, New Delhi, Bhowali, Hyderabad and Thrissur stations. Aspects of PGR management such as plant exploration and collecting, characterization and evaluation, holistic conservation and use through conventional and modern approaches were taught. Standard Operating Procedures (SOPs), biotechnological approaches, bioinformatics, documentation and database management and international policies on exchange of PGR were elaborated by the experienced faculty. The trainees had the opportunity to attend a special lecture on biodiversity by World Food Prize Laureate Dr G.S. Khush, delivered during the '1st Dr D.S. Athwal Memorial Lecture' held on March 13, 2018, at NBPGR, New Delhi. The trainees also visited facilities of ICAR-NBPGR, Issapur Farm, Herbal Garden and Krishi Unnati Mela. Dr N.S. Rathore, DDG (Agricultural Education), ICAR was the Chief Guest and Dr D.K. Yadava, ADG (Seed), ICAR was the Guest of Honour for the valedictory function.

20.1.2 Training on "Long-term conservation techniques for vegetable and rice germplasm"

A model training course sponsored by VNR Seeds Ltd., Raipur on "Long-term conservation techniques for vegetable and rice germplasm was organized in the Division of Germplasm Conservation, ICAR-NBPGR, New Delhi , from November 26-30, 2018. Course was designed to give the participants a complete overview on different conservation methods, seed quality, seed health testing, seed priming, cryo-preservation techniques and designing of seed genebank and storage modules (MTS & LTS) for vegetable and rice germplasm. A

Fig. 20.2. Participants of training on Long-term conservation techniques for vegetable and rice germplasm

total of six participants from VNR Seeds Ltd., Raipur attended the training course. Course lectures and practicals were conducted by mainly from division of germplasm conservation, quarantine and tissue culture and from division of Seed Science and Technology, ICAR- IARI, New Delhi. Resource persons were also invited from Blue Star, Pvt. Ltd. The valedictory function was graced by Dr S C Dubey and participants appreciated the customized training course. An e-manual containing compendium of lectures and other literature was provided to the participants.

20.1.3 National training course on 'Contemporary Approaches to Plant Genetic Resources Management'

National training course on 'Contemporary Approaches to Plant Genetic Resources Management was organized by ICAR-NBPGR, New Delhi, during Nov. 27 to Dec. 17, 2018. It was inaugurated by Dr D.K. Yadava, ADG (Seed), ICAR and total of 14 participants from ICAR/SAU institutes located in nine states across India attended the course. In all, 82 resource persons imparted training, comprising 12 from ICAR, IARI, PPV&FRA, TAAS and Bioversity International, New Delhi, and IIMR, Hyderabad, and remaining from NBPGR, New Delhi, Shimla, Bhowali, Hyderabad and Thrissur stations. Aspects of PGR management such as plant exploration and collection, characterization and evaluation, holistic conservation and use through conventional and modern approaches were taught through lectures (21) and hands on training sessions (18). Standard Operating Procedures (SOPs), biotechnological approaches, bioinformatics, documentation and database management and international policies on exchange of PGR were elaborated by the experienced faculty. Hands-on training was provided on various aspects of PGR management, including use of newly developed software's, databases and apps. Exhaustive literature was provided both as hard copy and e-resources to the trainees. A special interactive session of the trainees with Padma Bhushan Dr R.S. Paroda, Chairman, TAAS, was held, to discuss generic issues in PGR and agricultural research. The trainees visited Yamuna Biodiversity Park, Dayalbagh Educational Institute (DEI), Dayalbagh, Nanaji Deskmukh Phenomics Centre and Phytotron Facility, IARI and Herbal Garden in Delhi. Dr A.K. Vyas, ADG (HRM) gave the certificates to the trainees in the valedictory function. Based on the positive feedback received from trainees, he appreciated the efforts made by the Course Organizers (Drs S.K. Kaushik and Dr. Anuradha Agrawal) and Coordinators (Drs. Sundeep Kumar and S. Rajkumar).

Fig. 20.3. National Training Course on 'Contemporary Approaches to Plant Genetic Resources Management'

20.1.4 Training workshop on 'Digital Field Book'

One day learning workshop on "Digital Field Book" was organized by ICAR-Indian Institute of Millets Research (IIMR), Rajendranagar, Hyderabad in collaboration with NBPGR-RS, Akola and Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola at Dr. MS Swaminathan e-Class Room, Department of Agricultural Botany. Dr. DV Durge, Professor (Plant Physiology) & In-Charge, Head, Department of Agricultural Botany and Dr. Nilamani Dikshit, Principal Scientist & Officer-In-Charge, ICAR-NBPGR Regional Station Chaired the one day session. Dr. Sunil S. Gomashe, Scientist (Plant

Breeding), ICAR-NBPGR, RS, Akola and Dr. MV Kayande, Asst. Prof. (Plant Breeding), Dr. PDKV, Akola Coordinated the event. Dr. Sunil Gomashe gave brief outline of the workshop. Dr. Nilamani Dikshit delivered a welcome address and presented the brief Bio-data of Dr. M Elangovan. One of the organizers Dr. M Elangovan, Principal Scientist (Economic Botany & PGR) delivered the presentation on each and every aspect of the "Field Book" android application. He highlighted the use of this application for data recording of Agricultural experiments, exploration tours, social science questionnaires etc. In the afternoon session, the hand on training of Field Book application was given to each and every participant. For illustrations, agricultural experiment layouts were used and data was recorded in android phone itself. About 80 participants consisting of faculty members, research fellows and post graduate students of Department of Agricultural Botany attended the workshop. Participants expressed highly encouraging feedback and they requested to organize similar training for other disciplines also. Dr. P.K. Nagre, Associate Dean, Post Graduate Institute, Dr. PDKV, Akola requested to organize same workshop on larger scale in the month of July, 2018.

20.2 Trainings undertaken during 2018

Name of employee	Title of training programme	Place and Period
S Nivedhitha	Empowering knowledge on protection of plant varieties, IPRs and PGR related issues in cereals	ICAR-IIWBR, Karnal, Haryana, Mar. 12-21
Sunil S Gomashe	Genomics assisted prebreeding in vegetable crops	Division of Vegetable Science, IARI, New Delhi, Jun. 25 – Jul. 04
Gowthami R.	Developing Winning Research Proposals	ICAR-NAARM, Hyderabad, Aug. 23-28
Sheikh M Sultan	Intellectual Property Valuation and Technology Management	ICAR-NAARM, Hyderabad, Aug. 24-29
Mamta Arya and Subarna Hajong	Contemporary Approaches to Plant Genetic Resource Management	ICAR-NBPGR, New Delhi, Nov. 27-Dec. 17
Gowthami R.	Conservation and utilization of plant genetic resources in medicinal and aromatic plants	College of Horticulture UHS, Bagalkot, Karnataka, Dec. 3-23
Amit Kumar Singh, Gayacharan, Kuldeep Tripathi, Rashmi Yadav and Lalit Arya	Breeding approaches for enhancing genetic gains in Grain Legumes and Dryland Cereals	NASC Complex, New Delhi 10-14 December
Sandhya Gupta	Management Development Programme on Leadership Development	ICAR-NAARM, Hyderabad, Dec. 18-29
Technical staff		
NS Panwar and OP Dhariwal	Motivation, positive thinking and communication skills for technical officers	NAARM, HyderabadJune 20-28
PS Mehta	Farm Management	ICAR-IIFSR, Modipuram Sept 14-20

20.3 Capacity building

20.3.1 Deputations abroad

- **Gurinderjit Randhawa** participated and provided technical inputs in the panel discussions in Training Workshop on Practical aspects for regulatory GMO control implementation at Geel, Belgium from March, 6-8.

- **Ruchira Pandey, Neelam Sharma** and **Sandhya Gupta** participated in the 'Third International Symposium on "Plant Cryopreservation" at Bangkok, Thailand during March 26-28.

- **Sunil Archak** participated in "International Training for Software Testing to Support DOI Implementation" organized in Bogor, Indonesia from 22 April – 1 May.

- **Ruchira Pandey** and **Neelam Sharma** undertook a study visit to Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben, Germany, under the Indo-Germany Bilateral Cooperation on Seed Development, on aspects of *in vitro* cryopreservation techniques and management of cryobanking of vegetatively propagated crops during May 7-26.

- **Anuradha Agrawal** participated in "Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnership to Improve Livelihood of Farmers in Asia-Pacific', organized by APAARI, APCoAB, COA, Thailand, ACIAR, Australia, GLDC, CGIAR, BCIL, India and DOA Taiwan, Bangkok, Thailand, May 29-31.

- **Kuldeep Singh** and **Sunil Archak** participated in 3rd Meeting of the Scientific Advisory Committee on Article 17 of ITPGRFA at FAO, Rome during June, 21-22.

- **Kuldeep Singh** and **Sandhya Gupta** attended the XXXth International Horticultural Congress at Istanbul, Turkey during Aug.12-16.

- **V Celia Chalam** participated in 11th International Congress of Plant Pathology (ICPP) 2018: Plant Health in A Global Economy held at Boston, USA on July 28 to August 3.

- **Harish GD** participated in workshop "Genebank Operations and Advanced Learning (GOAL) Master Class 2018" on September 27 organised by Crawford Fund and Crop Trust at Mardi Headquarters, Serdang, Selangor, Malaysia.

- **Kuldeep Singh** and **Pratibha Brahmi** participated in 6th Workshop on "Heat and Drought Tolerant Orphan Legumes" at Abuja, Nigeria organized by Federal University of Agriculture Makurdi under the Project "Evaluation of Stress Tolerant Orphan Legumes for dryland farming system across Sub-Saharan Africa and India" from November 1 -2.

- **Raj Kiran** attended the advance course on "Plant diseases caused by *Xylella fastidiosa*: detection, identification, monitoring and control" jointly organized by International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) through the Mediterranean Agronomic Institute of Zaragoza and the Ministry of Agriculture, Fisheries and Food of Spain at Zaragoza, Spain from Nov. 12-16, 2018

- **Gurinderjit Randhawa** as Technical Assessor for GM detection conducted assessment of National Food Testing Laboratory Bhutan Agriculture & Food Regulatory Authority on behalf of National Accreditation Board for Testing and Calibration Laboratories, Quality Council of India, at Thimpu, Bhutan November 17-18.
- **SC Dubey, V Celia Chalam** and **Jameel Akhtar** participated in International Conference on "Soil and Plant Health Towards Achieving Sustainable Development Goals"organized jointly by Indian Phytopathological Society, New Delhi and APAARI at Bangkok, Thailand during Nov. 21-25.
- **Archana P Raina** participated in International Symposium on "High Performance Thin-Layer Chromatography" at Bangkok, Thailand from November 28-30.

20.3.2 Participation in seminars / conferences / symposia / workshops / meetings

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Anitha K	12th Academic Council Meeting	NIPHM, Hyderabad, Jan. 8
IS Bisht, Vikender Kaur, Gayacharan, Rashmi Yadav, Rakesh Bhardwaj and Kuldeep Tripathi	Training workshop on "Baseline Survey and Impact Assessment"	ICAR-NBPGR, New Delhi, Jan. 9-11
KC Bhatt, K Pradheep, RS Rathi, DP Semwal, Soyimchiten, PK Malav	Workshop on "Mainstreaming agricultural biodiversity conservation & utilization in agricultural sector to ensure ecosystem services & reduce vulnerability"	ICAR-NBPGR, New Delhi, Jan. 9-11
SB Choudhary	National Seminar on "ICT Application in Changing Face of Agriculture"	BAU, Ranchi, Jan. 19-20
V Celia Chalam	State Level Biosafety Capacity Building Workshop under Phase II Capacity Building Project on Biosafety	Assam Agricultural University (AAU), Jorhat, Feb. 10
Vandana Tyagi	Digitization of PGR Management	ICAR-NBPGR, New Delhi, Jan. 19
Suma A	30th Kerala Science Congress organized by the KSCSTE and CWRDM	Kannur, Kerala, Jan. 28-30
Suma A, Shri R Asokan Nair & Smt A Indiradevi	National Science Exhibition in connection with 30th Kerala Science Congress	Kannur, Kerala, Jan. 28-30
DR Pani, Vimala Devi S,	3rd ARRW International Symposium on "Frontiers of rice research for improving productivity, profitability and climate resilience"	ICAR-NRRI, Cuttack, Feb. 6-9
MC Yadav	NICRA project progress during "Review Workshop for Institutes under Crop Sciences of NICRA"	NASC, New Delhi, Feb. 12-13
Vandana Tyagi	राजभाषा कार्यान्वयन खुम्ब की उपज पर	Feb. 13, 2018

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Kuldeep Singh, MC Yadav, Amit Kumar Singh, Kuldeep Tripathi	International conference on sustainability of smallholder agriculture in developing countries under changing climate scenario	CSAUAT, Kanpur, Feb. 14-17
V Celia Chalam	70th Annual Meeting and National Symposium on Plant Health Management: Embracing Ecosustainable Paradigm	Assam Agricultural University (AAU), Jorhat, Feb. 15-17
Z Khan	20th Biennial Group Meet of AICRP- Nematodes in cropping systems organized by Project Coordinating Unit, ICAR-AICRP- Nematodes.	Anand Agricultural University, Anand, Gujrat, Feb. 15-17
M Abdul Nizar	Wayanad Community Seed Festival and National Seminar on Agro-biodiversity Conservation	Wayanad, Kerala, Feb. 24
Kuldeep Tripathi and Ashok Kumar	Rabi Pulses Scientist Meet	ICAR-IIPR, Kanpur, Feb. 24-25
IS Bisht, Mamta Arya, PS Mehta	FGD meeting on with farmer representatives of core villages of Someshwar valley in Almora district of Uttarakhand, to be involved in ICAR-Bioversity GEF project.	Almora UK, Feb. 27
Rashmi Yadav	International Training Workshop on "Precision Nitrogen Nutrition in Wheat: Integrating Genetics and Precision Agronomy for Improving Nitrogen Use Efficiency"	BISA-CIMMYT, Ludhiana Mar. 1- 5
IS Bisht	Seminar on "Emerging trends in Hi-tech Hill Horticulture under changing climate"	CITH, RS-Mukteshwar, Mar. 6
Raj Kiran, KM Rai	Training program on Management of Plant Genetic Resources	ICAR-NBPGR, New Delhi , Mar. 6-19
Joseph John K	Training programme on "Management of Plant Genetic Resources"	ICAR-NBPGR, New Delhi, Mar. 7
S Nivedhitha, AK Misra Subarna Hajong	National Seminar on "Himalayan Plant Diversity Taxonomy, Conservation and Sustainable Utilization"	BSI, Shillong, Mar. 8-9
Era V Malhotra	National Workshop on 'Revisiting Foundation Course for Agricultural Research Services (FOCARS): Reflections and feedback of trained scientists'	ICAR-NAARM, Hyderabad, Mar. 15-16
Joseph John K	Task Force meeting on DUS guidelines for Yam bean and Greater yam (PPVFRA)	NASC Complex, New Delhi, Mar. 20
DP Semwal	National Conference on Emerging Environmental Challenges and Sustainable Development	University of Delhi, Delhi, Mar. 21-23
V Celia Chalam	State Level Biosafety Capacity Building Workshop under Phase II Capacity Building Project on Biosafety	IGKV, Raipur, Mar. 28
B Sarath Babu, SK Chakrabarty, Anitha Kodaru, N Sivaraj, SR Pandravada, P Pranusha and Prasanna Hollajer	National Consultation Meeting on Doubling of farmers Income	IIRR, Hyderabad, Mar. 31
V Celia Chalam	State Level Biosafety Capacity Building Workshop under Phase II Capacity Building Project on Biosafety	BCKV, Kalyani, April 3

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Kuldeep Singh, Ashok Kumar, Sherry R Jacob and Jyoti Kumari	Annual maize workshop	CSK-HPKV, Kullu, April 7-9
Sunil S Gomashe	Annual Group Meeting of AICRP on Small Millet	IGKVV, Raipur, April 12-13
Joseph John K	ICAR-Regional Committee Mid-Term Review Meeting	ICAR-SBI, Coimbatore, April 17
N Sivaraj	Annual Groundnut workshop organized by the All India Coordinated Research Project on Groundnut	PJTSAU, Hyderabad, April 18
B Sarath Babu, SK Chakrabarty, Anitha Kodaru, Kamala Venkateswaran, N Sivaraj, SR Pandravada, P Pranusha and Prasanna Hollajer	Emerging Plant Protection Technologies: Opportunities and Challenges	NIPHM, Hyderabad, April 20
Joseph John K	Stake-holders Meet for Planning ICAR- Krishi Unnathi Mela	ICAR-CPCRI, Kasaragod, April 21
Sunil Archak	International Training for Software Testing to Support DOI Implementation	Bogor, Indonesia, April 22- May 1
B Sarath Babu, Anitha K	Identification of Pest-free areas in Andhra Pradesh and Telangana states against mango pests.	NIPHM, April 23
Mamta Arya	Training on baseline survey guidelines under ICAR-GEF project	Bioversity International, New Delhi, April 25-26
Anuradha Agrawal	First Meeting of National Advisory Committee on Management of Genetic Resources (NACMGR)	ICAR-NBPGR, New Delhi, April 26
V Celia Chalam	State Level Biosafety Capacity Building Workshop under Phase II Capacity Building Project on Biosafety	MPUAT, Udaipur, April 27
SK Yadav, SK Kaushik, Sandeep Kumar, Raiger HL, BS Phogat and Kuldeep Singh	XXVIII Group Meet of All India Coordinated Research Network on Potential Crops held at, 2018.	CSKHPKV, Palampur, April 27-28
Joseph John K	AICRP Tuber Crops Group Meeting	ICAR-CTCRI, Thiruvananthapuram, April 27-29
N Sivaraj	Road map of vegetable oil production by 2022	PJTSAU, Hyderabad, April 28
B Sarath Babu	Seed Festival	Visakhapatnam, April 28
IS Bisht	Summit on Climate Resilient Mountain Agriculture	Dehradun, May 2-4
V Celia Chalam	One Day Laboratory Course on Changes in ISO/ IEC 17025:2005 to ISO/IEC 17025:2017	NABL, New Delhi, May 14
Suma A	Stakeholder Workshop on Framing Operational Guidelines for implementing National Agro-forestry Policy for Kerala	KAU, Thrissur, May 14-15
Monika Singh	Training Programme on Laboratory Quality Management System & Internal Audit as per IS/ISO/IEC 17025:2017 (Organized by Bureau of Indian Standards)	NITS, Noida, May 21-24
Sunil S Gomashe	Farmers training “Unnat Krishi Samridh Kisan” for alternative cropping systems for sustainable farm production	Amravati, Jun. 02

