वार्षिक प्रतिवेदन

Annual Report 2019

भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संस्थान ब्यूरो

पूसा कैम्पस, नई दिल्ली – 110012

ICAR-National Bureau of Plant Genetic Resources

Pusa Campus, New Delhi - 110012

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ICAR-National Bureau of Plant Genetic Resources

(भारतीय कृषि अनुसंधान परिषद्)

(Indian Council of Agricultural Research)

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ICAR-NBPGR Annual Report 2019

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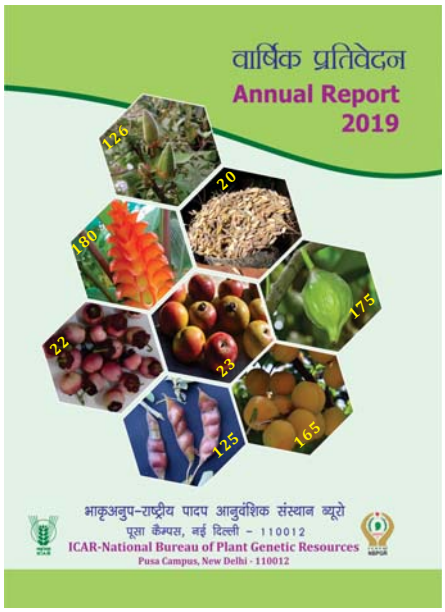
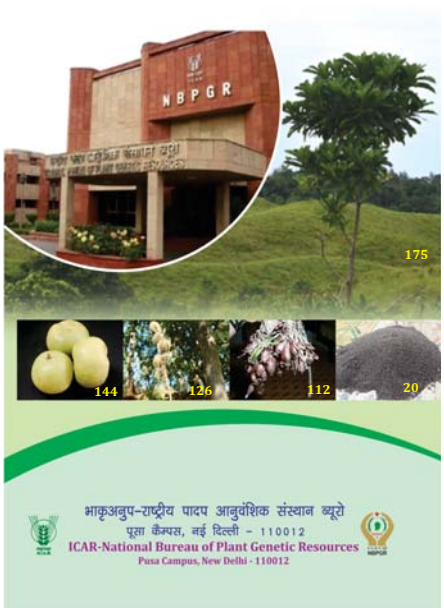
Dr Kuldeep Singh, Director

Supervision
Pratibha Bramhi

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





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NBPGR

Mandate

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

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

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

Preface

I am pleased to put forth Annual Report 2019 as this was a very satisfying year for ICAR-NBPGR. *Knowledge creation* has been the defining role of research institutions and the manner in which we create knowledge and conduct research, must undergo a major change if an institution has to retain its relevance to the society. In that perspective, we have implemented various new programmes and network projects with a vast number of national partners for a diverse and highly franchised PGR research in 2019.

ICAR-NBPGR is the leading plant genetic resources institute dedicated to the exploration, conservation, exchange, quarantine and characterization of crop PGR. We place special emphasis on investing in PGR management and research with an eye on the current need of the nation as we know through our almost five decades of experience that presence of a broad based PGR benefits crop breeders and farming communities. The world is in desperate need of sustainable solutions to planet-threatening issues like climate change, biodiversity loss, human health and food shortages. PGR research is arguably the most powerful weapon for solving these problems.

In this direction, NBPGR persevered to provide national and international service in the areas of crop germplasm supply, exchange and quarantine as well as endeavoured to characterize and document the PGR research. Numerical focus on the work done last year is presented in the next page. Despite this, ability of the annual report to showcase the real portrait of NBPGR— its intellectual workforce, its stakeholders and patrons— is limited.

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

In these exigent times we received unwavering support of ICAR and I gratefully acknowledge the liberal leadership of Dr T Mohapatra, the Hon'ble Secretary, DARE and Director General, ICAR; Dr T R Sharma, DDG (Crop Science); Dr A K Singh, DDG (Hort. Science) and Dr DK Yadava, ADG (Seeds), for their stimulus in proposing new alternatives and rewarding the pivotal mandate of ICAR-NBPGR.