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
N Sivaraj	45th FCARPM reunion	ICAR-NAARM, Jun. 02-03
N Sivaraj	MDP on Leadership Development	ICAR-NAARM, Hyderabad, Jun. 4-15
Lalit Arya, BH Gawade, Kuldeep Tripathi, Era V. Malhotra	World Environment Expo and World Environment Conference	Pragati Maidan, New Delhi, Jun. 5-7
Prasanna Holajjer	Plant Biosecurity and Incursion Management	NIPHM, Hyderabad, Jun. 5-25
Sheikh M Sultan, Mamta Arya	XXV Meeting of ICAR Regional Committee No. 1	SKUAST (K) Srinagar, Jun. 11-12
DR Pani	Meeting for *in house* discussion on post graduate courses on Plant Genetic Resources	OUAT, Bhubaneswar, Jun. 20
Sunil Archak	3rd Meeting of the Scientific Advisory Committee on Article 17 of ITPGRFA	FAO, Rome, Jun. 21-22
DR Pani	XXIVth meeting of ICAR-Regional Committee-II	ICAR-CIFA, Bhubaneswar, Jun. 22-23
Dinesh Chand, Smita Karale	NARAKAS (First Six monthly) meeting: Rajbhasha	Akola, Jun. 26
B Sarath Babu, SK Chakrabarty, Anitha Kodaru, Kamala Venkateswaran, N Sivaraj, SR Pandravada, P Pranusha and Prasanna Hollajer	National Consultation Meeting for doubling the farmers income	ICAR-CRIDA, Hyderabad, Jul. 3
Mamta Arya	Fish Farmer's Day	ICAR-DCFR, Bhimtal, Jul. 10
Pratibha Brahmi	Consultation meeting to discuss the zero draft of NR6	MoEFCC, Jul. 17
Mamta Arya	45th Institute Management Committee (IMC) of ICAR-VPKAS, Almora, Uttarakhand	ICAR-VPKAS, Almora, Jul. 28
V Celia Chalam	11th International Congress of Plant Pathology (ICPP) 2018: Plant Health in A Global Economy	Boston, USA, Jul. 28 to Aug. 3
Vandana Tyagi	Meeting on Implementation of CBD	NBA, Chennai, Aug. 7
MC Yadav Jyoti Kumari, Ruchi Bansal	Sixth NICRA Review workshop	NASC Complex, New Delhi, Aug. 7-8
M. Latha, Suma	Meeting organised by the Kerala State Biodiversity Board (for Project presentation)	Thiruvananthapuram, Aug. 9
Joseph John K	Visit to two tribal hamlets for assessing the landrace diversity on-farm for claim of Plant Genome Saviour Award (by PPV&FRA)	Chinnar Wild Life Sanctuary, Aug. 13
M Abdul Nizar	Consultation workshop for identifying the issues on biodiversity/ mainstreaming biodiversity by the Kerala State Biodiversity Board.	Thiruvananthapuram, Aug. 14
Anuradha Agrawal	Dialogue on realization on Farmer's Rights and Benefit Sharing, Compulsory License, Provisions of Conservation under PPVFRA Act 2001	New Delhi, Aug. 17
S Nivedhitha	International Conference on Recent Advances in Food Processing Technology	IIFPT, Thanjavur, Aug. 17-19
Gurinderjit Randhawa	Role of technology in community level disaster mitigation	LBSNAA, Mussoorie, Aug. 20-24

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Amit Kumar Singh	Developing Winning Research Proposals (DWRP)'- one at NAARM	NAARM, Hyderabad, Aug. 23-28
Jyoti Kumari	57th All India Wheat & Barley Research Workers' Meet	BAU, Ranchi, Aug. 24-26
Sandhya Gupta, SP Singh Pardeep Kumar, DP Semwal and Vartika Srivastava	Auditor/Internal Auditor Training Course on 'Implementation and assisting in consultancy of ISO:9001:2015 (Quality Management System)'	ICAR-NBPGR, New Delhi, Aug. 28-Sept. 1
S Nivedhitha, Meena Shekhar, Pardeep Kumar and Raj Kiran, Anuradha Agrawal, Kuldeep Tripathi, Era V. Malhotra	Regional Conference on Motivating and Attracting Youth in Agriculture (MAYA)	NASC complex, New Delhi, Aug. 30-31
Sunil Archak	20th Meeting of CDFD's Research Area Panels and Scientific Advisory Committee	CDFD, Hyderabad, Aug. 31- Sept. 01
Veena Gupta and Anjali Kak (Principal Scientists)	ICAR sponsored training on Increasing Farmers Income and Livelihood Security: Role of Agricultural Diversification and Value Additions	SKUAST, Wadura, Sept. 3-12
B Sarath Babu and N Sivaraj	Special Lecture on Genebank activities at EMBRAPA, Brazil	ICRISAT, Sept. 4-5
Rakesh Singh	Proteomics and its application in agriculture	PAU, Ludhiana, Sept. 5-14
Susheel Kumar Raina	National Group Meet (Rabi) AICRP on Forage Crops and Utilization	CCSHAU, Hisar, Sept. 7-8
Ashok Kumar, SK Yadav, SK Kaushik, MC Singh, Vinay Mahajan, SP Singh, Sandeep Kumar, HL Raiger, BS Phogat, Sunil Gomashe and Kuldeep Singh	V Rabi Group Meet of All India Coordinated Research Network on Potential Crops	PAU, Ludhiana, Sept. 10
Kuldeep Tripathi	Annual Group Meet on Rabi Pulses of AICRP on MULLaRP crops	AAU, Jorhat, Sept. 14-15
KM Rai	Apple Day/show cum FAP Climate Resilient Ppple Production Technologies for Farmers	ICAR-CITH RS- Mukteshwar (Nainital), Sept. 22
V Celia Chalam	Special National Symposium on Extension Plant Pathology: Technological Backstopping to the Farmers and Other Stakeholders	IGKV, Raipur, Sept. 25
Kamala Venkateswaran and SR Pandravada	Maize Field Day	IIMR, Hyderabad, Sept. 25
N Sivaraj	CRP monitoring the evaluation of Rice germplasm	IIRR, Hyderabad, Sept. 25
V Celia Chalam	Gujarat State Biotechnology Mission (GSBTM)-sponsored three day Workshop on Transgenic Trait Detection in Crops	JAU, Junagadh, Sept. 26
Kamala Venkateswaran	CRP monitoring team for Rice	ICRISAT, Hyderabad, Sept. 26
Kamala Venkateswaran	CRP monitoring team for Sorghum and millets	IIMR, Hyderabad, Sept. 26
S Mani	One day Hindi workshop conducted by TOLIC	Hotel Garuda, Thrissur, Sept. 26
Archana P Raina & Ishwar Singh	XXVI Group Meeting of AICRP on Medicinal and Aromatic Plants	AAU, Jorhat, Sept. 28-30

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Prasanna Holajjer	First International Conference on Biological Control: Approaches and Applications	ICAR-NBAIR Bengaluru, Sept. 27-29
Dinesh Chand	Monitoring of winged bean trial under AICRN on Potential Crops	MPKV, Rahuri, Oct. 5
Anuradha Agrawal	XXIV Institute Management Committee Meeting of ICAR-NRC for Banana, Trichy	ICAR-NRC-Banana, Trichy, Oct. 6
Jyoti Kumari	13th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Ludhiana, Oct. 8-10
Sunil S Gomashe	Finger Millet Field Day and monitoring of finger millet germplasm trial under CRP on Agro-biodiversity	ICAR-IIMR, Hyderabad, Oct. 11
Anuradha Agrawal	Programme on Science administration and research management	Administrative Staff College of India, Hyderabad, Oct. 22-Nov. 2
Vandana Tyagi	Regional Training Workshop on Development and Implementation of ABS Legal Framework to Implement Nagoya Protocol on ABS and TKDL	NBA, Chennai, Oct. 22-25
Anitha K, Prasanna Holajjer	Awareness programme on Phytosanitary issues	ICRISAT, Oct. 24
Ishwar Singh	XXI Biennial National Symposium on 'Doubling Farmers' Income Through Agronomic Interventions Under Changing Scenario'	MPUA&T, Udaipur, Oct. 24–26
Anitha K	11th Foundation day celebrations	NIPHM, Oct. 25
Joseph John K	Live TV phone-in programme on "*Karshika Jaiva Vaividhya Sampathinte Samrakshna Pravarthanangal*" (in Malayalam) in "Krishidarshan"	Doordarshan Kendra, Trivandrum, Oct. 26
MC Yadav	International Conference Krishi Kumbh-2018.	ICAR-IISR, Lucknow, Oct. 26-28
Yasin JK	International Conference on Rural Livelihood Improvement by Enhancing Farmer's Income through Sustainable Innovation Agri and Allied Enterprises	BIT, Patna, Oct. 30 - Nov. 1
Joseph John K	Radio talk on Activities of NBPGR and Services Rendered to Farming Community	All India Radio, Thrissur, Nov. 1
M Latha	Live TV phone-in programme on "*Paramparagatha Nellingal*" (in Malayalam) in "Krishidarshan"	Doordarshan Kendra, Trivandrum, Nov. 2
V Celia Chalam	INTERVIROCON 2018 International Conference of Virology: Global Viral Epidemics: A Challenging Threat	PGIMER, Chandigarh, Nov. 12-14
Joseph John K	ICAR-Krishi Unnathi Mela Organizing Committee meeting	ICAR-CIFT, Ernakulam, Nov. 16
S Rajkumar, Ruchi Bansal	National Symposium on 'Connecting Innovations in Plant Biology for Food and Nutritional Security'	ICAR-IARI, New Delhi, Nov. 19
Kuldeep Tripathi	International Conferences on Agriculture & Horticulture (Agritek-2018)	Puri, Odisha, Nov. 26-27
Sangita Bansal	56th Project Screening Committee (PSC-II) Meeting on Research and Development (R&D)	AYUSH Bhawan, New Delhi Nov. 28
S Mani	One day Hindi workshop conducted by TOLIC	Thrissur, Nov. 29

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Ruchi Bansal	International Plant Physiology Conference 2019	Indira Gandhi Pratishthan, Lucknow, Dec. 2-6
Rakesh Bhardwaj	3rd National Workshop of ICAR Research Data Management (ICAR Research Data Repository for Knowledge Management: KRISHI Portal)	New Delhi, Dec. 04-05
Anitha K, Prasanna Holajjer	National Symposium on entomology 2018: Advances and Challenges	PJTSAU, Hyderabad, Dec. 10-12
Kavita Gupta, M C Yadav, Pragya, Pratibha Brahmi, Ruchi Bansal, Sherry R Jacob, Sunil Archak, Vandana Tyagi, Vartika Srivastava, and Veena Gupta	Asian Regional Workshop on Implementation and Reporting of ITPGRFA	NASC Complex, New Delhi, Dec. 11-13
SC Dubey, Meena Shekhar, J Akhtar, P Kumar, V Celia Chalam	Annual Zonal Meeting and National Symposium on 'Microbes for integrated plant disease management and bioprospecting' organized by Indian Phytopathological Society, Delhi Zone at ICAR-IARI.	New Delhi, Dec. 13
Ashok Kumar, Jyoti Kumari, DP Semwal, Z Khan	1st National Genetics Congress on "Genetics for sustaianable food, health and nutrition security" organized by ISGPB, New Delhi	ICAR-IARI, New Delhi, Dec. 14-16
Vikender Kaur, Gayacharan, Rashmi Yadav, Rakesh Bhardwaj, Kuldeep Tripathi and Mamta Arya	Participatory approaches for mainstreaming crop diversity on farm and policies issues for PGR conservation and use	ICAR-NBPGR, New Delhi, Dec. 17-20
Prasanna Holajjer, Raj Kiran	1st International Conference on 'Climate Change and Adaptive Crop Protection for sustainable Agri-horticulture land scape' organized by Society of Plant Protection Sciences, New Delhi	ICAR-NRC SS, Ajmer, Rajasthan, Dec. 20-22
V Celia Chalam	National Symposium on Cutting Edge Approaches for Sustainable Plant Disease Management and Ensuring Farmers' Profit	ICAR-NRC-Banana, Tiruchirapalli, Dec. 21-23
Suma A, R Asokan Nair, S Mani & A Indiradevi	National Exhibition during the VAIGA-2018 & ICAR-Krishi Unnati Mela	Thrissur, Dec. 27 -30

GENERAL INFORMATION 21

Summary: In total, 117 scientific, 69 technical, 45 administrative and 54 supporting staff personnel were in position at ICAR- NBPGR including regional stations, as of December 31. During the year, 13 promotions, 8 transfers and 17 retirements were effected across all staff categories. The scientific staff were bestowed with 12 young/best scientist awards, five best paper awards and ten scientists were given other recognitions. Dissemination of research outputs was achieved in the form of peer-reviewed research articles (104), books (16), book chapters (65), bulletins (13), popular articles (15), tv talks (4), reports (3), plant germplasm reporter (2) and e- publications (10). As a part of outreach activities, the institute organized eight field days, and ten PGR awareness-cum- biodiversity fair programmes under TSP or MGMG.

21.1 Institute management committee (IMC)

Director, ICAR-NBPGR, Pusa Campus, New Delhi-110012	Chairman
The Director (Agriculture), Delhi Govt., 5/9 under hill road, Delhi-54	Member
The Director (Agriculture), Dept. Agri., Haryana Krishi Bhawan, Sector-21, Panchkula, Haryana-134112	Member
The Head, Plant Pathology Division, ICAR-IARI, New Delhi-12	Member
Smt. Sushma Chhapalkar, Director (Biotechnology), Vidya Pratishthan, Baramati	Member
Dr. KS Ravi, Lead-Vegetable Research Centre, Mahyco, Maharastra	Member
Dr. DK Yadava, Head and Pri. Sci., Div. Seed Sci. Tech., ICAR-IARI, New Delhi-110012	Member
Dr. Raj Kumar, Head and Pri. Sci., ICAR-IARI-RS, Katrain (Kullu valley), HP	Member
Dr. TR Sharma, Director, ICAR-IIAB, Garhkhatanga, Ranchi, Jarkhand, PDU Campus, IINRG Tata Road, Namkum, Ranchi-834010	Member
Dr. Sarvjeet Singh, Pri. Sci., Div Plant Breeding (Pulse Section)	Member
ADG (Seeds), ICAR-HQ, Krishi Bhawan, New Delhi-110001	Member
The Comptroller, ICAR-IARI, New Delhi-110012	Member
Senior Admn. Officer, ICAR-NBPGR, New Delhi	Member Secretary

21.2 Research advisory committee (RAC)

Dr SK Sharma, Ex-Vice-Chancellor, CSK-HPKV, Palampur	Chairman
Dr DK Yadava, ADG (Seed) acting, ICAR, New Delhi	Member
Dr. Sujata Arora, Advisor, Ministry of Environment, Forest & Climate Change	Member
Dr Pritam Kalia Emeritus Scientist, ICAR-IARI	Member
Dr SR Yadav, Emeritus Scientist, Professor, Dept of Botany, Shivaji Univ. Kolhapur	Member
Dr SR Bhat, Emeritus Scientist, NRCPB, ICAR-IARI	Member
Dr VV Ramamurthy, Emeritus Scientist,	Member
Dr Kuldeep Singh, Director, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr SC Dubey, Principal Scientist & I/C DGR, ICAR-NBPGR, New Delhi	Member Secretary

The XX meeting of the RAC of ICAR-NBPGR was held on August 6 -7, 2018 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.

Institute research council (IRC)

The 29th Institute Research Council (IRC) meeting from August 8-10, 2018 was held under the Chairmanship of Dr Kuldeep Singh, Director, ICAR-NBPGR with Dr. Mukesh Kumar Rana as Member secretary. The Principal Investigators / OICs / scientists of the respective regional stations presented the progress report of the 86 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.

21.3 Institute joint staff council (IJSC)

Elected members of IJSC for different categories: Technical Staff: Mr Satya Prakash (TO) and Mr Braham Prakash (TO); Administrative staff: Mr Yogesh Kumar (Assistant) and Mrs. Vijay Lakshmi Sharma (Assistant); Skilled Supporting Staff: Mr Yatish Chandra and Braham Dev Paswan. Office side members were: Dr. Rakesh Bhardwaj (Pr. Sci.), Dr. S.P. Ahlawat (Head, Exploration Div.), Dr. Anuradha Aggarwal (OIC, TCCU), Dr. Amit Kumar (Sci.), Sr.AO, and Sr. F&AO.

21.4 Prioritization monitoring and evaluation (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 MK Rana	IRC member secretary
Dr Rakesh Bhardwaj	Nodal officer Krishi Portal

PME cell coordinated scientific activities such as forwarding and maintenance of project proposals (8), manuscripts (48)/ abstracts (95); training/ fellowship proposals (38) etc. as per the ICAR guidelines. It also coordinates 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 (reports target and achievements), half-yearly reports (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 were duly provided.

FMS-MIS at 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 2018-19 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) at ICAR.

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.

21.5 Personnel

(i) Scientific staff in position as on 31st December 2018:

S.No.	Name	Designation (specialization)
1	Dr Kuldeep Singh	Director (Genetics and Plant Breeding)
Division of Plant Exploration and Germplasm Collection		
2	Dr SP Ahlawat	Head (Plant Breeding)
3	Dr Anjula Pandey	Principal Scientist (Economic Botany)
4	Dr KC Bhatt	Principal Scientist (Economic Botany)
5	Dr K Pradheep	Principal Scientist (Economic Botany)
6	Dr RS Rathi	Principal Scientist (Economic Botany)
7	Dr DP Semwal	Senior Scientist (Economic Botany)
8	Sh Soyimchiten	Scientist (Horticulture)
9	Ms S Nivedhitha	Scientist (Economic Botany and PGR)
10	Sh Pavan Kumar Malav	Scientist (Economic Botany and PGR)
Germplasm Exchange Unit		
11	Dr Pratibha Brahmi	Principal Scientist (Economic Botany) and OIC
12	Dr Vandana Tyagi	Principal Scientist (Economic Botany)
13	Dr SK Yadav	Principal Scientist (Horticulture)
14	Dr Pragya	Principal Scientist (Horticulture)
Division of Plant Quarantine		
15	Dr SC Dubey	Head (Plant Pathology)
16	Dr Meena Shekhar	Principal Scientist (Plant Pathology)
17	Dr V Celia Chalam	Principal Scientist (Plant Pathology)
18	Dr Kavita Gupta	Principal Scientist (Agrl. Entomology)
19	Dr Moolchand Singh	Principal Scientist (Agronomy)
20	Dr Surendra Pal Singh	Principal Scientist (Agrl. Entomology)
21	Dr Zakaullah Khan	Principal Scientist (Nematology)
22	Dr Jameel Akhtar	Principal Scientist (Plant Pathology)
23	Dr T Boopathi	Senior Scientist (Agril. Entomology)
24	Dr BH Gawade	Scientist (Plant Nematology)
25	Dr Pardeep Kumar	Scientist (Agrl. Biotechnology)
26	Ms Raj Kiran	Scientist (Plant Pathology)
27	Ms Pooja Kumari	Scientist (Plant Pathology)
Division of Germplasm Evaluation		
28	Dr Ashok Kumar	Principal Scientist (Plant Breeding) & Head (Officiating)
29	Dr. Vinay Mahajan	Principal Scientist (Genetics and Plant Breeding)
30	Dr KK Gangopadhyay	Principal Scientist (Horticulture)
31	Dr SK Kaushik	Principal Scientist (Genetics and Plant Breeding)
32	Dr Archana P. Raina	Principal Scientist (Biochemistry-Pl. Sci.)
33	Dr Ishwar Singh	Principal Scientist (Agronomy)

34	Dr Rakesh Bhardwaj	Principal Scientist (Biochemistry)
35	Dr Sandeep Kumar	Principal Scientist (Biochemistry)
36	Dr Rakesh Srivastava	Senior Scientist (Horticulture)
37	Dr Jyoti Kumari	Principal Scientist (Plant Breeding)
38	Dr Rashmi Yadav	Principal Scientist (Agronomy)
39	Dr Vinod Kumar Sharma	Senior Scientist (Vegetable Science)
40	Dr Vikender Kaur	Scientist (Economic Botany)
41	Dr Gayacharan	Scientist (Agrl. Biotechnology)
42	Dr Ruchi Bansal	Scientist (Plant Physiology)
43	Dr Kuldeep Tripathi	Scientist (Economic Botany and PGR)
44	Dr VS Meena	Scientist (Horticulture-fruit science)
45	Dr Mamta Singh	Scientist (Genetics and Plant Breeding)
46	Ms Sapna	Scientist (Biochemistry-Pl. Sci.)
47	Sh Nand Lal Meena	Scientist (Biochemistry-Pl. Sci.)
Division of Genomic Resources		
48	Dr Gurinderjit Randhawa	Principal Scientist (Plant Physiology) and OIC
49	Dr MC Yadav	Principal Scientist (Genetics / Cytogenetics)
50	Dr SS Marla	Principal Scientist (Biotechnology)
51	Dr MK Rana	Principal Scientist (Plant Breeding)
52	Dr Rakesh Singh	Principal Scientist (Biotechnology)
53	Dr Ambika Baldev Gaikwad	Principal Scientist (Biotechnology)
54	Dr Lalit Arya	Principal Scientist (Plant Biochemistry)
55	Dr Manjusha Verma	Principal Scientist (Plant Biochemistry)
56	Dr Sundeep Kumar	Principal Scientist (Biotechnology)
57	Dr Rajesh Kumar	Principal Scientist (Plant Biotechnology)
58	Dr S Rajkumar	Senior Scientist (Genetics / Cytogenetics)
59	Dr Amit Kumar Singh	Scientist Sr. Scale (Biotechnology)
60	Dr R Parimalan	Scientist Sr. Scale (Biotechnology)
61	Dr Monika Singh	Scientist Sr. Scale (Agrl. Biotechnology)
62	Dr Yasin Jeshima K	Scientist (Genetics)
63	Ms Sheel Yadav	Scientist (Biotechnology-Pl. Sci.)
64	Dr DP Wankhede	Scientist (Genetics)
Division of Germplasm Conservation		
65	Dr Veena Gupta	Principal Scientist (Economic Botany) and Head (Officiating)
66	Dr Neeta Singh	Principal Scientist (Plant Physiology)
67	Dr J Radhamani	Principal Scientist (Plant Physiology)
68	Dr Anjali Kak Koul	Principal Scientist (Economic Botany)
69	Dr Chithra Devi Pandey	Principal Scientist (Seed Science & Technology)
70	Dr Sushil Pandey	Principal Scientist (Seed Science & Technology)
71	Dr Vimala Devi	Senior Scientist (Genetics and Plant Breeding)
72	Dr Sherry Rachel Jacob	Senior Scientist (Seed Science & Technology)
73	Sh J Aravind	Scientist (Plant Genetics)

74	Ms Padmavati G Gore	Scientist (Economic Botany and PGR)
Tissue Culture and Cryopreservation Unit		
75	Dr Anuradha Agrawal	Principal Scientist (Economic Botany) and OIC
76	Dr Rekha Chaudhury	Principal Scientist (Economic Botany)
77	Dr Ruchira Pandey	Principal Scientist (Economic Botany)
78	Dr Neelam Sharma	Principal Scientist (Economic Botany)
79	Dr Sandhya Gupta	Principal Scientist (Economic Botany)
80	Dr Sangita Bansal	Principal Scientist (Agrl. Biotechnology)
81	Dr Vartika Srivastava	Scientist (Horticulture-Fruit Sciences)
82	Ms Gowthami R	Scientist (Genetics and Plant Breeding)
83	Dr Era Vaidya Malhotra	Scientist (Agrl. Biotechnology)
Policy Planning Unit		
84	Dr Pratibha Brahmi	Principal Scientist & Incharge
Agricultural Knowledge Management Unit		
85	Dr Sunil Archak	National Fellow & OIC
86	Ms M Priyadarshi	Scientist (Computer Application)
AICRN-PC		
87	Dr BS Phogat	Principal Scientist (Agronomy) and Network Coordinator
88	Dr HL Raiger	Principal Scientist (Agrl. Statistics)
Regional Station, Akola		
89	Dr Dinesh Chand	Senior Scientist (Economic Botany and PGR) OIC
90	Dr Sunil Shriram Gomashe	Scientist (Plant Breeding)
Regional Station, Bhowali		
91	Dr Mamta Arya	Scientist (Plant Genetics) &OIC
92	Dr KM Rai	Scientist (Fruit Sciences)
Base Centre, Cuttack		
93	Dr Dipti Ranjan Pani	Principal Scientist (Economic Botany) and OIC
94	Dr RC Mishra	Principal Scientist (Economic Botany)
Regional Station, Hyderabad		
95	Dr B Sarath Babu	Principal scientist (Agrl. Entomology) and OIC
96	Dr SK Chakrabarty	Principal Scientist (Plant Pathology)
97	Dr SR Pandravada	Principal Scientist (Economic Botany)
98	Dr V Kamala	Principal Scientist (Economic Botany)
99	Dr Natarajan Sivaraj	Principal Scientist (Economic Botany)
100	Dr Anitha Kodaru	Principal Scientist (Plant Pathology)
101	Ms P Pranusha	Scientist (Plant Genetics)
102	Dr Prasanna Holajjer	Scientist (Nematology)
Regional Station, Jodhpur		
103	Dr Omvir Singh	Principal Scientist (Plant Breeding) and OIC
104	Dr Kartar Singh	Scientist (Plant Pathology)
105	Dr Neelam Shekhawat	Scientist (Genetics and Plant Breeding)

Base Centre, Ranchi		
106	Dr SB Choudhary	Scientist (Genetics and Plant Breeding) & OIC
Regional Station, Shillong		
107	Dr Harish GD	Scientist (Genetics and Plant Breeding) & OIC
108	Dr Subarna Hajong	Scientist (Economic Botany and PGR)
Regional Station, Shimla		
109	Dr Mohar Singh	Principal Scientist (Plant Breeding) and OIC
110	Sh Badal Singh	Scientist (Economic Botany and PGR)
111	Sh Rahul	Scientist (PGR)
112	Dr Narendra Negi	Scientist (Fruit Sciences)
Regional Station, Srinagar		
113	Dr SM Sultan	
114	Dr SK Raina	Senior Scientist (Economic Botany) and OIC Scientist (Genetics and Plant Breeding)
Regional Station, Thrissur		
115	Dr Joseph John K	Principal Scientist (Economic Botany) and OIC
116	Dr M Latha	Principal Scientist (Plant Breeding)
117	Ms Suma A	Scientist (Economic Botany and PGR)

(ii) Technical staff in position as on 31st December 2018.

S.No.	Name	Designation
Division of Plant Exploration and Germplasm Collection		
1	Dr NS Panwar	Chief Technical Officer
2	Smt Rita Gupta	Technical Officer
3	Sh Om Prakash Dhariwal	Technical Assistant
4	Sh SK Sharma	Technical Officer
5	Ms Suman Meena	Technical Assistant
Germplasm Exchange Unit		
6	Sh SP Singh	Chief Technical Officer
7	Sh SS Ranga	Chief Technical Officer
8	Sh PC Binda	Technical Officer
9	Sh SK Ojha	Senior Technician
Division of Plant Quarantine		
10	Sh AK Maurya	Chief Technical Officer
11	Sh DS Meena	Chief Technical Officer
12	Sh Sunil Kumar	Senior Technical Assistant
13	Sh Naresh Kumar	Technical Assistant
14	Ms Sadhna	Technical Assistant
Division of Germplasm Evaluation		
15	Ms Poonam Suneja	Chief Technical Officer
16	Sh BL Meena	Chief Technical Officer
17	Sh Babu Ram	Assistant Chief Technical Officer

18	Sh BS Panwar	Assistant Chief Technical Officer
19	Sh YS Rathi	Assistant Chief Technical Officer
20	Sh OS Ahlawat	Senior Technical Officer
21	Sh Narendra Pal	Technical Officer
22	Sh RK Sharma	Senior Technical Officer
23	Sh SS Bhoj	Technical Officer
Division of Genomic Resources		
24	Dr SK Singh	Senior Technical Officer
25	Sh D Gautam	Senior Technical Officer
26	Sh Rohtash Singh	Technical Assistant
27	Ms Prakriti Sharma	Technical Assistant
28	Ms Kushaldeep Kaur Sodhi	Technical Assistant
Division of Germplasm Conservation		
29	Dr AD Sharma	Chief Technical Officer
30	Dr Rajvir Singh	Assistant Chief Technical Officer
31	Smt Smita Lenka Jain	Assistant Chief Technical Officer
32	Sh Satya Prakash	Technical Officer
33	Smt Nirmala Dabral	Technical Officer
34	Sh Lal Singh	Technical Assistant
35	Ms Anjali	Technical Assistant
Tissue Culture and Cryopreservation Unit		
36	Sh DK Nerwal	Assistant Chief Technical Officer
37	Sh Anang Pal	Assistant Chief Technical Officer
38	Sh Ramesh Chandra	Technical Officer
39	Sh DPS Meena	Senior Technical Officer
Agricultural Knowledge Management Unit		
40	Sh Rajiv Gambhir	Chief Technical Officer
41	Sh VK Mandal	Technical Assistant
Library		
42	Smt Sangita Tanwar	Assistant Chief Technical Officer
43	Sh Om Prakash	Senior Technical Officer
Director Technical Cell		
44	Sh AK Sharma	Technical Officer
45	Sh Abhay Sharma	Senior Technical Assistant
Vehicle Cell		
46	Sh Brahm Prakash	Technical Officer (Driver)
47	Sh Balwant Singh	Technical Officer (Driver)
48	Sh Wazir Singh	Senior Technical Assistant (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, Bhowali		
53	Dr PS Mehta	Assistant Chief Technical Officer
54	Sh Mohan Ram	Senior Technical Assistant (Driver)
55	Sh Gopal Singh	Technical Assistant (Driver)
Regional Station, Hyderabad		
56	Sh Babu Abraham	Assistant Chief Technical Officer
57	Sh R Gunashekharan	Technical Officer
58	Sh MAA Khan	Senior Technical Assistant (Driver)
59	Sh MV Reddy	Technical Assistant (Driver)
Regional Station, Jodhpur		
60	Sh Bhatta Ram	Technical Officer
Base Centre, Ranchi		
61	Sh AK Gupta	Senior Technical Officer
62	Sh Narendra Ram	Technical Officer (Driver)
Regional Station, Shimla		
63	Sh Ram Chander	Technical Assistant
64	Sh Dayal Singh	Senior Technical Assistant
65	Sh Joginder Singh	Senior Technical Assistant
Regional Station, Thrissur		
66	Sh S Mani	Assistant Chief Technical Officer
67	Sh R Ashokan Nair	Assistant Chief Technical Officer
68	Smt A Indra Devi	Assistant Chief Technical Officer
Others		
69	Ms Anshu	Unauthorized absence

(iii) Administrative staff in position as on 31st December 2018.

S. No.	Name	Designation
Establishment Section		
1	Sh Vivek Purwar	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	Assistant
7	Sh KC Kundu	Senior Clerk
8	Sh Arvind Kumar	Senior Clerk
9	Sh Dev Kumar	Senior Clerk
Accounts Section		
10	Smt Kamna Tandon	Administrative Officer
11	Smt Yashoda Rani	Assistant Administrative Officer

12	Sh Mahabir Singh Yadav	Assistant
13	Smt Madhu Chawla	Assistant
Stores		
14	Sh Dinesh Prasad	Assistant Administrative Officer
15	Sh Dinesh Sharma	Assistant
Purchase		
16	Sh Avdhesh Kumar	Assistant Administrative Officer
17	Sh Sanjay Dangwal	Assistant
Audit Section		
18	Sh KK Sharma	Senior Finance & Accounts Officer
19	Sh Mahesh Kumar	Finance & Accounts Officer
20	Sh Surender Kumar	Assistant
21	Smt Bharti Sharma	Assistant
22	Smt Vijaylakshmi Sharma	Assistant
23	Sh Prabal Dasgupta	Assistant
Pension & Records		
24	Smt Amrita Negi	Assistant
Director's Cell		
25	Smt Kanchan Khurana	Personal Secretary
Prof. PGR & GCD		
26	Sh Ganga Nand	Personal Secretary
Division of Plant Quarantine		
27	Smt V Vijayalakshmi	Personal Assistant
Division of Plant Exploration and Germplasm Collection		
28	Smt Urmila Singh	Personal Assistant
Division of Germplasm Evaluation		
29	Smt Neelam Khatri	Personal Assistant
Hindi Unit		
30	Smt Archna Raghav	Assistant Director (Official Languages)
Security		
31	Sh UC Sati	Security Officer
32	Sh Sandeep Gaur	Assistant (on Lien)
33	Ms Sanjoo Verma	Assistant
34	Sh Hemant Ankur	Assistant
Regional Station, Akola		
35	Sh Purushottam Dhoke	Assistant
36	Smt Smita D Karale	Lower Division Clerk
Regional Station, Bhowali		
37	Sh NS Patwal	Assistant Administrative Officer
Base Centre, Cuttack		
38	Sh SK Lal	Assistant

Regional Station, Hyderabad		
39	Smt Radha Rani	Assistant
40	Sh M Srinivasa Rao	Assistant
41	Sh P Suleiman	Senior Clerk
Regional Station, Jodhpur		
42	Smt Leela Sharma	Assistant
Regional Station, Shimla		
43	Smt Pratibha Bhatt	Assistant Administrative Officer
Regional Station, Shillong		
44	Smt Lakshmilian Kharnary	Assistant
Regional Station, Thrissur		
45	Sh S Bhadra Kumar	Assistant Administrative Officer

(iv) Skilled support staff in position as on 31st December 2018.

S. No.	Name
Director's Cell	
1	Sh Surender Kumar
2	Sh Hari Chand Paswan
Director's Technical Cell	
3	Om Prakash
DGEPC	
4	Smt Manju Devi
5	Smt Sharda Devi
Germplasm Exchange Unit	
6	Sh Arun Kumar
Division of Plant Quarantine	
7	Sh Suresh Chand Rai
8	Sh Sat Narayan Thakur
Division of Germplasm Evaluation	
9	Sh Mahesh Ram
10	Sh Kush Kumar
11	Sh Braham Dev Paswan
12	Sh Ram Kalit Rai
13	Sh Yatish Chandra
14	Smt Rukmani
15	Sh. Rajinder
Division of Genomic Resources	
16	Smt Agya Devi
17	Sh Ramesh Chand
TCCU	
18	Smt Geeta Devi
19	Sh Nand Kishore
20	Sh Chandeshwar Rai

S. No.	Name
AKMU	
21	Sh Lalu Rai
AICRN-PC	
22	Sh Mahadev Maurya
Library	
23	Sh Umesh Kumar
Despatch Section	
24	Sh Anant Swaroop
Accounts Section	
25	Sh Sanjeev Paswan
Audit Section	
26	Sh Sunil Kumar
27	Sh Yogesh Kumar
28	Sh Suresh Ram
Establishment	
29	Sh Roshan Lal
Experimental Farm, Issapur	
30	Sh Dhir Singh
31	Sh Mahabir Singh
Regional Station, Akola	
32	Sh SR Pacherwal
33	Sh RC More
34	Sh RP Barsse
35	Sh AD Godlinga
36	Sh MB Nikose
Regional Station, Bhowali	
37	Sh Anand Kumar

S. No.	Name
38	Sh GC Arya
39	Smt Tulsi Devi
Base Centre, Cuttack	
40	Sh Sarangdhar Barik
Regional Station, Hyderabad	
41	Mohd. Mazhar Pasha
42	Sh M Shankar
43	Sh E Satyanarayan
44	Sh MB Keshwa Raju
45	Sh M Srinivas
Regional Station, Jodhpur	
46	Sh DS Rajpurohit
Base Centre, Ranchi	
47	Sh Vijay Kumar
Regional Station, Shimla	
48	Sh Paras Ram
49	Sh Rohit
50	Sh Sukhdev
51	Sh Dalip Singh
52	Sh Inder Singh
Regional Station, Shillong	
53	Sh AK Deka
Regional Station, Thrissur	
54	Sh MK Prakassen

21.6 Staff transferred / superannuated / new appointments / promotions

21.6.1 Transfers

Dr. N Dikshit, Principal Scientist & OIC, RS Akola, was transferred to ICAR-IGFRI, Jhansi on 30th June 2018.

Dr. Bharat Bhushan, Scientist, ICAR-NBPGR, New Delhi was transferred to ICAR-IIMR, Ludhiana on 6th July 2018.

Dr. AK Misra, Principal Scientist & OIC, RS, Shillong was transferred to International Relations Section, ICAR, New Delhi, on 07th July 2018.

Dr. Vinay Mahajan, Principal Scientist, joined ICAR-NBPGR, New Delhi on 18th June upon transfer from ICAR-IIMR, Ludhiana.

Ms. Sapna, Scientist (Biochemistry), joined ICAR-NBPGR, New Delhi on 29th June upon transfer from ICAR-IIMR, Ludhiana.

Dr. Nand Lal Meena, Scientist (Biochemistry), joined ICAR-NBPGR, New Delhi on 02nd July 2018 from ICAR-IIMR, Ludhiana.

Dr. T. Boopathi, Senior Scientist (Entomology), joined ICAR-NBPGR, New Delhi on 16th July 2018 from ICAR-RC for NEH region, Mizoram.

Dr. Meena Shekhar, Principal Scientist, joined ICAR-NBPGR, New Delhi on 4th September 2018 from ICAR-IIMR, Ludhiana (Campus New Delhi).

21.6.2 Retirements

Dr. Shashi Bhalla, Principal Scientist, PQD & OIC, PME Cell retired on 31.01.2018.

Sh. EN Prabakaran, Senior Technician, RS, Thrissur retired on 28.02.2018.

Sh. BP Dahiya, CTO, Division of Germplasm Conservation retired on 31.03.2018.

Sh. Ram Nandan, Senior Technician, AICRN-PC, retired on 30.04.2018.

Sh. JK Singh, UDC, NBPGR HQ, retired on 30.04.2018.

Dr. Kalyani Srinivasan, Principal Scientist, DGC retired on 31.05.2018.

Dr. IS Bisht, Principal Scientist & OIC, RS Bhowali retired on 30.06.2018.

Dr. DB Parakh, Principal Scientist, DPQ, retired on 30.06.2018.

Sh. Bhagwan Singh Negi, SSS, RS, Shimla, retired on 31st August 2018.

Sh. Gopesh Pandey, Assistant, left ICAR service on 25th September 2018 (AN).

Dr Baleshwar Singh, Principal Scientist, PQD retired on 30th September 2018.

Sh. Abdul Rasheed, SSS, RS, Shillong, retired on 30th September 2018.

Sh. Thaneshwar Pokhrel Pandey, SSS, NBPGR, HQ, retired on 31st October 2018.

Dr. M. Abdul Nizar, Scientist (SG), RS, Thrissur retired on 30th November 2018.

Mr. Ramit Joshi, Sr. Technical Assistant, RS, Bhowali, retired on 30th November 2018.

Mrs. V. Vijayalakshmi, PA, DPQ, retired on 31st December 2018.

Sh. Rajender, SSS, Division of Germplasm Evaluation, retired on 31st December 2018.

21.6.3 Appointments

Ms. Kushaldeep Kaur Sodhi, joined at Divisoin of Genomic Resources as Technical Assistant.

Ms. Prakriti Sharma, joined at Division of Genomic Resources as Technical Assistant.

Ms. Suman Meena, joined at Division of Germplasm Exploration as Technical Assistant.

Ms. Anjali, joined at Division of Germplasm Conservation as Technical Assistant.

Ms. Sadhna, joined at Division of Plant Quarantine as Technical Assistant.

21.6.4 Promotions

Sh. R. Asokan Nair, promoted to the grade of ACTO at NBPGR-RS, Thrissur.

Sh. DS Meena, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Sh. BL Meena, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Smt.Indira Devi A, Promoted to the grade of ACTO at NBPGR, RS, Thrissur.

Dr. PS Mehta, Promoted to the grade of ACTO at NBPGR, RS, Bhowali.

Dr. NS Panwar, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Sh. Surender Singh, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Dr. AD Sharma, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Sh. AK Maurya, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Sh. Rajeev Gambhir, Promoted to the grade of CTO at NBPGR HQ, New Delhi.

Dr. Smita Lenka Jain, Promoted to the grade of ACTO at NBPGR HQ, New Delhi.

Smt. Sangeeta Gambhir, promoted to the grade of AAO at NBPGR HQ, New Delhi.

Sh. Sanjay Dangwal, promoted to the grade of Assistant at NBPGR HQ, New Delhi.

21.6.5 Obituaries

(Late) Smt. Satvinder Kaur, Assistant, HQ left for heavenly abode on 11.04.2018.

(Late) Sh. Ram Kishan, Supporting Staff of Bureau left for heavenly abode on 12.06.2018.

(Late) Sh. Basant Kumar, Supporting staff of Bureau left for heavenly abode on 03.08.2018.

(Late) Sh. Sandesh Kumar, Supporting staff of Bureau left for heavenly abode on 22.09.2018.

(Late) Smt. Laxmi Devi, Supporting staff of Bureau left for heavenly abode on 09.12.2018.