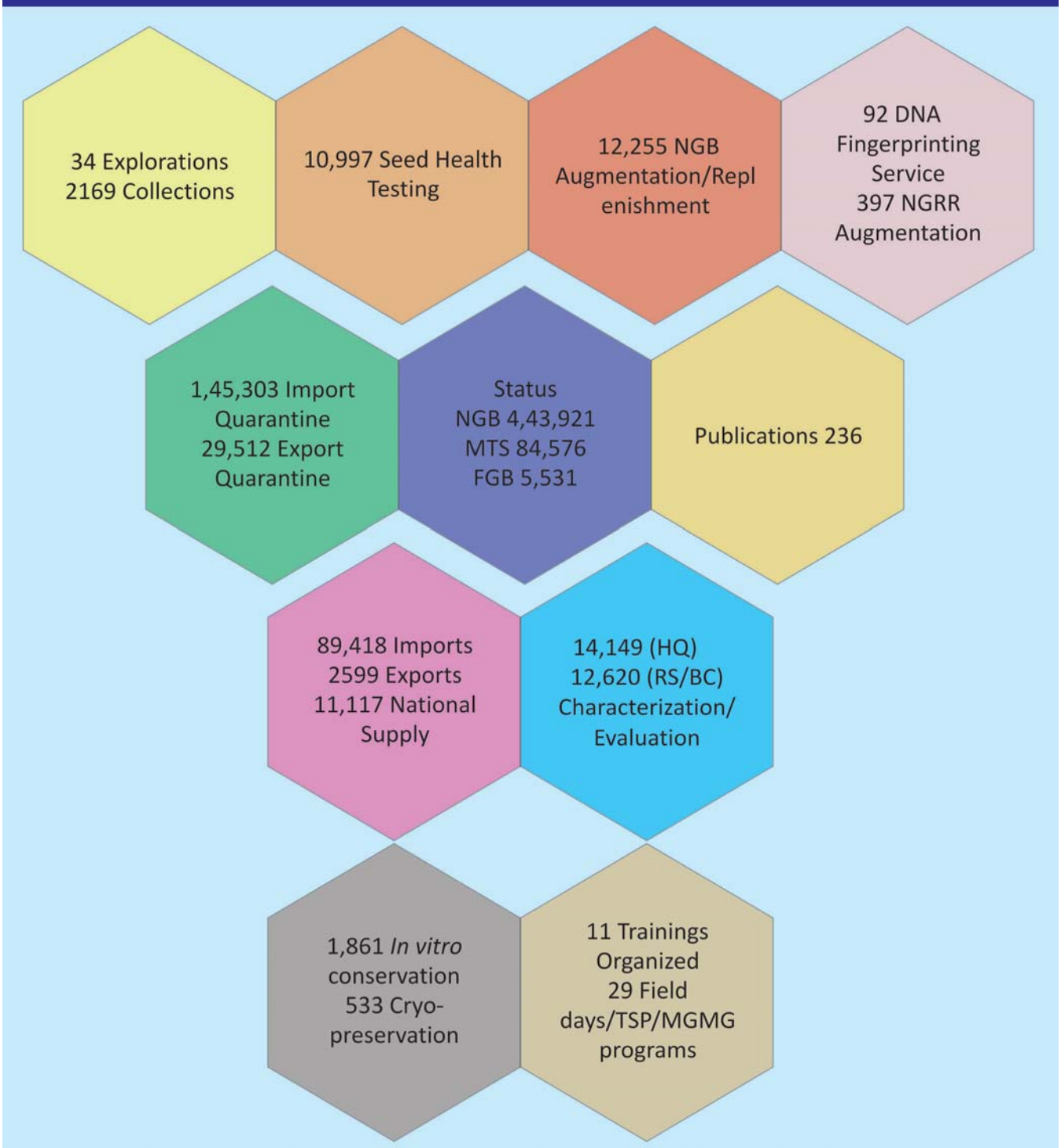
Looking ahead, despite enormity of the challenges before us in the Covid19 circumstances, we are operating with the same spirit and audacious thinking as before to deliver new dimensions in PGR management and research. We enterprise to bring forth a truly multi-disciplinary research environment that will bridge the boundaries between the PGR, basic research and varietal development.

I encourage you to read this Annual Report and appreciate the outstanding progress that was made at NBPGR during 2019.