21.7 Award/ honours/ prizes during 2018

- **D.P. Wankhede** received Early Career Research Award (ECRA) from Science& Engineering Research Board (SERB), Department of Science and Technology, Government of India in the form of three year research project (2018-2021).

- **Parimalan R** received Dr RS Paroda Young Scientist award 2017 on 13th March 2018
- **Kamala Venkateswaran** and N. Sivaraj received the honour Top-25 List Awards-2018 – Certificate of Excellence (Scientist Category) by EET CRS –Research Wing for Excellence in Professional Education & Industry held at Hyderabad, Telangana on March 18, 2018.
- **Kamala Venkateswaran** received 'Dr APJ Abdul Kalam Life Time Achievement Award' instituted by IRDP Journals at Chennai on May 30, 2018.
- **Madhu Chawla**, Assistant and **Smita D Karle**, LDC were jointly awarded best employee award during ICAR-NBPGR Annual Day function.
- **Mool Chand Singh** received third ICAR Award in Inter-Institutional Hindi Essay writing competition held on October 23, 2018 at ICAR, New Delhi.
- **N Sivaraj** received 'Life Time Achievement Award' from IRDP Journals, Chennai on 30.05.2018.
- **Rahul**, Scientist RS-Shimla, received Green Maple foundation award-2018.
- **Vijay Singh Meena**, Scientist Sr. Scale, awarded by Young Scientist Award by SSDAT (Society for Scientific Development in Agriculture and Technology) in *International Conference* on "Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2018)" during 28–30 October, 2018 at Rajasthan Agriculture Research Institute, Durgapura, Rajasthan.
- **Yasin JK** conferred with Young Scientist award on the occasion of "International Conference on Rural Livelihood Improvement by Enhancing Farmer's Income through Sustainable Innovation Agri and Allied Enterprises" held from 30th October to 1st of November 2018 at Birla Institute of Technology, Patna.
- **Vinod Kumar**, Senior Scientist received Distinguished Scientist Award in the national conference on Promoting and reinvigorating agri-horti technological innovations held from Dec 15-16, 2018 at Jaipur.
- हिंदी पखवाड़ा के दौरान सितम्बर 18, 2018 को आयोजित प्रश्नमंच प्रतियोगिता में **संगीता बंसल** व **वर्तिका श्रीवास्तव** ने तृतीय पुरस्कार तथा **संध्या गुप्ता** व **वंदना त्यागी** ने सांत्वना पुरस्कार प्राप्त किया ।
- हिंदी पखवाड़ा के दौरान सितम्बर 25, 2018 को आयोजित श्रुतलेख प्रतियोगिता में **संध्या गुप्ता** ने द्वितीय तथा **डॉ संगीता बंसल** ने सांत्वना पुरस्कार प्राप्त किया ।
- **गौतमी आर** ने हिंदी पखवाड़ा के दौरान सितम्बर 14, 2018 को आयोजित वाद–विवाद प्रतियोगिता में सांत्वना पुरस्कार प्राप्त किया।
- **संध्या गुप्ता** ने हिंदी पखवाड़ा के दौरान सितम्बर 17, 2018 को आयोजित निबंध प्रतियोगिता में द्वितीय पुरस्कार प्राप्त किया ।
- **Prasanna Holajjer** (Scientist) received "Young Scientist Award-2018" by Society of Plant Protection Sciences, New Delhi on 20th December, 2018 at ICAR-NRCSS, Ajmer (Rajasthan) during 1st International Conference on "Climate Change and Adaptive Crop Protection for Sustainable Agri-horticulture Land Scape" for his significant contribution in the field of Nematology.

Other recognition

- **Anuradha Agrawal** elected as 'General Secretary' of the Indian Society of Plant Genetic Resources, New Delhi, for the period 2019-2021, w.e.f. Dec. 31, 2018.
- **Anuradha Agrawal,** invited by Asia Pacific Association of Agricultural Research Institutes (APAARI), Thailand to be Facilitator and

Rapporteur in the '*Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnership to Improve Livelihoods of Farmers in Asia Pacific* May 29-31, 2018 and to contribute in preparation of its proceedings.

- **Rekha Chaudhury,** nominated by ICAR as a member of 'Broad Subject Matter Area (BSMA)' committee for Plant Sciences on the recommendation of National Core Group. She visited Orissa University of Agriculture and Technology for participation in the 1st round meeting as a member of BSMA, June 18-20, 2018.
- **Rekha Chaudhury,** nominated as a member of 'Project Monitoring and Evaluation Committee' of National Certification System for Tissue Culture Raised Plants (NCSTCP) of Department of Biotechnology.
- **SC Dubey** was Chairman, Assessment Committee for Technicals at IARI, New Delhi (October 31, 2018).
- **SC Dubey** was Chairman, Poster Evaluation Committee during Special National Symposium on Extension Plant Pathology: Technical Backstopping to the farmers/other stakeholders at IGKV, Raipur during September 25 to 26, 2018.
- **Sandhya Gupta,** held the position of the '*Vice Chair of ISHS Commission of Plant Genetic Resources*' from 2014-2018 and received '*ISHS medal*' during the International Horticulture Congress (IHC 2018). She convened the '5th International Symposium on Plant Genetic Resources: Management and Utilization for Food Nutrition and Environmental Security' and chaired two technical sessions, Istanbul, Turkey, Aug. 13-14, 2018.
- **V Celia Chalam** is nominated as Expert Member by MoEF&CC for the Online Discussion on Public Awareness regarding Living Modified Organisms by the Secretariat of Convention on Biological Diversity, United Nations Environment Programme, Canada.
- **V Celia Chalam** is recognized as Member, APS Collections and Germplasm Committee, American Phytopathological Society, USA.
- **Veena Gupta**, was nominated as Member, Research Advisory Committee (RAC) of Directorate of Medicinal and Aromatic Plants, Anand, Gujrat by ICAR.

Best paper/poster/oral presentation

- **Nivedhitha S,** Anjula Pandey, Rakesh Bhardwaj and Ahlawat SP (2018). "*Flemingia procumbens* (Roxb.) Potential underutilized root tuber of Meghalaya, India- Scope for enhancing income of tribal farmers through food processing" during International Conference for Recent Advances in Food Processing Technology, Indian Institute of Food Processing Technology (August 17-19, 2018) Thanjavur, Tamil Nadu.
- **Raj Kiran**, Pardeep Kumar, Jameel Akhtar, Baleshwar Singh, Krishna Nair and Sunil Chandra Dubey received the 2nd Prize awarded for poster entitled "Development of multiplex PCR for simultaneous detection of *Alternaria brassicicola* and *Xanthomobnas campestris* pv. *campestris* from brassica seeds" during a special National Symposium on 'Extension Plant Pathology: Technological Backstopping to the Farmers/ Other Stakeholders' organized by Indian Phytopathological Society at Indira Gandhi Krishi Vishwavidyalaya, Raipur on Sep. 25-26, 2018.
- **Raj Kiran**, Pardeep Kumar, Jameel Akhtar, Baleshwar Singh, Krishna Nair and SC Dubey awarded Best Poster award for poster entitled 'Simultaneous detection of dark leaf spot and black rot pathogen of crucifers' presented in 1st International Conference on *'Climate Chnage and Adaptive Crop Protection for sustainable Agri-horticulture land scape*' organized by Society of Plant Protection Sciences, New

Delhi held at ICAR-NRC on Seed Spices, Ajmer on Dec. 20-22, 2018.

- **Rekha Chaudhury** *et al*., received *'Best poster award'* for the paper entitled "Post-harvest handling of pods, seeds and pollinia of selected orchid species" in 'National Conference on Floriculture for Rural and Urban Prosperity in the Scenario of Climate Change', Sikkim, Feb. 16-18, 2018.
- The poster entitled "Population dynamics of some plant parasitic nematodes in the rhizosphere of tuberose and marigold" (authors: **Holajjer, P.,** T. N. Saha, K. S. Girish, K. P. Singh, Deppak E Ebhad & K. V. Prasad) awarded best poster (2nd position) during the National Conference on "Floriculture for Rural and Urban Prosperity in the Scenario of Climate Change" held at CAE&PHT (CAU), Ranipool, Sikkim from 16-18 February, 2018.
- The poster entitled "Mapping the climate suitability using maximum entropy modelling approach for Dinanath grass (*Pennisetum pedicellatum* Trin.) cultivation in India" (authors: **Nilamani Dikshit,** Tejveer Singh, Natarajan Sivaraj, Seva nayak D and Geetanjali Sahay) awarded best poster award during National Symposium on Forage and Livestock based technological innnovations for doubling the farmers' income organised Range Management Society of India, Jhansi at Dharwad December 13-14, 2018.
- The poster entitled 'Reinvigorating small ethnic farmers through agri-biodiversity conservation, technology development and IPR protection in peninsular India' (authors: **S.R.Pandravada,** N. Sivaraj, Kamala Venkateswaran and B. Sarath Babu) was awarded Best Poster Award during Seminar on Sustainability of Small Farmer in Changing Agricultural Scenario, December 22, 2018, organized by Retired ICAR employees' Association, Hyderabad.
- **Yasin JK** conferred with Best Paper award on the occasion of "International Conference on Rural Livelihood Improvement by Enhancing Farmer's Income through Sustainable Innovation Agri and Allied Enterprises" held from 30th October to 1st of November 2018 at Birla Institute of Technology, Patna

21.8 Publications

21.8.1 Research papers

Agrawal A, A Pandey, KS Varaprasad, RK Tyagi and RK Khetrapal (2018) Regional expert consultation on underutilized crops for food and nutritional security in Asia and the Pacific. *Indian J. Pl. Genet. Resour.* **31(2):** 194-195.

Ahlawat SP, A Pandey, PK Malav, R Bhardwaj and OP Dhariwal (2018) A less-known vegetable melon landrace "Arya" (*Cucumis melo* L.) from Rajasthan and Haryana, India: morphological, biochemical and taxonomic study. *Genet. Resour. Crop Evol.* **65:** 2037-2047.

Arivalagan M, R Bhardwaj, S Padmanabhan, P Suneja, K B Hebbar and S Kanade (2018) Biochemical and nutritional characterization of coconut (*Cocos nucifera L. haustorium*). *Food Chemistry* **238**: 153-159.

Arumugam M, A Pillai, J Chandran, S Chaudhary, BK Mishra, V Gandhi, N Verma, N Singh, C Vanniyarajan, TN Arumugam, AK Singh and JK Yasin (2018) DG (RG) 55-High yielding short duration dwarf line of pigeonpea. *Journal of AgriSearch*. Mar 5;5(01).

Arun Kumar P, Ravinder Reddy K, Reddy, RVSK, Pandravada SR and Saidaiah P (2018). Comparative performance of dual purpose tomato hybrids for yield and processing traits. *Journal of Pharmacognosy and Phytochemistry*. **7 (1):** 828-835.

Baite, MS and SC Dubey (2018) Pathogenic variability of *Ascochyta rabiei* causing blight of

chickpea in India. *Physiological and Molecular Plant Pathology* 102: 122-127.

Banerjee S, SS Gill, BH Gawade, PK Jain, K Subramaniam, and A Sirohi (2018) Host delivered RNAi of two cuticle collagen genes, *Micol-1* and *Lemmi-5* hampers structure and fecundity in *Meloidogyne incognita. Frontiers in Plant Science,* doi: 10.3389/ fpls.

Bansal S, S Thakur, M Mangal, AK Mangal and RK Gupta (2018) DNA barcoding for speciûc and sensitive detection of *Cuminum cyminum* adulteration in *Bunium persicum*. *Phytomedicine* **50**: 178-183.

Bashyal BM, BS Kharayat, J Kumar, SC Dubey and R Aggarwal (2018) Histopathological studies of *Rhizoctonia solani* infection process in different cultivars of mungbean [Vigna radiata (L.) Wilczek]. *National Academy Science Letters* https://doi.org/10.1007/s40009-018-0669-3.

Bhardwaj J, P Pandey and A Pandey (2018) Study on local storage methods in some *Allium* species in India. *J. Allium Research*, **1(1):** 51-56.

Bhardwaj V, Dalamu, A K Srivastava, S Sharma, V Kumar, S K Kaushik, R Singh, R K Singh, S K Chakrabarti (2018) Late blight resistance status in wild potato species against Indian population of *Phytophthora infestans. Indian. J Hort.* **75(1):** 99-104.

Bhatt KC, PK Malav and SP Ahlawat (2018) 'Jumin' a traditional beverage of Nocte tribe in Arunachal Pradesh: an ethnobotanical survey**.** *Genet. Resour. Crop Evol.* **65**:671–677.

Bisht IS (2018). Food-based approaches towards community nutrition and health: A case of Uttarakhand hills in north-western India. *J Food Sci Toxicol*, **2**:5.

Bisht IS, PS Mehta, KS Negi, R Rawat, R Singh, and SC Garkoti (2018) Wild plant food resources in agricultural systems of Uttarakhand hills in India and its potential role in combating malnutrition and enhancing human health. *J Food Sci Toxicol*, **2**:3.

Bisht IS, PS Mehta, KS Negi, SK Verma, RK Tyagi and SC Garkoti (2018) Farmers' rights, local food systems and sustainable household dietary diversification: A case of Uttarakhand Himalaya in north-western India. *Agroecology and Sustainable Food Systems,* **42**:73-113. DOI:10.1080/21683565.2017.1363118.

Bisht, IS, PS Mehta, SK Verma, and KS Negi (2018) Traditional land and food systems: A case of Uttarakhand State in North-western Indian Himalayas. *Indian J. Plant Genet. Resour.,* **31**: 215–230. DOI 10.5958/0976-1926.2018.00026.8.

Chalam VC and AK Maurya (2018) Role of quarantine in ensuring biosecurity against transboundary plant viruses. *Agricultural Research Journal* 55 **(4):** 612-626.

Chand D, N Dikshit, N Sivaraj, SS Gomashe and MA Nizar (2018) Diversity assessment in *Abelmoschus tuberculatus*. A DIVA-GIS study. *Journal of Environmental Biology.* **39:** 426-431.

Choudhary R, SK Malik and R Chaudhury (2018) Development of an efficient cryoconservation protocol for Himalayan mulberry (*Morus laevigata* Wall. ex Brandis) using dormant axillary buds as explants. *Indian J. Exp. Biol.* **56**: 342-350.

Dhananivetha M, T Ragavan, R Gowthami, KV Raghavendra and S Gangadharan (2018) Farmers traditional practices for pre and post-harvest pest control in crop production. *Int. J Agric. Sci.* **10**: 5350-5352.

Djanaguiraman M, PVV Prasad, J Kumari, Z Rengel (2018) Root length and root lipid composition contribute to drought tolerance of winter and spring wheat. *Plant and Soil*. 1-17. https://doi.org/10.1007/s11104-018-3794-3.

Dubey SC, A Tripathi, and R Tak (2018) Expression of defense-related genes in mung bean varieties in response to *Trichoderma virens* alone and in the presence of *Rhizoctonia solani* infection. *3 Biotech.* **8:**432.

Dubey SC, B Singh and A Tripathi (2018) Integrated management of wet root rot, yellow mosaic, and leaf crinkle diseases of urdbean by seed treatment and foliar spray of insecticide, fungicide, and biocontrol agent. *Crop Protection.* **112:** 269–273.

Elayaraja K, R N Gadag, J Kumari, U Mishra (2018) Combining ability and gene action in experimental hybrids of Sweet Corn (*Zea mays* var. *saccharata*). *Indian Journal of Horticulture*. **75(1):** 64-69.

Gautam NK, R Bhardwaj, S Yadav, P Suneja, K Tripathi and B Ram (2018) Identification of lentil (*Lens culinaris* Medik.) germplasm rich in protein and amino acids for utilization in crop improvement. *Indian J. Genet.* **78(4):** 470-477.

Gayacharan, IS Bisht, A Pandey, MC Yadav, AK Singh, SR Pandravada, and JC Rana (2018) Population structure of some indigenous aromatic rice (*Oryza sativa* L.) landraces of India. *Indian Journal of Biotechnology* **17(1):** 110-117.

Gupta K, S Bhalla, SP Singh and DS Meena (2018) Seed beetles intercepted in imported legume germplasm from 2001- 2015 *Legume Research* **41(4):** 629-635.

Henry R, A Furtado and R Parimalan (2018) Wheat seed transcriptome reveals genes controlling key traits for human preference and crop adaptation. *Curr. Opin. Plant Biol*. **45:** 231-236.

Hiremani, NS and SC Dubey (2018) Race profiling of *Fusarium oxysporum* f. sp. *lentis* causing wilt in lentil. *Crop Protection* **108:** 23-30.

Holajjer P, R Dey, KK Pal, K Chakraborty, G Harish, MV Nataraja and E Deepak (2018) Assessment of nematicidal properties of fluorescent pseudomonads using peanut root-knot nematode, *Meloidogyne arenaria*. *Journal of biological Control* **32 (3):**193-202.

Holajjer P, TN Saha and KS Girish (2018) Bio-efficacy of *Bacillus subtilis* in the management of root-knot nematode, *Meloidogyne incognita* infesting tuberose. *Annals of Plant Protection Sciences* **26(2):** 393-395.

Holajjer P, TN Saha, KS Girish, KP Singh and E Deepak (2018) Population dynamics of some plant parasitic nematodes in the rhizosphere of tuberose and marigold. *HortFlora Res. Spectrum* **7(2):**149-151.

Indhu SM, C Vanniyarajan, K Monisha, P Magudeeswari, KR Ramya and R Gowthami (2018) Genetic divergence among pigeonpea genotypes using mahalonobis D^2 statistics. *Int. J. Curr. Microbiol. App. Sci.* **7:** 510-514.

Jain A, Z Hussain, RP Yadav and R Bhardwaj (2018) Effect of carbendazim on *in vitro* conservation and genetic stability assessment in *Curcuma longa* and *Zingiber officinale*. *Journal of Herbs, Spices & Medicinal Plants*. DOI: 10.1080/ 10496475.2017.1423528

Joo, GN, SK Raina and SM Sultan (2018) *Eruca sativa* Mill. - A neglected naturalized wild multipurpose plant of Kashmir. *Journal of Indian Botanical Society* **97(3&4):** 153-157.

Jyothi reddy K, BN Prabhakar, P Saidaiah and SR Pandravada (2018) Genetic divergence, variability, heritability and genetic advance for growth, pod quality and yield characters in dolichos bean (*Dolichos lablab* L.var. *typicus* Prain) germplasm. *Legume Research*. **41(6):** 804-809.

Jyothi reddy K, BN Prabhakar, P Saidaiah, and SR Pandravada (2018) Correlation and path coefficient analysis in dolichos bean (*Dolichos lablab* L. var. *typicus* Prain) genotypes. *Journal of Pharmacognosy and Phytochemistry*. **7(2):** 1207-1212.

Kadamanda R and S Natarajan (2018) Salinity influence on soil pH and EC in roselle landraces (*Hibiscus sabdariffa* L.). *Green Farming.* **9(1):** 151-153.

Kamala V, N Sivaraj, S R Pandravada and B Sarath Babu (2018) *In-situ* Assessment of Diversity in Sugandapala (*Hemidesmus indicus* (L) R. Br.) with special reference to leaf traits. *Int J Ayu Pharm Chem.* **8(2):** 1-12.

Katyal M, AS Virdi, N Singh, A Kaur, JC Rana, J Kumari (2018) Diversity in protein profiling, pasting, empirical and dynamic dough rheological properties of meal from different *durum* wheat accessions. *Journal of Food Science and Technology* **55(4):** 1256-1269.

Kaur V, J Kumari, Manju, SR Jacob and BS Panwar (2018) Genetic diversity of indigenous and exotic germplasm of barley (*Hordeum vulgare* L.) and identification of trait specific superior accessions. *Wheat and Barley Research* **10(3):** 190-197.

Kaur V, S Kumar, R Yadav, DP Wankhede, J Aravind, J Radhamani, JC Rana and A Kumar (2018) *Analysis of genetic diversity in Indian and exotic linseed germplasm* and identification of trait specific superior accessions. *Journal of environmental biology* **39 (5): 702-709.**

Kavya P, M Sujatha, SR Pandravada and TV Hymavathi (2018) Determination of protein and carbohydrate content and its correlation with grain yield in foxtail millet germplasm. *Int. J. Curr. Microbiol. App. Sci.* **7(6):** 363-367.

Khan Z, NK Gautam, BH Gawade and SC Dubey (2018) Evaluation of cowpea (*Vigna unguiculata* L.) germplasm for resistance to root-knot nematode, *Meloidogyne incognita. Nematropica* **48(1):**23-27

Kumar C, SK Singh, KK Pramanick, MK Verma, M Srivastav, R Singh, C Bharadwaj, KC Naga (2018) Morphological and biochemical diversity among the *Malus* species including indigenous Himalayan wild apples. *Scientia Horticulturae* **233:** 204–219.

Kumar P, J Akhtar, A Kandan, B Singh, R Kiran, K Nair, SC Dubey (2018) Efficacy of URP and ISSR markers to determine diversity of indigenous and exotic isolates of *Curvularia lunata. Indian Phytopathology* **71 (2):** 235-242.

Kumar S, AK Choudhary, KS Rana, A Sarker, M Singh (2018) Bio-fortification potential of global wild annual lentil core collection. *PLoS ONE*, **13(1):** DOI: e0191122.

Kumar S, J Kumari, R Bansal, B R Kuri, D Upadhyaya, A Srivastava, B Rana, M K Yadav, R S Senger, A K Singh and R Singh (2018) Multi-environmental evaluation of wheat genotypes for drought tolerance. *Indian J Genet.* **78(1):** 26-35.

Kumar S, S Vats, P Barman, R Parimalan, R Kumari, P Bangar, B Tiwari, S Sachdeva and KV Bhat (2018) Morpho-physiological studies on moisture deficit stress tolerance in F2:3 population of muskmelon (*Cucumis melo* L.). *Electronic J. Plant Breed*. **9(3):** 879-893.

Kumari J, S Kumar, N Singh, SS Vaish, S Das, A Gupta and JC Rana. (2018) Identification of New Donors for Spot Blotch Resistance in Cultivated Wheat Germplasm. *Cereal Research Communications.* **46(3):** 467–479. DOI: 10.1556/0806.46.2018.028.

Kumari S, N Arumugam, R Singh, M Srivastav, S Banoth, AC Mithra, MB Arun, AK Goswami, Jeshima Khan Yasin. 2018. Diversity analysis of guava (*Psidium guajava*) germplasm collection. *Ind. J. Agri. Sci*. **88(3):** 489-497

Mangal AK, D Tewari, TR Shantha, S Bansal and M Mangal (2018) Pharmacognostical standardization and HPTLC fingerprinting analysis of *Crocus sativus* L. *Indian J. Traditional Knowledge* **17**: 592-597.

Manju KP, K Vijaya Lakshmi, B Sarath Babu and K Anitha (2018) Evaluation of okra germplasm for their reaction to whitefly, *Bemisia tabaci* and *Okra yellow vein mosaic virus* (OYVMV). *J Ento. and Zoology Studies.* **6**: 2491-2496.

Misra RC, DR Pani, P Kumar and P Das (2018) Vegetation mapping and management strategy of mangroves of Bhitarkanika wildlife sanctuary, Odisha: A remote sensing approach. *E-planet* 16 (2):89-101.

Mohan H, L Arya, M Verma, IS Bisht, D Saha and BS Dhillon (2018) Morpho-molecular Variation in Indian Finger Millet (*Eleusine coracana* (L.) Gaertn.) Varieties and Landraces. *Indian J. Pl. Genet. Resour*. **31(3):** 276–285. DOI 10.5958/0976-1926.2018.00032.3

Motha K, SK Singh, AK Singh, R Singh, M Srivastav, MK Verma and C Bhardwaj (2018) Molecular Characterization and Genetic Relationships of Some Stress Tolerant Grape Rootstock Genotypes as Revealed by ISSR and SSR Markers. *Pl Tissue Cult & Biotechnol.* **28(1):** 77-90.

Nagar A, AK Sureja, A Kar , R Bhardwaj , SG Krishnan and AD Munshi (2018) Profiling of Mineral Nutrients and Variability Study in Pumpkin (*Cucurbita moschata*) Genotypes *Agric Res*. https://doi.org/10.1007/s40003-018-0329-3

Negi KS, A Pandey , AJ Gupta, JK Singh and B Lepcha (2018) Notes on the distribution of a rare and little known species: *Allium fasciculatum* Rendle from Sikkim and West Bengal. *Indian J. Pl. Genet. Resour.* **31:** 97-100.

Nemappa L, SK Malik, S Kaur, R Choudhary, MR Rohini, KV Bhat and R Chaudhury (2018). Physico-chemical diversity analysis in lime [*C. aurantiifolia* (Christm.) Swingle], lemon (*C. limon* Burm. f.) and hill lemon (*C. pseudolimon* Tan.) species collected from the foothills of Himalaya, India. *Int. J. Curr. Microbiol. App. Sci.* **7:** 3220-3227.

Nirmal RC, AK Singh**,** A Furtado, R Henry (2018) Analysis of the expression of transcription factors and other genes associated with aleurone layer development in wheat endosperm. *J. Cereal Sci*. https://doi.org/10.1016/j.jcs.2018.11.010

Pandey A, K Pradheep and R Gupta (2018) Two-leaf nightshade (*Solanum diphyllum* L.)- An addition to the flora of Delhi, India and weed risk assessment of the species. *Indian J. Pl. Genet. Resour.* **31(2):** 164-168.

Pandey A, P Malav, K Pradheep, KS Negi and R Pandey (2018) An underutilized species *Allium fasciculatum* Rendle "Shanu Dungdunge" (subgenus Amerallium, section Bromatorrhiza) from North eastern India: study on variability, eco-geography and domestication trends. *Genetic Resour. Crop Evol.* **65**: 1049-1058.

Pandit E, RK Panda, DR Pani, R Chandra, S Singh, SK Pradhan (2018) Molecular marker and phenotypic analyses for low phosphorus stress tolerance in cultivars and landraces of upland rice under irrigated and drought situations. *Indian J. Genet*. **78 (1):** 59-68.

Pang J, H Zhao, R Bansal, E Bohuon, H Lambers, M Ryan and K H M Siddique (2018) Leaf transpiration plays a role in phosphorus acquisition among a large set of chickpea genotypes. *Plant Cell Environ* DOI:10.1111/pce.13139.

Pang J, R Bansal , H Zhao , E Bohuon , H Lambers , M Ryan , K Ranathunge and K H M Siddique (2018) The carboxylate-releasing phosphorus-mobilising strategy can be proxied by foliar manganese concentration in a large set of chickpea germplasm under low phosphorus supply. *New Phytol* DOI: 10.1111/nph.15200.

Pedapati A, SK Yadav, V Tyagi, SP Singh, SS Ranga, PC Binda and P Brahmi (2018) Ornamental Germplasm: Potential New Resources for Floriculture Industry. *Int. J. Curr. Microbiol. App. Sci* 7(12): 1731-1742.

Peer SS, P Syam Sundar Reddy, S Sadarunnisa, DS Reddy and SR Pandravada (2018) Genetic divergence in field bean (*Lablab purpureus* L.) genotypes. *Plant Archives*. **18**(1): 690-692.

Pradhan SK, E Pandit, SP Mohanty, RK Panda, D Panigrahi, and D Pani (2018) Simultaneous mapping of multiple QTLs and complex traits in rice: Association mapping-indispensable for effective molecular breeding. *Oryza*, Vol.55 (Special Issue) (18-23).

Pradheep K, A Pandey, ER Nayar, Soyimchiten, SP Ahlawat and R Gupta (2018) Extended Naturalization Records of Five Non-Native Plant Species to Indian States. *Indian J. Plant Genet. Resour.* 31(1): 72-77.

Pradheep K, M Singh, S Mohmmad, K Singh, Parimalan and SP Ahlawat (2018) Diversity in wild relatives of wheat - An expedition collection from cold-arid Indian Himalayas. Genetic Resour Crop Evolution, DOI:10.1007/s10722-018-0706-6

Pragya, B Singh, PM Singh, JK Ranjan, V Sagar, R Bhardwaj and CD Pandey (2018) Flower and fruit colour variability in Indian spinach (*Basella alba*). *Vegetable Science* **45 (1)**: 116-117.

Pragya, B Singh, PM Singh, JK Ranjan, V Sagar, R Bhardwaj and CD Pandey (2018) Flower and fruit colour variability in Indian spinach (*Basella alba*). *Vegetable Science* **45(1):** 116-117.

Raina AP and RC Misra (2018) Chemical evaluation of *Mucuna* species for L-dopa content- an anti-Parkinson's drug yielding medicinal plant from India. *Indian J. Trad.Knowledge* **17 (1):**148:154.

Raina AP and V Gupta (2018) Chemotypic characterization of diversity in essential oil composition of *Ocimum* species and varieties from India. *Journal of Essential Oil Research:* **30(6):** 1-13.

Rajashekar Reddy D, P Saidaiah, K Ravinder Reddy, S R Pandravada and A Geetha. 2018. Genetic variability for growth, pod and quality attributes in germplasm of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.). *Legume Research*.

Ranjan JK, AK Chakrabarti, SK Singh and Pragya (2018) Callus mediated regeneration through cotyledonary and hypocotyl explants in chilli (*Capsicum annuum* L.) *Vegetable Science* **45 (1):** 73-78.

Reddy MT, N Sivaraj, V Kamala, SR Pandravada, N Sunil and N Dikshit (2018) Classification, characterization and comparison of aquatic ecosystems in the landscape of Adilabad district, Telangana, Deccan region, India. *Open Access Library Journal*. **5**: e4459.

Saabale PR, SC Dubey, P Kumari and TR Sharma (2018) Analysis of differential transcript expression in chickpea during compatible and incompatible interactions with *Fusarium oxysporum* f. sp. *ciceris* Race 4. *Biotech 3*, 8:111.

Semwal DP, SP Ahlawat and K Pradheep (2018) Pigeonpea (*Cajanus cajan* (L.) Millsp.] and its wild spp. Germplasm Collection Status, Diversity Distribution and Trait-Specific Germplasm Mapping using GIS Tools in India. *Legume Res.* **41(5):** 656-662.

Singh AK, S Chaurasia, S Kumar, R Singh, J Kumari, MC Yadav, N Singh, S Gaba, SR Jacob (2018) Identification, analysis and development of salt responsive candidate gene based SSR markers in wheat. *BMC Plant Biology*. **18(1):** 249.

Singh B, J Akhtar, A Kandan, P Kumar, D Chand, AK Maurya, PC Agarwal, SC Dubey (2018) Risk of pathogens associated with plant germplasm imported into India from various countries. *Indian Phytopathology* **72(1):**91-102.

Singh BK, SB Choudhary, S Yadav, EV Malhotra, R Rani, S Ambawat, Priyamedha, A Pandey, R Kumar, S Kumar, HK Sharma, DK Singh, PK Rai (2018) Genetic structure identification and assessment of interrelationships between Brassica and allied genera using newly developed genic-SSRs of Indian Mustard (*Brassica juncea* L.). *Ind. Crops & Products* **113:** 111–120.

Singh I, KGV Anand, S Solomon, SK Shukla, R Rai, ST Zodape and A Ghosh (2018) Can we not mitigate climate change using seaweed based biostimulant: A case study with sugarcane cultivation in India. *Journal of Cleaner Production* **204**: 992-1003.

Singh I, RR Verma and TK Srivastava (2018) Growth, yield, irrigation water use efficiency, juice quality and economics of sugarcane in Pusa hydrogel application under different irrigation scheduling. *Sugar Tech*. **20(1):** 29-35.

Singh M, RK Bhoge and GJ Randhawa (2018) Loop-mediated isothermal amplification for detection of endogenous *Sad1* gene in cotton: An internal control for rapid on-site GMO testing. *J AOAC Int.* **101(5):**1657-1660.

Singh M, RK Bhoge, S Nain and GJ Randhawa (2018) Loop-mediated isothermal amplification: A rapid detection method for rice actin and nopaline synthase promoters in genetically modified crops.

J Pl. Biochem. & Biotech. https://doi.org/10.1007/s13562-018-0479-1.

Singh M, SK Sharma, B Singh, N Malhotra, R Chandora, A Sarker, K Singh and Dorin Gupta (2018).Widening the genetic base of cultivated gene pool following introgression from wild *Lens* taxa. *Plant Breeding* doi: 10.1111/pbr.12615

Singh MC, BS Phogat and I Singh (2018) Effect of herbicides on weed control and yield of maize. *International J. Sci., Environ. and Tech.* **7(2):** 728 – 731.

Singh OV, K Singh and N Shekhawat (2018) Quantitative GXE Interaction Estimation in the Germplasm of Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] in the Hot Arid Climate of Rajasthan. *Int.J.Curr.Microbiol.App.Sci.,* **7(10):** 3152-3158.

Singh OV, N Shekhawat and K Singh (2018). Stabilty Analysis for Yield and Yield Component Traits in Cowpea (*Vigna unguiculata* L. Walp) Germplasm in Hot Arid Climate. *Legume Res.,* DOI: 10.18805/LR-4044

Singh OV, N Shekhawat, K Singh and R Gowthami (2018) Assessment of Genetic Variability and Inter-Character Association in the Germplasm of Cowpea (*Vigna unguiculata* L. Walp) in Hot Arid Climate. *Legume Res*. DOI: 10.18805/LR-3983

Singh OV, Neelam Shekhawat, Kartar Singh and Gowthami, R. (2018) Genetic Divergence Studies in Cowpea [*Vigna unguiculata* (L.) Walp.] Germplasm using Mahalanobis D^2 Analysis. *Int. J. Curr. Microbiol. App. Sci*. **7(03):** 2616-2624.

Singh OV, R Gowthami, K Singh and N Shekhawat (2018) Assessment of Inter Characters Associations in the Germplasm of Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] Over Five Years in Hot Arid Climate of Rajasthan, India. *Int. J. Curr. Microbiol. App. Sci.* **7(**01): 3133-3149.

Singh OV, R Gowthami, K Singh and N Shekhawat (2018) Genetic Divergence Studies in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] Based on Principal Component Analysis. *Int. J. Curr. Microbiol. App. Sci*. **7(06):** 522-527.

Singh OV, R Gowthami, N Shekhawat and K Singh (2018) Genetic Divergence Studies in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] Germplsam Using Mahalanobis D^2 Analysis Over Five Years in Hot Arid Climate of Rajasthan. *Int. J. Curr. Microbiol. App. Sci*. **7**(06): 515-521.

Singh P, J Prakash, AK Goswami, K Singh, Z Hussain, AK Singh (2018) Genetic variability and correlation studies for vegetative, reproductive and yield attributing traits in papaya. *Ind. J. Horti.* 75:1-7

Srivastava S, P Saidaiah, N Sivaraj and K Ravinder Reddy (2018) Correlation and path analysis studies of yield and yield components in brinjal (*Solanum melongena* L.). *J. Pharmacognosy and Phytochem.* **7(6):** 1910-1914.

Sultan SM, N Dikshit, CS Mohanty, PK Rout and SK Raina (2018) Biochemical evaluation of dent corn (*Zea mays* L.) genotypes cultivated under rainfed conditions in the hills of north western Indian Himalayan state of Jammu and Kashmir. *J. Applied and Natural Sci.* **10(1):** 196- 201.

Sundaresha S, S Sharma, RK Shandil, S Sharma, V Thakur, V Bhardwaj, SK Kaushik, BP Singh and SK Chakrabarti (2018) An insight into the downstream analysis of RBgene in F1 RB potato lines imparting ûeld resistance to late blight. *Functional Plant Biology:* DOI:10.1071/FP17299.

Thimmaiah MR, SB Choudhary, HK Sharma, AA Kumar, H Bhandari, J Mitra, PG Karmakar (2018) Late-acting self-incompatibility: a barrier to self fertilization in sunnhemp (*Crotalaria juncea* L.). *Euphytica* . 214:219 https://doi.org/10.1007/s10681-017-2096-9.

Tripathi K, PG Gore, Gayacharan, S Kumar, S Bhalla and IS Bisht (2018) Population Structure and Genetic Diversity of Wheat Landraces from North-western Indian Himalaya, *Indian J. Plant Genet. Resour.* **31(2):** 169-177.

Trivedi AK, L Arya, SK Verma, RK Tyagi and A Hemantaranjan, M Verma, VP Singh and D Saha (2018) Molecular profiling of foxtail millet (*Setaria italica* (L.) P. Beauv) from Central Himalayan region for genetic variability and nutritional quality. *J. Agricul. Sci.* 333-341

Wankhede DP, J Aravind and SP Mishra (2018) Identification of Genic SNPs from ESTs and Effect of Non-synonymous SNP on Proteins in Pigeonpea. Proc. Natl. Acad. Sci., India. *Sect. B Biol. Sci.* https://doi.org/10.1007/s40011-018-0973-1.

Yadav S, C Ram, S Singh and MK Rana (2018) Plant Genomic DNA Isolation – the Past and the Present, a Review, *Ind. J. Pl. Genet. Resour.* 31(3):315–327.

Yasin JK, BK Mishra, C Sakshi, V Nidhi, AK Singh (2018) Balanced gene expression: network of genes in legumes. *Journal of AgriSearch*.**5(2):**83-9.

21.8.2 Books

Agrawal A, SK Kaushik, S Kumar, S Rajkumar and K Singh (eds) (2018) *Compendium for 'Training Program on Management of Plant Genetic Resources'.* ICAR-National Bureau of Plant Genetic Resources, New Delhi, March 6-19, 2018, 227 p.

Agrawal PK and Sherry Rachel Jacob (2018) *Techniques in seed science and technology, 3rd Edition,* Brillion publishing, New Delhi, 328p.

Bhalla S, VC Chalam, B Singh, K Gupta and SC Dubey (2018) *Biosecuring Plant Genetic Resources in India: Role of Plant Quarantine.* ICAR-National Bureau of Plant Genetic Resources, New Delhi, 216 p +vi. ISBN 978-81-937111-1-8

Bhalla S, VC Chalam, Z Khan, B Singh and SC Dubey (eds) (2018) *Potential Quarantine Pests for India in Tropical and Sub-tropical Fruit Crops*. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India. 510 p +x. ISBN 978-81-937111-0-1

Chalam VC, SC Dubey, C Murali Krishna, S Bhalla and Kuldeep Singh (eds) (2018) *Transboundary Movement of Living Modified Organisms: Strengthening Capacities of Enforcement Agencies*. ICAR-National Bureau of Plant Genetic Resources and Ministry of Environment, Forest and Climate Change, New Delhi, India. vi+159 p. ISBN 978-81-937111-2-5.

Gupta K, S Archak, K Pradheep, S kumar, Sheery R Jacob, V Tyagi, M K Rana, Sandhya Gupta, Jyoti Kumar, G J Randhawa and Kuldeep Singh (2018). ICAR-NBPGR: Bridging Science with Service (2012-2018), ICAR-NBPGR, New Delhi, 74 p

Rajkumar S, S Kumar, SK Kaushik and A Agrawal (eds) (2018) *Compendium for 'National Training Course on Contemporary Approaches to Plant Genetic Resources Management'*. ICAR-National Bureau of Plant Genetic Resources, New Delhi, Nov. 27-Dec. 17, 2018, 170p.

Rana JC, Rameshwar Singh, Dayal Singh, Rahul Chandora, Mohar Singh. (2018) *Traditional Crops-Pillars of Foods & Nutrition Security*, pp 1- 39.

Tripathi K, R Bhardwaj, S Bhalla, V Kaur, R Bansal, R Yadav, KK Gangopadhyay, A Kumar and R Choudhary (2018) PGR Evaluation: Principles and Procedures, Indian Council of Agricultural Research- National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi, vi+50 p.

Tyagi RK, A Agrawal, A Pandey, KS Varaprasad, RS Paroda and RK Khetarpal (2018) Proceedings and Recommendations of 'Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific'. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, November 13-15, 2017, ix + 56p.