May 25, 2020
New Delhi

Kuldeep Singh
Director

ICAR-NBPGR in numbers – 2019



List of Acronyms

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

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

कार्यकारी सारांश

वर्ष 2019 के दौरान भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवांशिकी संसाधन ब्यूरो द्वारा पादप आनुवांशिक संसाधनों के विभिन्न पहलुओं–पादप अन्वेषण एवं जननद्रव्य संग्रह, जननद्रव्य विनियम, पादप जननद्रव्य संगरोध, जननद्रव्य लक्षन वर्णन एवं मूल्यांकन, *इन–सिटू* एवं *इन–विट्रो* संरक्षण, डी एन ए, फिंगरप्रिंटिंग, जीनोमिक संसाधनों की पीढ़ी एवं जी एम परीक्षण का प्रतिपादन 21 संस्थागत वित्त पोषित कार्यक्रमों एवं 39 बाह्य वित्त पोषित परियोजनाओं के अन्तर्गत किया गया, जिसकी प्रमुख उपलब्धियाँ का सारांश यहाँ प्रस्तुत किया गया है।

पादप अन्वेषण एवं जननद्रव्य संग्रहण

वर्ष 2019 में, देश भर में कुल 34 अन्वेषण किए गए, जिसमें भारत के 20 राज्यों में स्थित 104 जिलों से विभिन्न कृषि–बागवानी फसलों की जंगली प्रजातियों एवं अन्य आर्थिक महत्व वाली प्रजातियों की कुल 2,169 प्रविष्टियाँ एकत्रित किए गए। इनमें से 707 प्रविष्टियाँ भा.कृ.अनु.प.–रा.पा.आ.सं.ब्यूरो, नई दिल्ली मुख्यालय द्वारा 147 अन्वेषणों के माध्यम से संग्रहित किए गए। कुल 458 हर्बेरियम नमूनों (61 अपूर्वदृष्ट सहित) को प्रसंस्कृत किया गया एवं नई दिल्ली स्थित नेशनल हर्बेरियम ऑफ कल्टिवेटड प्लांट्स (NHCP) में जोड़ा गया। बायोसिस्टमेटिक अध्ययनों से देश में ट्राइकोसेन्थेस (*जिमनोपेटलम* को छोड़कर) की 13 प्रजातियों (16 टैक्सा) की उपस्थिति को प्रकाशित किया गया। कुछ ट्राइकोसेन्थस प्रजातियों की नई एवं विस्तृत वितरण की सूचना दी गई एवं भारतीय टैक्सा की पहचान के लिए लक्षण कुंजी तैयार की गई।

अकोला स्टेशन ने 3 अन्वेषण किए और महाराष्ट्र, कर्नाटक के चयनित जिलों से सब्जियों, दलहनी और अन्य फसलों के कुल 257 संग्रह किए गए। भवाली स्टेशन में, अरुणाचल प्रदेश, उत्तराखंड और उत्तर प्रदेश से विभिन्न फसलों के 81 संग्रह किए गए। कटक आधार केंद्र द्वारा तीन अन्वेषण किए गए और ओडिशा और पश्चिम बंगाल से विभिन्न फसलों के 211 संग्रह किए गए। हैदराबाद क्षेत्रीय केन्द्र द्वारा एक सहयोगात्मक खोज की गई, और विभिन्न फसलों के 152 एक्सेस एकत्र किए गए। जोधपुर क्षेत्रीय केन्द्र द्वारा यूपी, एमपी और राजस्थान में चंबल नदी के कैचमेंट क्षेत्र से एक सर्वेक्षण का आयोजन किया गया था और स्थानीय भूप्रजातियों के 30 जननद्रव्य एकत्र किए गए। रांची बेस सेंटर से झारखंड और बिहार में गौण फलों (43 प्रविष्टियाँ), सब्जियों और बाजरा (50 प्रविष्टियाँ) का संग्रह करने के लिए दो अन्वेषण किए गए। दो अन्वेषण शिलॉन्ग क्षेत्रीय केन्द्र द्वारा किए गए, एक मेघालय में और दूसरा मिजोरम में 171 जननद्रव्य के संग्रह के लिए किया गया। दो अन्वेषण शिमला क्षेत्रीय केन्द्र द्वारा किए गए और परिणामस्वरूप मेघालय और उत्तराखंड की विभिन्न कृषि–बागवानी फसलों के 121 जननद्रव्य का संग्रह हुआ। श्रीनगर क्षेत्रीय केन्द्र पर, कश्मीर में फेबा बीन्स पर एक अन्वेषण किया गया और 28 विविध संग्रह एकत्र किए गए थे। त्रिशूर क्षेत्रीय केन्द्र ने 3 अन्वेषण किए और उत्तरी सिक्किम और निकोबार से जननद्रव्य के 409 नमूने एकत्र किए।