Tyagi RK, A Pandey, A Agrawal, KS Varaprasad, RS Paroda and RK Khetarpal (2018) Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific – Thematic, Strategic Papers and Country Status Reports. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, November 13-15, 2017, x+349 p.

Tyagi RK, A Agrawal, A Kodaru, KS Varaprasad, and RK Khetarpal (2018) *Regional Expert Consultation on Agricultural Biotechnology – Scoping Partnerships to Improve Livelihoods of Farmers in Asia and the Pacific - Proceedings and Recommendations.* Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand; May 29-31, 2018, xviii+62 p.

Tyagi RK, K Anitha, A Agrawal, KS Varaprasad, RK Khetarpal (eds) (2018) *Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnership to Improve Livelihoods of Farmers in Asia Pacific – Strategic Papers and Country Status Reports.* APAARI, Bangkok, Thailand, May 29-31, 2018, xviii+258 p.

21.8.3 Chapters in books, Review Articles, Proceedings, Bulletin, Manuals etc.

Ahlawat SP and S Nivedhitha (2018) Agrobiodiversity Index: Role in Germplasm collection and conservation Training program on management of plant genetic resources, ICAR-NBPGR, New Delhi, pp 61-66.

Akhtar J, B Singh, P Kumar, A Kandan and SC Dubey (2018) Fungi of quarantine significance in tropical and sub-tropical fruit crops. *In: Potential Quarantine Pest for India in Tropical and Sub-Tropical Fruit Crops* (Eds.S Bhalla, VC Chalam, Z Khan, B Singh and SC Dubey). ICAR- National Bureau of Plant Genetic Resources, New Delhi, pp 204-251.

Akhtar J, VC Chalam, P Kumar, R Kiran, M Shekhar and AK Kumar (2018) Plant quarantine processing for detection, identification and salvaging of fungi, bacteria and viruses in imported plant genetic resources. *In: Contemporary Approaches to PGR Management* (Eds. S Rajkumar,Sandeep Kumar, SK Kaushik and Anuradha Agarwal). ICAR- National Bureau of Plant Genetic Resources, New Delhi, pp 39-46.

Akhtar J, VC Chalam, Z Khan, P Kumar, R Kiran and SC Dubey (2018) Plant quarantine: a phytosanitary requirement for disease-free import of plant genetic resources in India. *In: Model training course on Integrated pest management in major hill crops.* (Eds. J. Staley, KK Mishra, ARNS Subbanna, Rajashekara H and A Pattnayak). ICAR-Vivekananda Parvatiya Krishi Anusandhan Ansthan, Almora, pp 112-119.

Anjali Kak, Vimala Devi S and Sherry R Jacob. 2018. Seed moisture testing, Drying and Packaging and database management for Genebank Conservation. In: Training Course on "Long-term conservation techniques for vegetable and rice germplasm" held at Germplasm Conservation Division, ICAR-NBPGR, New Delhi during November 26-30, 2018, pp 53-55.

Bhardwaj, R. (2018) Estimation of ash and minerals. In: Singh, S., Islam, S., Mangal, M., Lyngdoh, Y.A., Sharma, B.B., Tomar, B.S. and Behera, T.K. (Eds.) A practical manual forbreeding, molecular and biochemical analysis of vegetable crops. TB-ICN: 184/2018. Division of Vegetable Science, IARI, New Delhi, pp. 40-43.

Bhatt KC (2018) Germplasm Exploration and Collecting: Principles and Practices. In: Training program on management of plant genetic resources, NBPGR, New Delhi, pp 23-27.

Brahmi P and Vandana Tyagi (2018) Policy Issues in PGR Management In Training Program on Management of Genetic Resources, March 6-19, 2018, ICAR-NBPGR, New Delhi pp 11-19.

Brahmi P, Anjula Pandey and DC Bhandari (2018) Crop Diversity and Conservation. In: Plant Diversity in India (ed Bhatnagar AK, Rupam Kapoor). IK International Publ. House Pvt. Ltd., New Delhi, 525-41.

Chalam VC and K Gupta (2018) Risk assessment of plant diseases - concept and principles. *In: Training Manual on Advanced technology in Plant Health Management and Pest Risk Analysis for Improvisation of Indian Agriculture and Farmers Income*. September 5-25 2018, GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India.

Chalam VC and RK Khetarpal (2018) Exclusion of Plant Viruses for Ensuring Biosecurity - A Critical Appraisal. *In: Plant Viruses, Diversity, Interaction and Management* (Eds. RK Gaur, SMP Khurana and Y Dorokhov). CRC Press, Taylor & Francis Group, New York, USA, pp 361-376.

Chalam VC, AK Maurya, B Singh, DB Parakh, K Gupta, MC Singh, SP Singh, Z Khan, J Akhtar, BH Gawade, P Kumar, R Kiran, P Kumari, DS Meena and SC Dubey (2018) Detection and Identification of Pests in Exotic Germplasm including Transgenics. *In: Management of Plant Genetic Resources,* (Eds. Anuradha Agarwal, SK Kaushik, S Rajkumar, Sandeep Kumar and Kuldeep Singjh). ICAR- National Bureau of Plant Genetic Resources, New Delhi, pp 162-179.

Chalam VC, DB Parakh, AK Maurya, C Priyadarshini, A Tripathi and R Sharma (2018) Viruses, viroids, phytoplasmas and spiroplasma of quarantine significance in tropical and sub-tropical fruit crops. *In: Potential Quarantine Pests for India in Tropical and Sub-tropical Fruit Crops* (Eds. S Bhalla, VC Chalam, Z Khan, B Singh and SC Dubey). ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, pp 277-373.

Chaudhury R, S Bansal, V Srivastava and A Pal (2018) Cryopreservation of pollen/seeds - concepts and techniques. *In: Manual of Training on 'Long-term Conservation Techniques for Vegetable and Rice Germplasm',* ICAR-NBPGR, New Delhi, pp 99-111.

Chaudhury R, S Bansal, V Srivastava and A Pal (2018) Procedures for cryopreservation of seeds, pollen and dormant buds. *In:* Rajkumar S, S Kumar, SK Kaushik and A Agrawal (eds) *Compendium for 'National Training Course on Contemporary Approaches to Plant Genetic Resources Management'*. ICAR-NBPGR, New Delhi, Nov. 27-Dec. 17, 2018, pp 85-98.

Chitra pandey, Vimala Devi S and Rajvir Singh, 2018. Techniques for storage of orthodox seeds in LTS. In: National training course on "Contemporary Approaches to Plant Genetic Resources Management" during Nov 27 to Dec 15, 2018 at ICAR-NBPGR, New Delhi, pp 55-66.

Dubey SC and A Tripathi (2018) Biological control agent based management of major diseases of chickpea. *In: Biological control of crop diseases: recent advances & perspectives (Part2: cereals, pulses, oilseed and other crops)* (Eds. Singh *et al*.). Indian Phytopathological Society, New Delhi, Today & Tomorrow's Printers and Publishers, Daryaganj, New Delhi, pp 537-555. (ISBN 81-7019-592-2, India and ISBN 1-55528-438-8, USA).

Gangopadhyay KK, SK Kaushik and Kuldeep Tripathi (2018) Principles and Practices of Plant Germplasm Characterization and Evaluation. In Training manual on Contemporary approaches in Plant Genetic Resources management. November 27-December, 17, 2018.

Gupta K, S Bhalla, SP Singh and DS Meena (2018) Insects Pests of Quarantine Significance in Tropical and Sub-tropical Fruits. *In: Pests of Quarantine Significance in Tropical and Sub-tropical Fruits* (eds. Bhalla, S, VC Chalam, B Singh, Z Khan and SC Dubey). ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, pp 1-122.

Gupta S (2018) Strategies to conserve genetic resources in horticultural crops. *In: Training Manual of Winter School course on 'Innovative Approaches for Improvement of Perennial Horticultural Crops',* Nov. 16 - Dec. 6, 2018, ICAR-Indian Agricultural Research Institute, New Delhi, pp 303-309.

Kak A (2018). Registration of Trait Specific Germplasm in Training Programme on Management of Plant Genetic Resources, March 6-19, 2018. 100-104

Kak A and Rajeev Gambhir (2018) Procedures for Filling Online Application for Germplasm Registration in "National Training course on contemporary approaches to plant genetic resources". November27-December 17, 2018. 169-170.

Kamala V, M Elangovan and N.Sivaraj (2018) Origin, Domestication and Diffusion of *Sorghum bicolor*. In Aruna et al., Breeding Sorghum for diverse end uses. Elsevier-Wood Head Publishing, UK pp. 15-31.

Kamala V, N.Sivaraj, S.R. Pandravada, M. Thirupathi Reddy and B. Sarath Babu (2018) Classification, Distribution and Biology. In Aruna *et al*., Breeding Sorghum for diverse end uses. Elsevier-Wood Head Publishing, UK pp. 33-60.

Kaur V, K Shubha, P Kumar and Manju (2018) Role of crop wild relatives in crop improvement under changing climatic conditions. *In: Crop Improvement for Sustainability* (Eds. PK Yadav, S Kumar, S Kumar and RC Yadav), Agrobios (International), Jodhpur, pp 13-35.

Kaur V, Kumari Shubha, Pardeep Kumar and Manju (2018) Role of crop wild relatives in crop improvement under changing climatic conditions. In: Yadav PK, Kumar S, Kumar S and Yadav RC (Eds.) *Crop improvement for sustainability.* Astral International Pvt. Ltd., New Delhi, India, pp 13-36. ISBN 978-93-5124-942-9.

Khan Z, B Gawade, J Akhtar and SC Dubey (2018) Biological control of plant parasitic nematodes using beneficial soil nematodes. *In: Bio-intensive Approaches, Application and Effectiveness in Plant Protection* (Eds MR Khan, AN Mukhopadhyay, RN Pandey, MP Thakur, D Singh, MA Siddiqui, M Akram, FA Mohiddin and Z Haque). Indian Phytopathological Society, New Delhi, pp 117-143.

Kumari J, K Tripathi, R Bansal, V Kaur and Gayacharan (2018) Methods of data recording for characterization and evaluation of field crops. In Training manual on Contemporary approaches in Plant Genetic Resources management. November, 27 –December, 17, 2018.

Singh M & GJ Randhawa (2018) DNA-based methodologies for GMO testing in seeds. *In: Techniques in Seed Science and Technology 3rd Revised Edition* (eds. PK Agrawal & SR Jacob) Brillion Publishing. pp. 281-292.

Sivaraj N and D.P. Semwal 2018. Analysis of Diversity using DIVA-GIS: A practical demonstration. Practical Manual; National Training Course on Contemporary Approaches to Plant Genetic Resources Management (Nov.27-Dec.17, 2018). ICAR-National Bureau of Plant Genetic Resources, New Delhi pp.15-22

Sivaraj N and Kamala Venkateswaran 2018. Role of National Bureau of Plant Genetic Resources in plant genetic resources management – Collection, characterization, evaluation, conservation, plant quarantine, exchange and documentation. Training manual for IFS Officers-Training course on forest genetic resource management for Indian Forest Service officers, sponsored by MoEF &CC, Institute of Forest Genetics and Tree Breeding. Pp. 59-83.

Sivaraj N, V. Kamala, S.R. Pandravada, M.Thirupathi Reddy, Babu Abraham, JJ Rajappa and B. Sarath Babu 2018. Plant genetic resources conservation with special reference to Maximum Entropy (MaxEnt) modelling for on-farm conservation of climate resilient crop varieties for food and nutritional security. Souvenir: International Conference on Climate Change, Biodiverity and Sustainable Agriculture (ICCBSA-2018, 13-16 December), Assam Agricultural university, Jorhat, Assam. Pp73-81

Nivedhitha S (2018) Collection status of Plant Genetic Resources from Mizoram Plant Genetic Resources in North East India, pp 36-39.

Padmavati G Gore, Kuldeep Tripathi, Rakesh Bharadwaj and I. S. Bisht (2018) Role of Plant Genetic Resources in Nutritional Security and Agricultural Sustainability. In: Hemlata Pant, DK Srivastava, Preeti Singh, Devendra Swaroop, Kamlesh Singh (Eds.) *New approaches in Agricultural, Environmental and Nutritional Technology Vol.*1 pp. 76-82.

Pandey A (2018) Underutilized Plant Species in Asia-Pacific Region. In: Tyagi RK, A Agrawal, A Pandey, KS Varaprasad, RS Paroda and RK Khetarpal (eds) Proceedings and Recommendations of 'Regional

Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific'. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, November 13-15, 2017, pp27-40.

Pandey A, Soyimchiten and S Nivedhitha (2018) Tribal Dominated Tracts are the 'Hot spots' of Agrobiodiversity- Priorities and concerns for PGR management In Training program on management of Plant Genetic Resources, March 6-19, 2018 pp 28-33.

Pandey CD and Gore P (2018). Processing of Orthodox seeds for Long Term Conservation in National Genebank In: Management of Plant Genetic Resources, National Bureau of Plant Genetic Resources, New Delhi, March 6-9, 2018, 183-188pp

Pandey CD and Pandey S (2018). Plant Genetic Resources Management: National Genebank In:Seed Production and Quality Evaluation, Sponsored by Ministry of Rural Development, Government of India and African-Asian Rural Development Organization (AARDO).14-28 January, 2018, ICAR-Indian Agricultural Research Institute, New Delhi. (TB-ICN: 181/2018), 410-417pp.

Pandey CD, Pandey S and V Gupta (2018). Conservation of vegetable genetic resources: National Genebank In: Molecular breeding for higher productivity, quality, food colorants, nutraceuticals and bioactive health compounds in vegetable crops. 13 Feb -5 March, 2018. ICAR-Indian Agricultural Research Institute, New Delhi. (TB-ICN: 185/2018), 30-40pp.

Pandey R, N Sharma, and A Agrawal (2018) Methods, tissues and species requiring *in vitro* conservation. In: A. Agrawal, S.K. Kaushik, S. Kumar, S. Rajkumar and K. Singh (eds) *Compendium for 'Training Program on Management of Plant Genetic Resources'.* ICAR-NBPGR, New Delhi, March 6-19, 2018, pp. 123-129.

Pandey R, R Gowthami, EV Malhotra, N Sharma, R Chandra, DPS Meena, DK Nerwal and A Agrawal (2018) *In vitro* conservation and cryopreservation of clonally propagated crops. *In:* Rajkumar S, S Kumar, SK Kaushik and A Agrawal (eds) *Compendium for 'National Training Course on Contemporary Approaches to Plant Genetic Resources Management'*. ICAR-NBPGR, New Delhi, Nov. 27-Dec. 17, 2018, pp 73-84.

Phogat BS and KC Bhatt (2018) Indigenous knowledge and innovations for managing neglected and underutilized genetic resources. In: Training programme on Management of Plant Genetic Resources, NBPGR, New Delhi, pp 23-27.

Pradheep K, S Nivedhitha and Rita Gupta (2018) Methods in Preparation of Herbarium In National Training Course on Contemporary Approaches to PGR Management, ICAR-NBPGR, New Delhi, Nov. 27- Dec. 7th 2018.

Prakash BG and R Gowthami (2018) Guava and papaya descriptors and breeding perspectives. *In: ICAR Sponsored Centre for Advanced Faculty Training (CAFT) on 'Exploitation and conservation of plant genetic resources in major, minor and underexploited fruits',* pp 126-139.

Semwal DP (2018) Plant Genetic Resources (PGR) Status of Tripura. In Plant Genetic Resources in North East India, ICAR-National Bureau of Plant Genetic Resources, New Delhi, pp 36-39.

Semwal DP, Anjula Pandey and Rita Gupta (2018) Introduction to Procedures for Preparing Herbarium Specimens of Cultivated Plants. Published in e-manual on Management of Plant Genetic resources, ICAR-NBPGR, New Delhi, pp 157-161.

Shalini S, A Singla, M Goyal, V Kaur and P Kumar (2018) Omics in Agriculture: Applications, Challenges and Future Perspectives. *In: Crop Improvement for Sustainability* (Eds. PK Yadav, S Kumar, S Kumar and RC Yadav). Agrobios (International), Jodhpur, pp 333-360.

Sherry RJ, J Aravind and AD Sharma (2018) Methods for monitoring seed germination and storability for germplasm conservation. In National training course on "Contemporary Approaches to Plant Genetic Resources Management" during Nov 27 to Dec 15, 2018 at ICAR-NBPGR, New Delhi, pp 67-72.

Singh AK, Singh R, Kumar R, Chaurasia S, Yadav S, Kumar S Wankhede DP (2018) Genomics technologies for improving salt tolerance in wheat. In Gupta SK, Goyal MR and Singh Anshuman (eds). Engineering practices for management of soil salinity; agricultural, physiological and adaptive approaches *CRC Press, Taylor & Francis,* pp 251-304.

Singh B, J Akhtar, P Kumar, A Kandan and SC Dubey (2018) Bacteria of quarantine significance in tropical and sub-tropical fruit crops. *In*: *Pests of quarantine significance in tropical and sub-tropical fruits* (Eds. S Bhalla, VC Chalam, Z Khan, B Singh and SC Dubey). ICAR-NBPGR, New Delhi, India, pp 251-276.

Singh K, Shashi Bhalla, BS Phogat, Mohar Singh, JC Rana and Kalyani Srinivasan (2018). Strategies on Underutilized Crops for Food and Nutritional Security: Pseudocereals. In RK Tyagi, A Pandey, A Agarwal, KS Varaprasad, RS Paroda, RK Khetarpal (Eds.) Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific – Thematic, Strategic Papers and Country Status Reports. Asia Pacific Association for Agricultural Research Institutions (APAARI) Bangkok, Thailand, November 13-15, 2017. Pp.101 – 108.

Singh SP, K Gupta, S Bhalla and DS Meena (2018) Mite Pests of Quarantine Significance in Tropical and Sub-tropical Fruits. *In: Pests of Quarantine Significance in Tropical and Sub-tropical Fruits* (eds. Bhalla, S, VC Chalam, Z Khan and A Kandan). ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, pp 123-141.

Singh T P, Jyoti Kumari, Sunil Kumar, Vikender Kaur and P.S. Deshmukh (2018) Terminal heat stress: A major problem of wheat production, Advances in *Plant Physiology*, vol. (18), 97-121.

Singh T P, Sunil Kumar, Jyoti Kumari and Vikender Kaur (2018) Impact of terminal heat on wheat production in India, *Advances in Plant Physiology*, vol. (18), 85-95.

Singh, MC, SC Dubey and S Kumar (2018) Interception of weed species in quarantine and weed risk analysis. *In: Fifty Years of Weed Science Research in India.* (Eds. Sushil Kumar and JS Mishra). Indian Society of Weed Science, Jabalpur, MP, pp150-160.

Singh N (2018) Seed storage behaviour -concepts and techniques. In: Long term conservation techniques for vegetable and rice germplasm.

Srivastava U, KC Bhatt and Anjula Pandey (2018) Wild Edible Plants in Asia-Pacific: A case study with Bastar tribal Pockets in Chhattisgarh, India. In : Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific , Thematic, Strategic Papers and Country Status Reports (eds Tyagi RK, A Pandey, A Agrawal, KS Varaprasad, RS Paroda and RK Khetrapal), Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, pp 54-69.

Thakur AK, Singh KH, Sharma D, Singh L, Parmar N, Nanjundan J, Yasin JK. 2018.Transgenic Development for Biotic and Abiotic Stress Management in Horticultural Crops. In Genetic Engineering of Horticultural Crops (pp. 353-386).

Tyagi V (2018) . Introduction and Exchange of Plant Genetic Resources. In Training Program on Management of Genetic Resources, March 6-19, 2018, ICAR-NBPGR, New Delhi pp 42-50.

Tyagi V, SK Yadav, Pragya, SP Singh, S Singh, PC Binda and Pratibha Brahmi (2018). Procedures for exchange of germplasm. In National training Course on Contemprorary Approaches in Plant

Genetic Resources Management. ICAR-NBPGR, New Delhi pp 23-38.

Veena G and Sherry Rachel Jacob (2018). Gene Bank Management for *Ex Situ* Conservation of Germplasm In: Training on Management of Plant Genetic Resources during March 6 -19, 2018 at ICAR-NBPGR, New Delhi, pp 67-70.

Vimala Devi S and Veena Gupta, 2018. Role of Plant Biotechnology and Conservation of Genetic Resources in Increasing Crop Productivity. In: Core Issues in the Agricultural Sector, an induction-level training of the IES Officers organized by ICAR-NAIP, New Delhi during June 11-15, 2018.

Visaradha K B R S and Kamala Venkateswaran 2018 Wide Hybridization In Aruna et al., Breeding Sorghum for diverse end uses. Elsevier-Wood Head Publishing, UK pp. 131-139.

Yadav S, Chet Ram, and Wankhede DP (2018) Biodiversity and Conservation of Plant Genetic Resources (in-Situ and Ex-Situ). In: Advanced Molecular Plant Breeding Meeting the Challenge of Food Security Eds. D. N. Bharadwaj. Apple Academic Press.ISBN 987-1-7788-664-2.

21.8.4 Research bulletin/ information bulletin/ brochure

Aravind J, Sherry Rachel Jacob and Veena Gupta (2018) National Gene Bank (Brochure).

Chalam VC, SC Dubey, C Murali Krishna, S Bhalla and Kuldeep Singh (2018) *Strengthening Capacities of Enforcement Agencies (Plant Quarantine and Customs Officials) for Transboundary Movement of Living Modified Organisms.* ICAR-National Bureau of Plant Genetic Resources and Ministry of Environment, Forest and Climate Change, New Delhi, India, 6p.

Devi Vimala S, Chithra Devi Pandey, Veena Gupta and Kuldeep Singh (2018). *Training Manual on "Long-term Conservation Techniques for Vegetable and Rice Germplasm"* Division of Germplasm Conservation, ICAR-NBPGR, New Delhi 110 012. P 114.

Dubey SC, B Singh, S Bhalla, DB Parakh, VC Chalam, K Gupta, MC Singh, SP Singh, Z Khan, J Akhtar, BH Gawade, P Kumar, R Kiran, P Kumari, B Sarath Babu, SK Chakravarty, K Anitha and P Hollajer (2018) Plant Quarantine: An Armour for Indian Agriculture. Published by ICAR-NBPGR, New Delhi-110012, 6 pp.

Kak A and Veena Gupta (2018) Inventory of registered Crop Germplasm (2015-2017) ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, Indian Council of Agricultural Research (ICAR), New Delhi-110 012, 74p.

Mangesh YD, M Sujatha, HP Meena, K Alivelu, MKGhodke, YG Shadakshari, RK Tyagi, J Radhamani, ARG Ranganatha, KS Varaprasad and A. Vishnuvardhan Reddy (2018) Germplasm Catalogue of Sunflower (*Helianthus annuus* L.) P ICAR-IIOR, Rajendranagar, Hyderabad-500030

Pandravada SR, Sivaraj, N, Kamala, V, Swapna, M and Sarath Babu, B 2018. Checklist of cultivated crops of Telangana. ICAR-National Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad-500 030, Telangana. 12 pp.

Prabha, K., Holajjer, P., Shilpa shree, K.G., Naveen Kumar, P., and Prasad, K. V. (2018). Know about nematodes (Leaflet-English and Telugu) published by ICAR-Directorate of Floricultural Research, Pune.

Sivaraj N, Kamala Venkateswaran, S.R. Pandravada, K. Anitha, S.K. Chakrabarty, Prasanna Holajjer, P. Pranusha, Babu Abraham, A. Ravindra, M.L. Sanyasi Rao, T. Narasinga Rao, P. Devullu, N.V. Naidu, Jogi Naidu, K.S. Varaprasad and B. Sarath Babu 2018. Pigeon pea Landraces of North Coastal Andhra Pradesh. ICAR-National Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad 500 030, India. P.1-40.

Sivaraj N, S.R. Pandravada, Kamala Venkateswaran, S.K. Chakrabarty, K. Anitha, Prasanna Holajjer, P. Pranusha, Babu Abraham, A. Ravindra, M.L. Sanyasi Rao, T. Narasinga Rao, P. Devullu, N.V. Naidu, Jogi Naidu, K.S. Varaprasad, B. Sarath Babu, S.C. Dubey and Kuldeep Singh, 2018. Seed Atlas of Ethnic Crop Landraces: North Coastal Andhra Pradesh, India. ICARNational Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad 500 030, India. P.1-46.

Sivaraj N, S.R. Pandravada, Kamala Venkateswaran, S.K. Chakrabarty, K. Anitha, Prasanna Holajjer, P. Pranusha, Babu Abraham, A. Ravindra, M.L. Sanyasi Rao, T. Narasinga Rao, P. Devullu, N.V. Naidu, Jogi Naidu, K.S. Varaprasad, B. Sarath Babu, S.C. Dubey and Kuldeep Singh, 2018. Finger millet Landraces of North Coastal Andhra Pradesh. ICAR-National Bureau of Plant Geneti c Resources, Regional Stati on, Rajendranagar, Hyderabad 500 030, India. 1-24 p.

Sivaraj N, V Kamala, S R Pandravada, M Thirupathi Reddy and K Anitha. 2018. Application of geographical information system (GIS) tools in plant genetic resources management.

Tyagi V and Pratibha Brahmi (2018) Procedures for exchange of plant germplasm for research purposes, ICAR-NBPGR, New Delhi, 8 p.

21.8.5 Popular/ technical articles

Agrawal A, A Pandey, KS Varaprasad, RK Tyagi and RK Khetarpal (2018) Meeting Report, 'Regional Expert Consultation on Underutilized Crops for Food and Nutrition Security in Asia and the Paciûc' *Indian J. Plant Genetic Resour.* **31**: 194-195.

Akhtar J, Singh B., Chalam VC, Kumar P, Kiran R and Dubey SC (2018) *Rog mukt padap janandarvo ka aayat. Kheti*.40-43.

Archak S., A Agrawal, RK Tyagi, K Singh and RS Paroda (eds) (2018) *Proceedings and Action Points of the Brainstorming Meeting on 'Strategies for Implementation of Delhi Declaration for Agrobiodiversity Management in India'*. ICAR-National Bureau of Plant Genetic Resources and Indian Society of Plant Genetic Resources, New Delhi, Aug. 28, 2017, 44 p.

Bhatt KC, PK Malav and SP Ahlawat (2017) Trait-specific germplasm collection in Arunachal Pradesh. *ICAR News,* July-September **23** (3):22-23.

Gayacharan and Kuldeep Tripathi (2018) On-farm conservation: an approach to conserve landraces in fast changing climatic conditions *Indian Farmer* **5**(3):333-335.

Kak A and Tyagi RK.2018. Plant Germplasm Registration Notice. *Indian J. Plant Genet. Resour*. **31** (1): 101-122.

Kak A and Tyagi RK.2018.Plant Germplasm Registration Notice. *Indian J. Plant Genet. Resour*. **31** (2): 198-204.

Kak A and Tyagi RK2018. Plant Germplasm Registration Notice. *Indian J. Plant Genet. Resour*. **31** (3): 332-355.

Kaur V and R Yadav (2018) A glance at linseed improvement in recent past. *Indian Farming* **68 (03):** 6-8.

Kaur V, Manju, Kumari J and Meena BL (2018) Kisan aay samvardhan mein malt jau ki bhumika. *Gehun avem Jau Swarnima* **9**: 14-17.

Malhotra EV, Bansal S, Singh M, Srivastava V, Sreevathsa R. 2018. Conservation genomics – a new avenue for conservation biology. *Scientific India Magazine* **6**(2): 44-45.

Rathi RS, NS Panwar, KC Bhatt and SP Ahlawat (2018) Collection of rice landraces grown in flood prone area of eastern Uttar Pradesh, ICAR News, January - March, 2018, pp 10.

Sahoo HK and RC Misra (2018) Mankidiamane sangraha karuthiba keteka jangalajata khadya: Eka samiksha (Odia) Wild food among Mankirdias: A review. *Banabarata* 83:13-14.

Singh SP, Sandeep Kumar and Pooja Kumari (2018) Gannai ki fasal mein keet, bimari evam kharpatwar parbandhan. Kisan Vikas Sahyog (Hindi Patrika), February-March issue, pages 4-7.

Yadav R, Vikender Kaur, J C Rana, Anil K Singh and Kuldeep Tripathi (2018) Flax seed an amazing medicinal plant. *Indian Farming* **68 (6):** 15–16.

Yasin JK. 29th Jan 2018. இனி ஒரு தொழில் செய்வோம். தீக்கதிர் செய்தித்தாள் https://theekkathir.in/2018/01/29/

Yasin JK. 2nd Aug 2018. கூடிப் பயிர் செய்வோம் தீக்கதிர் செய்தித்தாள் https://theekkathir.in/2016/08/02/

21.8.6 Reports

Rathi RS, DP Semwal, KC Bhatt, SP Ahlawat and NS Panwar (2018) Pearl Millet: *Germplasm Status, Diversity Mapping* and *Gap analysis.* ICAR-National Bureau of Plant Genetic Resources, New Delhi.

Yadav SK, SK Kaushik, MC Singh, SP Singh, Sandeep Kumar, HL Raiger, BS Phogat and Kuldeep Singh (2018) *Kharif* Report (2017). All India Coordinated Research Network on Potential Crops, ICAR-NBPGR, New Delhi, 231p.

Yadav SK, SK Kaushik, MC Singh, SP Singh, Sandeep Kumar, HL Raiger, BS Phogat and Kuldeep Singh (2018) *Rabi* Report (2017-18). AICRN-PC, ICAR-NBPGR, New Delhi, 229p.

21.8.7 Participation in Radio/ TV programmes

Singh MC, Principal Scientist participated as an expert in Hello Kisan- a live TV programme on DD-Kisan channel, 04 times during 2018.

Sherry RJ, Senior Scientist, Division of Germplasm Conservation participated in the 'Njattuvela' Kisan Radio Talk programme of Farm Information Bureau, Department of Agriculture, Kerala

Veena Gupta, Head and Principal Scientist, Division of Germplasm Conservation interacted with farmers in Television programme in HELLO KISAN DD KISAN Channel on Cultivation of Medicinal and Aromatic Plants on 20-03-18 and Commercialization of medicinal plants in Hindi on 31-08-18.

Vijay Singh Meena delivered a TV talk on DD Kisan on *" Care of young orchard in winter"* during Dec.2018.

21.8.8 Training module/ working knowledge document/ CDs:

Chalam VC, SC Dubey, C Murali Krishna, S Arora and Kuldeep Singh (2018) CD on Training Workshop: *Strengthening Capacities of Enforcement Agencies (Plant Quarantine and Customs Officials) for Transboundary Movement of LMOs*, April 12-13, 2018, organized by ICAR- National Bureau of Plant Genetic Resources, New Delhi and Ministry of Environment, Forest & Climate Change, Govt. of India at Customs House, Marmagoa Harbour, Goa, India.

Chalam VC, SC Dubey, C Murali Krishna, Sujata Arora and Kuldeep Singh. 2018. CD on Training Workshop: *Strengthening Capacities of Enforcement Agencies (Plant Quarantine and Customs Officials) for Transboundary Movement of LMOs*, April 19-20, 2018, organized by ICAR-National Bureau of Plant Genetic Resources, New Delhi and Ministry of Environment, Forest & Climate Change, Govt. of India at National Academy of Customs, Indirect Taxes & Narcotics, Visakhapatnam, Andhra Pradesh, India.

Rajkumar, S. Anuradha Agrawal, Sandeep Kumar, S.K. Kaushik 2018. Practical Notes: Contemporary Approaches to Plant Genetic Resources Management In: National Training course from November 27 to December 17, 2018.

21.8.9 E-publication

Gawade BH and Z Khan (2018) Phytoalexins: Properties and role in nematode resistance in plants. http://www.biotecharticles.com

Gawade BH, Z Khan and S Biswas (2018) Nematodes as a biological indicators of soil health. http://www.biotecharticles.com

Mamta S and S Nivedhitha (2018) Role of Nanotechnology in Plant Tissue Culture. www.biotecharticles.com/Nanotechnology-Article/Role-of-Nanotechnology-in-Plant-Tissue-Culture-4336.html.

Sherry Rachel Jacob (2018) Provisions for protection of plant varieties and genetic stocks in India. Kerala Karshakan e-journal, Vol 5, Issue 7; published by Farm Information Bureau, Department of Agriculture, Kerala. http://www.fibkerala.gov.in.

Sherry Rachel Jacob (2018). The exotic plant genetic resources of India. Kerala Karshakan e-journal, Vol 5, Issue 1; published by Farm Information Bureau, Department of Agriculture, Kerala. http://www.fibkerala.gov.in

Yasin JK and Chaudhary S. 2018. Identified and mapped 7,34,810 genome wide SNPs of pigeonpea available with accession numbers PRJEB27956.

Yasin JK and Chaudhary S. 2018. PineElm_SNPdb - a set of 14,644 SNP markers with accession numbers PRJEB27177, ERZ663689 and ERZ663707.

Yasin JK and Chaudhary S. 2018. AppleElm_SSRdb with 1,39,116 SSRs markers.

कुलदीप त्रिपाठी, गयाचरण, राकेश भारद्वाज एवं अशोक कुमार (२०१८). शुष्क भूमि की मुख्य दलहन– मोठबीन, कृषि सेवा (११ जनवरी, २०१८)।

कुलदीप त्रिपाठी, नरेंद्र कुमार गौतम एवं बाबूराम (२०१८). मसूर की खेती के लिए उन्नत तकनीक, कृषि सेवा (३१ जनवरी, २०१८)।

Plant Germplasm Reporter/ Brochure

Bhatt KC, A Pandey, SP Ahlawat, K Pradheep, RS Rathi, DP Semwal, SK Sharma, NS Panwar, R Gupta and OP Dhariwal (2018) *Plant Germplasm Reporter-2017 (Indigenous Collections).* ICAR-National Bureau of Plant Genetic Resources, New Delhi.

Ahlawat SP, Anjula Pandey, KC Bhatt, K Pradheep, RS Rathi, DP Semwal, Soyimcheten, S. Niveditha, Pawan K Malav, Shashi K. Sharma, NS Panwar, Rita Gupta and OP Dhariwal (2018) Collecting Plant Genetic Resources. *Exploration Brochure*. ICAR-National Bureau of Plant Genetic Resources, New Delhi.

21.9 Germplasm Field Days Organized

21.9.1 Germplasm Field Day on *Rabi* Pulses: Germplasm Field Day on *Rabi* Pulses (Lentil and Pea) was organized on February, 26, 2018 at ICAR-NBPGR, New Delhi to showcase the natural diversity and variability among pre-bred lines of lentil (Fig.21.1) developed by the institute.

Fig. 21.1. Germplasm Field Day on *Rabi* Pulses

21.9.2: Oilseed Germplasm Field Days Organized: Germplasm Field Day on oilseed crops" on 22nd February, 2018 and "Germplasm Field Day on Sesame" on 29th September, 2018 at NBPGR, New Delhi. Scientists from different ICAR Research Institutes, State Agriculture Universities and other Institutions participated. During field visit, scientists selected promising germplasm for different traits to utilize in their crop improvement programmes.

21.9.3: Germplasm Field Day on Wheat and Barley : The Germplasm Field Day on Wheat and Barley was organized at NBPGR Farm, Issapur, New Delhi on 27 March 2018 (Fig. 21.2). The field day was attended by forty-five participants from 11 organizations namely ICAR-IIWBR, Karnal; ICAR-IARI, New Delhi; ICAR- NRCPB, New Delhi; ICAR-VPKAS, Almora; ICAR-NBPGR, New Delhi; IARI-RS, Indore; GBPUAT, Pantnagar; SDAU, Vijapur; CSAUAT, Kanpur; CSKHKV, RWRC, Malan; Jamia Hamdard University, New Delhi comprising six ICAR institutes, four SAUs and one deemed University. The participants visited the Issapur farm where 2820 accessions of wheat comprising 1804 indigenous and 1016 exotic material, and 2440 accessions of barley were grown for characterization and agronomic evaluation. In addition, 933 accessions of wheat were grown for evaluation against drought and 569 against terminal heat stress.

Fig. 21.2. Germplasm Field Day on Wheat & Barley

21.9.4: Germplasm field day for Yard-long bean: A field day for Yard-long bean was organized on 6 December 2018. About 150 accessions of yard long bean including released varieties were exposed in the field for the benefit of researchers. A total of 25 scientists and students from SAUs and Agricultural Department participated in the event.

21.9.5: Germplasm Field Day on Cowpea and Little millet: Cowpea (2,308 accessions) and little millet (1,816 accessions) Field Day was organized at Experimental Farm-Issapur, ICAR-NBPGR, New Delhi on 28th September 2018.; and 40 participants from eight organizations had attended (Fig. 21.3). The participants selected the specific germplasm during their visit to these fields. Dr. Kuldeep Singh, Director, ICAR-NBPGR, Dr Shiv Sewak, Coordintor, Network Research Project on Arid Legumes emphasized the need of collaborative multilocation evaluation for identification of trait specific germplasm.

Fig. 21.3. Germplasm Field Day on Cowpea & little millet

21.9.6: Farmer's field day on Okra: To increase the awareness on PGR and diversity in Okra, RS-Thrissur, organized an appreciation programme on okra for the benefit of farmers/ farmer groups on 28 September 2018. Over 600 accessions of diverse indigenous and exotic germplasm of Okra were exposed to the farmers in the experimental farm in full fruiting stage. A total of 73 farmers from various parts of Kerala and the Eco-Club students of Thejus Engineering College, Thrissur participated in the event. The farmers were given opportunity to select the germplasm of their choice for on-farm conservation. Interested farmers were also shown the germplasm of bitter-less gourds, rice and other potential economic plants.

21.9.7: Farmer's Field Day for paddy: A Farmers' field day for paddy was organized at Jhupulchaura village of Someshwar Valley (Distt Almora) on

October 8, 2018 under GEF project. Total 46 farmers from the adjoining villages participated in the program and discussed the present status of traditional paddy landraces and importance of their conservation. Twenty eight different landraces have been grown in the village under the project to promote on-farm conservation. During the program, farmers visited the field and selected paddy landrace of their choice for growing in their field for the next season.

21.9.8: Farmer's field day for Yard-long bean and small millets: ICAR-NBPGR Regional Station, Thrissur conducted a farmer's field day on 7 December 2018 and displayed the yard long bean and small millets (seven crops) germplasm grown in field for the benefit of farmers and tribals. A total of 160 farmers from various parts of Kerala participated in the event. The farmers were given opportunity to select the germplasm of their choice.

21.9.9 Exhibitions/ fairs/ field day organized/ participated: The Cuttack base centre participated in the "*State Agriculture Fair – Krushi Odisha*" at Biju Patnaik Playground, Barmunda, Bhubaneswar. Organized an exhibition stall and exhibited diversity in plant genetic resources among cultivated rice, *Ocimum, Mucuna, Hibiscus sabdariffa, Abelmoschus, Cucumis* and other M& AP in the fair during 6th to 9th March, 2018. It also co-organized one day rice germplasm field day with ICAR-NRRI, Cuttack on 30th October, 2018. It also participated and exhibited the available diversity and variability in plant genetic resources of Odisha in the *72nd Foundation day and Kisan Mela* organized at ICAR-NRRI, Cuttack during 23rd April, 2018 and participated in the *9th Krishi Fair – 2018,* and displayed available diversity in plant genetic resources of Odisha in the National Level Agricultural Exhibition organized by Shreekshetra Soochana at Puri, during 3rd to 7th June, 2018. 150 nos. of published brochures were distributed among the visitor farmers of Odisha.