जननद्रव्य विनियम आदान प्रदान

2019 में, 89,418 परिग्रहण (1,93,395 नमूने) आयात किए गए थे जिनमें 55,926 (56,570 नमूने) जननद्रव्य और 33,492 प्रविष्टियाँ (1,36,825 नमूने) शामिल हैं। वर्ष के दौरान कई विशेषता विशिष्ट बीज/रोपण सामग्री भी आयात की गई। इसके अतिरिक्त, विभिन्न फसलों के 11,117 नमूने सामग्री हस्तांतरण समझौते (एमटीए) के तहत विभिन्न फसल सुधार कार्यक्रमों में उपयोग के लिए राष्ट्रीय उपयोगकर्ताओं को दिए गए थे। इसके अलावा, 66,097 नमूनों को पुनर्जनन/गुणन/आकारिकीय लक्षण वर्णन/प्रारंभिक मूल्यांकन/टैक्सोनोमिक पहचान/डीएनए फिंगरप्रिंटिंग/ व्यवहार्यता परीक्षण के लिए आपूर्ति की गई। सहयोगी अनुसंधान परियोजनाओं के तहत विभिन्न देशों में कुल 2,599 नमूने निर्यात किए गए थे। इसके अलावा, ICRISAT जनादेश फसलों (FAO नामित अभिगम) के 7273 नमूनों की आपूर्ति और CIMMYT मक्का परीक्षणों/नर्सरी के 38540 नमूनों की सुविधा विभिन्न देशों को दी गई।

राष्ट्रीय आपूर्ति

मुख्यालय, नई दिल्ली ने फसल सुधार में उपयोग के लिए 85 इंडेंटर्स को विभिन्न फसलों की 4863 जननद्रव्यों की आपूर्ति की। अकोला ने भारत के भीतर 39 उपयोगकर्ता एजेंसियों को अनुसंधान उद्देश्यों के लिए विभिन्न फसलों की 1169 जननद्रव्यों की आपूर्ति की। विभिन्न फसलों की कुल 276 पहुंचों को भवाली

से एमटीए के तहत विभिन्न इंडेंटरों को आपूर्ति की गई थी। कटक में, तीन आईसीएआर–संस्थानों को विभिन्न फसलों के 126 जननद्रव्यों की आपूर्ति की गई। हैदराबाद स्टेशन द्वारा 23 इंडेंट के माध्यम से 24 एसएयू/आईसीएआर संस्थानों को 933 जननद्रव्य प्रदान किए गए। जोधपुर में, खरीफ 2019 के दौरान, विभिन्न फसलों की 1358 जननद्रव्य; गेहूं मिनी कोर के 236 जननद्रव्य, भारतीय सरसों के 35 जननद्रव्य और मेथी के 15 जननद्रव्य, बेर के दस जननद्रव्य और 24 जननद्रव्य अनार के, रबी 2019–2020 के दौरान विशेषता/मूल्यांकन किया गया था। कुल्थी के कुल 254 परिग्रहण और कटहल और इमली के परिग्रहण की विशेषता रांची में मूल्यांकन किया गया। शिलांग स्टेशन द्वारा एमटीए के अनुसार विभिन्न फसलों की कुल 176 जननद्रव्य इंडेंटर्स को आपूर्ति की गईं। श्रीनगर स्टेशन पर, विभिन्न फसलों के 40 परिग्रहणों को अनुसंधान प्रयोजन के लिए अलग–अलग इंडेंटरों को आपूर्ति की गई। त्रिशूर स्टेशन द्वारा सामग्री हस्तांतरण समझौते (एमटीए) के तहत 20 उपयोगकर्ता एजेंसियों को विभिन्न प्रजातियों/टैक्सा में कुल 1250 जननद्रव्य दिए गए।

पादप जननद्रव्य संगरोध

विभिन्न फसलों के आयातित जननद्रव्य के कुल 1,18,751 नमूनों को मुख्यालय, नई दिल्ली में संगरोध मंजूरी के लिए संसाधित किया गया था। संक्रमित 1,689/संक्रमित/दूषित नमूनों में से 1,565 को फिजियो–केमिकल विधियों के जरिए बचाया गया। शेष नमूनों का निस्तारण नहीं किया जा सका और इसलिए खारिज कर दिया गया। विभिन्न देशों/स्रोतों से आयातित अलग–अलग फलियां फसलों के विदेशी जननद्रव्य के कुल 1,478 नमूनों को पोस्ट–एंट्री संगरोध (पीईक्यू) ग्रीनहाउस में उगाया गया और वायरस से मुक्त पौधों की फसल को इंडेंटर्स को जारी किया गया। 2019 के दौरान विभिन्न इंडेंटर्स साइटों पर चालीस–प्रवेश पश्चात् संगरोध निरीक्षण किए गए थे। निर्यात के लिए विभिन्न फसलों के कुल 2768 नमूनों को संसाधित किया गया था और 15 फाइटोसैनिटरी प्रमाण पत्र जारी किए गए थे। आयातित ट्रांसजेनिक रोपण सामग्री के 20 नमूनों की संगरोध प्रसंस्करण ने यूएसए से धान के 19 नमूनों में *बाइपोलरिस ओरेजा* और *फुसैरियम वर्टिसिलिओइड्स* के साथ संक्रमण का पता लगाया और संक्रमित नमूनों का निस्तारण किया गया। टर्मिनेटर जीन की अनुपस्थिति सुनिश्चित की गई थीय सभी नमूनों को रिलीज से पहले और PEQ निरीक्षण किए जाने से पहले मुक्त कर दिया गया था। बीज स्वास्थ्य परीक्षण के तहत, जननद्रव्य संरक्षण विभाग से प्राप्त 10,997 नमूनों में से 334 नमूने संक्रमित पाए गए और कुल 18 नमूनों को अस्वीकार कर दिया गया क्योंकि उन्हें बचाया नहीं जा सकता था। ब्रूचिड्स और चाकलीड्स के छिपे हुए संक्रमण का पता लगाने के लिए कुल 2,715 नमूनों को एक्स–रे रेडियोग्राफी से अवगत कराया गया और 178 नमूनों को संक्रमित पाया गया जबकि 949 नमूनों में कीट–कीट के दृश्य संक्रमण दर्ज किए गए। विभिन्न कीटों द्वारा कुल 1,127 नमूने संक्रमित पाए गए और 953 को उबार लिया गया जबकि 174 को अस्वीकार कर दिया गया। इसके अलावा, क्रायो–संरक्षण से पहले/बाद में बीज स्वास्थ्य परीक्षण के लिए टीसीसीयू से 136 नमूने प्राप्त किए गए थे, जिनमें से सात नमूने अलग–अलग कवक से संक्रमित पाए गए थे और सभी को उबार लिया गया था। इसके अतिरिक्त, हैदराबाद स्टेशन में, 53,296 नमूनों (26, 552 आयातय 23,904 + 2840 निर्यात) को संगरोध ा मंजूरी के लिए संसाधित किया गया था। 49 फाइटोसैनेटरी प्रमाणपत्र जारी किए गए थे। आयात के नमूने (20,925) कीट/रोगजनकों से संक्रमित/संक्रमित थे और उन्हें मुक्त कर दिया गया था (20,269)। दक्षिण भारत में 98 संगठनों के लिए संगरोध सेवाओं का विस्तार किया गया। हैदराबाद में विभिन्न फसलों के 16,371 नमूनों पर प्रविष्टि के बाद संगरोध निरीक्षण किया गया था।

जननद्रव्य लक्षण वर्णन और मूल्यांकन

2019 के दौरान, मुख्यालय पर कृषि–बागवानी फसलों की बड़े पैमाने पर (14,149) विशेषता, मूल्यांकन एवं पुनर्जनन किया गया। बायोटिक स्ट्रेस के खिलाफ मूल्यांकन के लिए, 58 होनहार गेहूं के उपयोग, बैंगन के 6 जननद्रव्य के साथ जंगली बैंगन के 18 जननद्रव्य, *सोलनम इंकानम* के 4 होनहार जननद्रव्य और दालों के 762 जननद्रव्य की जांच /सत्यापन किया गया। अजैविक तनावों के तहत, गर्मी (तनाव) के खिलाफ मूंग (80) और सूखे के मुकाबले गेहूं (443), जौ (220) और दाल (150) युक्त 893 अभिग्रहणों का मूल्यांकन किया गया। विभिन्न फसलों सहित 1,239 परिग्रहणों के लिए गुणवत्ता मानकों। चावल (180), गेहूं (100), जौ (286), मक्का (45), अलसी (218) और फलों के पेड़ (37) का अध्ययन किया गया। औषधीय और सुगंधित पौध ों में, विभिन्न फाइटो–रासायनिक घटकों के लिए 189 परिग्रहणों का मूल्यांकन किया गया था। एग्रो–जैव विविधता पर सीआरपी के तहत, AICRP केंद्रों के बायोटिक और अजैविक तनावों के लिए चावल (1,022), गेहूं (917), चना (300) और भिण्डी (411) सहित कुल 2,650 परिग्रहणों का मूल्यांकन किया गया।

अकोला में, रबी (457) और खरीफ (1879) में विभिन्न फसलों के कुल 2336 परिग्रहणों की विशेषता और मूल्यांकन किया गया। इसके अलावा, अकोला में 1081 विभिन्न फसलों के जननद्रव्य पुनर्जीवित किए गए। विभिन्न रबी, खरीफ (688), सब्जी (66) और फल फसलों (95 परिग्रहण) के लगभग 375 उपयोगों को बीज के लिए गुणा किया गया था, भवाली में विशेषता और मूल्यांकन किया गया था। कटक बेस सेंटर में विभिन्न फसलों और जंगली प्रजातियों के 3798 परिग्रहणों के अलावा 425 चावल, जंगली *ओरिया* प्रजाति, *Ocimum* spp., *Hibiscus sddariffa* के विभिन्न प्रकार के मोर्फो–एग्रोनॉमिक लक्षणों की विशेषता है। हैदराबाद में, कुल 716 प्राप्तियों को विभिन्न कृषि–बागवानी फसलों को क्षेत्र के लक्षण वर्णन/मूल्यांकन/ स्क्रीनिंग/गुणा/कायाकल्प के लिए बोया गया था। विभिन्न कृषि–रूपात्मक लक्षणों के लिए शिलांग में विभिन्न फसलों के 63 विभिन्न उपयोगों की विशेषता थी। शिमला में, विभिन्न क्षेत्र की फसलों के कुल 1361 जननद्रव्य की विशेषता और मूल्यांकन महत्वपूर्ण ब्याज के खिलाफ किया गया था। श्रीनगर स्टेशन पर, तीन फसलों के 228 जननद्रव्य उनके कृषि–रूपात्मक लक्षणों के लिए विशेषता थे। त्रिशूर में कुल 490 जननद्रव्य की विशेषता थी।

जननद्रव्य संरक्षण

जननद्रव्य के कुल 31,455 परिग्रहण, जिसमें पुनर्जीवित जर्मप्लाज्म शामिल हैं, जिन किस्मों को अधिसूचित किया जाना है, जारी किए गए कलियों और विभिन्न फसलों के विशेषता–विशिष्ट पंजीकृत जननद्रव्य को राष्ट्रीय जीनबैंक में दीर्घकालिक संरक्षण के लिए प्राप्त किया गया था। इन्हें जीनबैंक मानकों के अनुसार संसाधित किया गया था, विभिन्न कृषि–बागवानी फसलों के 12,255 उपयोगों को आधार संग्रह में जोड़ा गया है, जिससे कुल जननद्रव्य 4,43,921 तक पहुंच गया है। संरक्षित परिग्रहणों में से, 4,203 नए थे और 8,052 पुनर्जनन के बाद प्राप्त हुए थे। अंकुरण/मूल्यांकन/उत्थान/अनुसंधान के लिए संग्रहित जननद्रव्य (9573 अभिग्रहण) और वितरण (56,481) में अंकुरण और बीज की मात्रा की निगरानी अन्य प्राथमिकता वाली गतिविधियाँ थीं। आपूर्ति किए गए जननद्रव्य में कंसोर्टियम रिसर्च प्लेटफार्म ऑन एग्रोबायोडाइवर्सिटी (सीआरपी–एबी) के तहत गुण और लक्षण वर्णन के लिए भेजा गया है। राष्ट्रीय जीनबैंक का उन्नयन/आधुनिकीकरण किया गया और अब तक 11 एलटीएस और 3 एमटीएस मॉड्यूल चालू किए गए हैं।

MTS और FGB में जननद्रव्य

अकोला में क्षेत्रीय स्टेशन के मध्यम अवधि के भंडारण में नियंत्रित परिस्थितियों में विभिन्न फसलों/प्रजातियों जननद्रव्य के कुल 20,838 परिग्रहणों को बनाए रखा जा रहा है। भवाली एमटीएस में कुल 11,316 परिग्रहणों का संरक्षण किया जा रहा है और क्षेत्र जीन बैंकों में 1,251 परिग्रहण बनाए हुए हैं। कटक में, औषधीय एवं सुगंधित पौधों, बागवानी फसलों, कंद/थायरॉयड फसलों और Fw में विभिन्न CWR युक्त 519 परिग्रहणों को बनाए रखा जा रहा है और 1430 वाउचर नमूनों को हर्बेरियम में संरक्षित किया गया है। जोधपुर में, फील्ड जीन बैंक में बागवानी पौधों के 423 जननद्रव्य बनाए जा रहे हैं और एमटीएस सुविधाओं में स्टेशन पर कृषि–बागवानी फसलों के 43085 उपयोग संरक्षित किए जा रहे हैं। रांची में, फील्ड जीन बैंक में कुल 617 बागवानी पौधों के उपयोग और 300 औषधीय पौधों के संरक्षण का संरक्षण किया जा रहा है। शिलांग में, एमटीएस में कृषि–बागवानी फसल जननद्रव्य के कुल 2,155 परिग्रहण बनाए जाते हैं। इन फसलों के अलावा, क्षेत्र में जीन बैंक में 528 परिग्रहण बनाए हुए हैं। क्षेत्रीय केन्द्र त्रिशूर में विभिन्न फसलों/बारहमासी बागवानी पौधों और उनके जंगली रिश्तेदारों के 9057 अभिग्रहण की एक जननद्रव्य होल्डिंग है, जिनमें से 7182 एमटीएस और 1875 में एफजीबी में हैं।

जननद्रव्य *इन–विट्रो* और क्रायो–संरक्षण

विभिन्न बागवानी फसलों की 145 पौधों की प्रजातियों की 1,886 पहुंचों की संस्कृतियों को *इन विट्रो* एक्टिव जीनबैंक में परिवेश और/या कम तापमान पर 2–24 महीनों से लेकर उप–कुल अवधि के साथ संरक्षित किया गया था। क्रायोजीनबैंक में कृषि–बागवानी प्रजातियों के कुल 13,896 प्राप्तियों को बीज, भ्रूण, पराग और जीनोमिक संसाधनों के रूप में संरक्षित किया गया था। नवीन प्रजातियों (21) को *इन–विट्रो* में जोड़ा गया और विभिन्न फसलों और जंगली प्रजातियों के कुल 533 नए उपयोग बीज, भ्रूण अक्ष, पराग और जीनोमिक संसाधनों के रूप में रोए थे। कुछ फसलों में *इन–विट्रो* गुणन और संरक्षण प्रोटोकॉल को परिष्कृत किया गया और विट्रिफिकेशन, एनकैप्सुलेशन– डिहाइड्रेशन, एनकैप्सुलेशन–विट्रीफिकेशन, ड्रापलेट विट्रीफिकेशन और वी– और डी–क्रायोप्लेट तकनीक

का उपयोग करके क्रायोप्रिसरवेशन प्रयोगों में अलग–अलग सफलता हासिल की गई। *इन–विट्रो* में क्रायोबैंकिंग सात फसलों के 56 परिग्रहण में किया गया। क्रायोप्रिसर्वड जननद्रव्य ने क्रायोप्रेसिव और पुनर्जीवित प्लांटलेट्स के प्रोफाइल में उच्च समानता और एलियम प्रजातियों में उनके संबंधित नियंत्रण का पता लगाया (30 एसएसआर मार्कर्रों का उपयोग करके) और जेंटियाना कौरू (30 एसएसआर और 39 आईएसएसआर मार्कर्रों का उपयोग करके)। बीज, भ्रूण अक्ष, पराग और जीनोमिक संसाधनों और सुप्त कलियों के रूप में कुल 533 परिग्रहणों को क्रायोस्टोर किया गया था।

डीएनए फिंगरप्रिंटिंग, जीनोमिक रिसोर्स और जीएम डिटैक्शन

कुल सोलह कृषि–बागवानी फसलों के 99 नमूने, अर्थात्, मिर्च, कपास, लोबिया, रागी, कंगनी, मूंग, धान, बाजरा, अरहर, तिल, सोयाबीन