Fig. 21.4. Exhibition organized

21.10 PGR awareness program and TSP

21.10.1 MGMG and other community-based interventions: A cluster of about 14 villages belonging to seven Village Panchayats, Suri, Garsyari, Inan, Matila, Suniakote, Harare and Bedgaon in Tarikhet Block of district Almora in Uttarakhand are part of MGMG programmes undertaken by ICAR-NBPGR RS, Bhowali. The community now known as **"Gramin Khadya Samprabhuta Samooha"** (Peasants association for indigenous food sovereignty) presents an excellent example of 'Indigenous food sovereignty', an approach addressing issues impacting native communities and their ability to respond to their need for healthy and culturally appropriate indigenous foods. The scientists at ICAR-NBPGR, Bhowali are closely working with the above farming community and helping the community to strengthen their on-going efforts to promote traditional hill farming in overall framework of indigenous food sovereignty. Creation of off-farm job opportunity at community level and aspects of food-based approaches to community nutrition and health are currently underway. Various campaigns like "Swachhata Abhiyan" was also conducted in the village and farmers were provided with quality planting material for better sutainability.

21.10.2 MGMG Programme at Cuttack: An exposure visit was organized for 22 farmers from MGMG cluster villages such as Radhakrishnapur, Udeipur, Itipur and Jaipurpatna to ICAR-NRRI and ICAR-NBPGR Base Centre, Cuttack. The farmers witnessed online-video address of 'Rashtriya Krishi

Unnati Mela 2018' by Hon'ble Prime Minister of India and participated in Farmers-Scientists interaction programme at ICAR-NRRI, Cuttack. Rice varieties *viz*. *Maudamani* and *Sumit* were distributed among three farmers of Radhakrishnapur cluster village under MGMG programme. Three farmers from Radhakrushnapur cluster village visited ICAR-NRRI and NBPGR Base Centre, Cuttack for interaction about rice plant protection measure.

21.10.3 MGMG at Thrissur: A technology dissemination programme on vegetable cultivation was organised under MGMG for the benefit of Residents' Association members of Korumbissery village, Thrissur district on 16 May 2018. Scientists of this station handled classes on cultivation practices and distributed seedlings/propagules. A total of 38 farmers participated.

21.10.4 Progress on TSP activities at Bhowali: An "Awareness Camp-cum-Biodiversity Fair" was organized on November 15, 2018 in Village Lata, Block Joshimath of district Chamoli, Uttarakhand under TSP. About 140 participants including farmers, state officials and resource persons participated in the program. A demonstration of native crop diversity was also made (hull-less barley, tartary buckwheat, proso-millet, foxtail millet, rajmash, amaranths, etc.) and petty farm implements (VL-Garden fork, VL-Kutla, VL- Daranti and VL-Khurpi) were distributed to farmers. Farmers were sensitized about the importance of bio-diversity with respect to agriculture and its conservation through conventional approach. There was one to one interaction with farmers and state officials regarding problems and their solution with respect to farming.

21.11 Capacity building of local stakeholders in developing quality planting materials

A training program was successfully organized for 7 days w.e.f. 1-7 January 2018 for nursery management, layout preparation, planting, production management and protection management of kiwi, walnut, peach, malta, kagazi lime, etc. and a total of 10 army personnel of Kumaon Regimental Centre, and one farmer representative each from Pass Pati, Champawat and Lodhi (Nathuakhan), Naninital, respectively, were trained.

The training programme for the army personnel was based on a written request received from the Commanding Officer, 130 Inf. Bn. (TA) Eco Kumaon, Pithoragarh, Uttarakhand. The 130 Inf. Bn is engaged in various community based activities in Uttarakhand including ecosystem restoration, afforestation, sustainable livelihood enhancement, etc. The farmer representatives also approached the station for training them and capacity building to develop the quality planting material on their own for sharing among the native farming community.

21.12 Extension and Awareness Programme

An awareness camp on PGR conservation and utilization was organized at Baisinga, Betanoti, Mayurbhanj, Odisha on 28th March, 2018 under TSP involving KVK, District level agriculture and horticultural office situated at Mayurbhanj, regional research station, Motto, (OUAT), Bhadrak and SOOVA (NGO), Udala, Mayurbhanj. About 150 tribal farmers were participated and diversity in available local plant genetic resources was displayed. Nine delegates from different departments (Agriculture, horticulture, and fisheries), from Govt. of Odisha were attended the programme.

21.12.1 Outreach / Social activities / students visiting NBPGR, Hyderabad: Students of B.Sc. (Agriculture) PJTSAU in two batches visited NBPGR facility on 21.02.18 & 26.02.18. The scientists who have facilitated the visit of students were Dr. K Anitha, Dr. Kamala Venkateswaran, Dr N. Sivaraj

and Ms. Pranusha. International trainees from NIPHM visited the station's facilities on 17.03.2018 and interacted with the scientists on various issues of quarantine and PGR Management. Students of B.Sc. (Ag.) (20 no.) of JNKVV, College of Agriculture, Tikamgarh, MP visited the Station's facilities on 20.03.18. Dr P. Holajjer and Dr P Pranusha interacted with the students and delivered presentations on importance of quarantine, evaluation and conservation of plant genetic resources.

Fig. 21.5: Biodiversity Awareness Program at Baisinga under TSP on 28th March 2018

Fig. 21.6: Farmers viewing the display of diversity during Biodiversity Fair cum Grassroot Level Awareness Programme on Crop Genetic Resources Conservation organized at Utnoor, Adilabad District, Telangana on 21st and 22nd March, 2018

21.13 Exhibitions or fairs organized

In collaboration with PJTSAU, KVK, Adilabad and ITDA, Utnoor, Telangana, NBPGR Regional Station organized a Biodiversity Fair cum Grass root Level Awareness Programme on Crop Genetic Resources Conservation on 21st and 22nd March, 2018 at Utnoor under the Tribal Sub Project to bring in awareness to the tribal farmers regarding the need and necessity of conservation of Agri-biodiversity especially for livelihood and nutritional security (Figs. 21.6 & 21.7). A total of 134 Tribal Farmers from tribal pockets in and around Utnoor participated in the two day programme. NBPGR Reg. Station, Hyderabad organized an Agri-biodiversity exhibition for the benefit of Tribal farmers, Womenfolk and Students which was inaugurated by Sri.K.Lakke Rao, Chairman, Aboriginal Tribal Welfare Advisory Committee, Utnoor, Adilabad District, Telangana. To promote PGR conservation among tribal farmers, a Kit each consisting of one Crow-bar, a Spade and an Iron Basket along with Literature published in vernacular language by the Station were distributed after identifying suitable needy beneficiaries during the inaugural session.

Fig. 21.7: Tribal farmers each received a kit consisting of one crow-bar, a spade and an iron basket along with literature published in Telugu during Biodiversity Fair cum Grassroot Level Awareness Programme on Crop Genetic Resources Conservation organized at Utnoor, Adilabad District, Telangana on 21st and 22nd March, 2018

ICAR-NBPGR Regional Station, Hyderabad Co-organised the National workshop on "Decentralized seed systems for climate resilient rainfed agriculture" held at MANAGE along with WASSAN, and others on 08-09, March 2018.

21.13.1 Participation in Seed Melas and Exhibitions: NBPGR RS Hyderabad participated in the Seed Mela organised by Professor Jayashankar Telangana State Agricultural University at the University Campus, Rajendranagar on 24.05.18. The Honble Agriculture Minister Shri Pocharam Srinivas Reddy inaugurated the event in which there was active participation by State Government agencies, the Agricultural University and ICAR institutes with their improved crop varieties and hybrids for display and sale. The Vice Chancellor, Dr V Praveen Rao, stated that such a seed mela is being organised in the State for the first time, the objective being to provide quality seed to the farming community at the right time to enhance production and productivity of crops. The NBPGR RS Hyderabad displayed the diversity in agri-horticultural crops and distributed seed of three farmer's varieties registered with PPVFRA *viz.,* Pigeon pea (*Erramacchha kandi*, Sorghum (*Pelala Jonna* and *Vayunowka Jonna*) along with samples of released varieties of brinjal, tomato and cowpea. Farmers visiting the stall expressed interest in the landrace diversity displayed particularly in landraces of pigeonpea (Siri kandulu), sorghum (Vayunowka Jonna, Pelala Jonna, yellow jowar), cowpea, greengram (Balintapesalu), tomato, cherry tomato and dolichos bean (Pandiri chikkudu). About 1200 farmers participated in the Seed Mela who were made aware of the best crop management practices.

21.13.2 Exhibition at Krishi Unnati Mela: RS, Thrissur set up a stall displaying the PGR activities of the station during the "VAIGA-2018 & ICAR-Krishi Unnati Mela" held at Thekkinkadu Maidanam, Thrissur from 27 to 30 December 2018. Live materials of *Amaranthus tricolor* (about 50 accessions), panicles of flood survived rice landraces, minor millets, various minor fruits, rhizome variability in various spices, tuber variability in wild and cultivated root crops, seeds of rice landraces, photographs and posters depicting the various activities and mandates of the station were exhibited. About one lakh people visited the stall and shown interest on the exhibits. Important personalities who visited the NBPGR stall include Retd. Justice P. Sathasivam (Hon. Governor of Kerala), Sri. Thomas Issac (Finance Minister, Govt. of Kerala), Shri. V.S. Sunilkumar (Agriculture Minister, Govt. of Kerala), Sri. P. Raju (Minister of Forests & Wild Life Protection, Govt. of Kerala), Shri. P. K. Biju (Member of Parliament), Mr. Devendra Kumar Singh IAS (Agriculture Production Commissioner, Govt. of Kerala), Mr. M. R. Ajithkumar IPS (IG of Police, Thrissur), Dr. Archana Mukherjee (Director, ICAR-CTCRI), Dr. K Nirmal Babu (Director, ICAR-IISR) and Dr. R. Chandra Babu (Vice Chancellor, KAU).

21.13.3 Regional Workshop and Agro-Biodiversity Exhibition (PPV & FRA and PJTSAU): Protection of Plant Varieties and Farmers' Rights Authority, and PJTSAU, had organized a regional workshop and agro-biodiversity Exhibition on 27th January 2018. ICAR-NBPGR RS, Hyderabad had participated in the same and displayed PGR activities of the station. Seed samples of farmers' varieties from Telangana and Andhra Pradesh [*Vayunowka jonna, Pelala jonna* (Sorghum) and *Erramachha kandhi* (Pigeonpea)] that were registered with the help of NBPGR, were displayed.

21.13.4 Farmers' fair at Ranchi: The ICAR-NBPGR-RS, Ranchi participated in the exhibition cum farmer fair held at ICAR-IINRG on 16.02.2018. Shri Raghubar Das, honorable Chief Minister of Jharkhand graced this occasion. Displayed germplasm diversity, and various on-going PGR activities at the Station were demonstrated to visitors.

21.13.5 Farmer-scientist interaction: A meeting on cultivation of promising vegetables on 26 May 2018; and tuber crops on 19th June 2018 was held at Thrissur Regional Station. More than 20 progressive farmers were participated, for whom the cultivation practices of bitter-less gourds, cucumber, and tubers were explained.

21.13.6 TSP Programme at RS-Jodhpur: One day awareness programme cum workshop was successfully organized in collaboration with Vidya Bhawan Krishi Vigyan Kendra (VBKVK), Badgaon, Udaipur under TSP programme at Kolyari village of Jhadol Block in Udaipur District, Rajasthan on 12-07-2018 (Fig. 21.8).

Fig. 21.8: TSP programme at KVK, Badgaon, Udiapur

21.13.7 Training for value added products on kokum (*Garcinia indica*): RS-Thrissur had organized a training-cum-demonstration program on 1st May 2018; and 21 progressive farmers from the selected MGMG villages and other parts of the district had participated. Dr. S Priya Devi, Principal Scientist, ICAR-CCARI, Goa was invited to be the resource person for the training in which she demonstrated seven value added products from kokum.

21.13.8 Field assessment of PGR loss due to the floods: The scientists of this station surveyed Thiruvambady area of Kozhikode, parts of Manathavady Block in Wayanad district and Parappukkara, Muriyad, Anandapuram, Puthoor, Mattathur, Kodali, Vellikulangara and Chalakkudy areas of Thrissur district during October 2018 to assess the loss of PGR due to the devastating floods that ravaged Kerala in August 2018. As far as the plant genetic resources are concerned, there is no report of complete devastation of any specific landrace of rice or locally specific landraces of vegetables. Even though transplantation could not be further carried out due to sediment deposit, the traditional landraces *Gandhakasala, Chenalthondi, Thondi, Veliyan, Chenthady* and *Chomala* were found to survive the flood.

21.13.9 'Hindi Pakhwada' celebrations: Observance of Hindi pakwada during 14 to 28 September 2018 was done across all the regional stations and base centres of NBPGR. Various programmes like debate, essay, poem recitation and slogan writing competitions were organized.

21.13.10 Vigilance Awareness Week: Vigilance Awareness week was observed during 29th October to 3rd November 2018, across all stations and base centres of NBPGR and the oath was taken and various activities pertaining to vigilance awareness was organized during the week long programme.

21.13.11 International biodiversity day celebrations: ICAR-NBPGR and its regional stations and Base centres celebrated international biodiversity day on 22 May 2018. Various stakeholders were invited to showcase the importance of biodiversity in the climate change regime. A quiz program pertaining to biodiversity of plants was organized for the school students who had participated in the programme.

21.13.12 World environment day celebrations: World environment day was celebrated on 5 June 2018 at RS-Thrissur station, by taking up the activity of 'Plant a Plant & Protect a Plant' by staff members of the Station.

21.13.13 Swachh Bharat Abhiyan: NBPGR, New Delhi and other stations had observed "Swachhata Hi Seva" during 15th September to 2nd October, 2018; and "Swachhta Pakhwada" during 16th to 31st



Fig. 21.9: Swachhta activities of NBPGR

December 2018. Drs Neelam Sharma and Lalit Arya delivered an awareness lecture on 'Swachhta Hi Sewa' on 17th Sept., 2018 at ICAR-NBPGR, New Delhi-12. Under "Swachhata Hi Seva (SHS)" Abhiyan, the staff of ICAR-NBPGR, New Delhi visited Shahid Captain Amit Verma Government Sarvodaya Vidyalya, Inderpuri and Vivek Summit School, East Patel Nagar and organized various activities to make students aware about SHS programme. Leaflets stating 'A step towards clean environment' were distributed. Dr. R.C. Misra delivered a talk on "Swachhta activities" at BC-Cuttack and "Swachhta mission" in an 'Awareness camp' organized at Kanheipur village, Cuttack by ICAR-NRRI, Cuttack. One day Swachata drive was observed at village Suri of district Almora (Uttarakhand) on December 28, 2018 by ICAR-NBPGR, RS Bhowali.

21.13.14 Kisan Diwas at Delhi: Division of Germplasm Evaluation organised *Kisan Diwas* on December 23, 2018 at Issapur Farm, ICAR-NBPGR, New Delhi on the birth anniversary of *Chaudhary Charan Singh* (23 December), former Prime Minister of India and a Kisan Leader. The farmers were appraised with his contributions *to farming community.*

Fig. 21.10: Kisan Diwas celebration at Issapur farm

21.14 Students or external visitors

Student groups from other public/private sector educational institutions viz.Adhunik Group of Institutions, NCR Campus, Duhai, Ghaziabad (UP); Vivekananda Vigyan Mahavidyalaya, Betul (MP), Mata Gujri College, Sri Fatehgarh Sahib (Punjab), Birla School Nainital had visited RS-Bhowali on study tours. At RS-Shillong, students from CHF, CAU, Pasighat; CAU (Imphal) Umiam Campus; Handique Girls' College, Guwahati; St. Edmund's College, Shillong; and ARS probationers made visits as a part of study tour or orientation programs.

Fig. 21.11: Dr. Nadiya Alsaady & Ali Al-Lawati Oman, Animal & Palnt Genetic Resources Centre, Muscat

Fig. 21.12: Dr. Sanjay Kalia, DBT, visited NBPGR field

Meteorological data (temperature in degrees Celsius and rainfall in mm) for the year 2018.

Station	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Akola	Max temp	30.2	33.1	37.4	41.8	43.7	36.6	30	29.6	32.1	35	33	29.1
	Min temp	10.9	15.8	20.3	25.4	30.3	25.2	23.9	23.7	23	18.8	15.8	13.8
	Rainfall	0.0	0.7	3.4	0.3	0.5	291.6	261.9	212.2	64.4	0.0	4.5	0.0
Bhowali	Max temp	16.4	18.1	22.3	24.3	26.4	27.3	24.7	23.7	24	22.7	18.2	13.6
	Min temp	0.9	4	7.4	12.3	14.6	18.3	18.7	18.9	16.6	8.8	6.1	1
	Rainfall	24	13.5	16.3	36.7	38.6	151.7	245	382.5	204.3	8	39.2	0.0
Cuttack	Max temp	26.9	31.7	33.4	36.9	34.6	33.4	31.4	32.3	32.5	32	30.6	26.3
	Min temp	11.8	15.4	22.9	26.3	25.9	25.5	25.5	23.9	23.4	22.3	18.4	13.8
	Rainfall	0.0	0.0	0.0	47	147	190	274	257	440	295	0	12
Hyderabad	Max temp	29.4	31.6	35.9	37.6	39.3	34.7	30.6	29.4	31.4	32.4	31.3	27.9
	Min temp	10.9	13	17.4	21.7	24.1	22.6	21.4	20.8	19.9	16.5	13.7	12.7
	Rainfall	0	0	0.1	0.8	1.2	1.7	2.8	5.1	1.4	1.4	0	0.4
Jodhpur	Max temp	27.2	30.5	36.1	40.8	43.3	40.5	35.6	33.9	35.3	37.5	32.5	26.3
	Min temp	10.1	14	19.5	25.2	29.3	29.8	27.8	26.5	24.4	21.4	15.8	10.7
	Rainfall	0	0	0	0	1.3	31.1	115.1	73.4	7.6	0	0	0
Ranchi	Max temp	22.2	24.7	33.6	34.4	37.7	30.1	29.8	28.6	29.9	27.8	25.9	18.4
	Min temp	9.57	12.04	16.79	21.17	23.91	25.06	25.69	23.62	23.66	21.83	21.1	8.8
	Rainfall	0.0	21	18	22	22	187	199	424	213	167	0.0	9
Shillong	Max temp	20.7	22.7	26.5	26.7	26.1	27.9	28.3	29	28.4	25.5	24.2	21.3
	Min temp	6.8	9.1	13.1	14.9	17	20	21	20.8	19.1	15.1	10.8	8.1
	Rainfall	8.6	24.4	31.3	208.2	281.3	424.3	354.7	435.7	258.6	214.9	7.3	28.6
Shimla	Max temp	15.8	16.8	20.6	23.0	26.5	26.3	23.7	23.0	23.4	21.5	18.2	14.2
	Min temp	4.76	5.31	8.89	11.77	15.02	16.08	16.37	16.09	14.79	10.99	8.51	4.3
	Rainfall	12.8	41.8	7.85	35.9	137.8	208.5	423.6	415.5	354.9	1.8	16.3	7.7
Srinagar	Max temp	7	8.2	14.1	20.5	24.5	29.6	30.1	29.6	27.4	22.4	15.1	8.2
	Min temp	-2	-0.7	3.4	7.9	10.8	14.9	18.1	17.5	12.1	5.8	0.9	-1.5
	Rainfall	60	70	100	80	80	50	70	60	30	20	20	50
Thrissur	Max temp	33.5	35.7	36.7	36.1	33.2	29.8	29.6	29.2	32.2	32.8	32.7	33
	Min temp	20.9	22.5	24	24.8	22.6	23.2	22.5	22.2	22.5	22.9	23.3	22.5
	Rainfall	0	5.2	33.2	28.9	483.6	730	793.2	928	29	393	66.6	0
New Delhi	Max temp	20.4	25.3	32.8	35.7	39.3	38.3	33.6	32.4	30.6	32.9	27.7	22
	Min temp	5.7	9.1	13.7	20.7	23.2	27.5	25.3	23.9	22.1	15.6	12.6	6.2
	Rainfall	0.2	0.0	0.0	0.7	0.9	2.5	12.3	7.1	8.2	0	0.1	0.0

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch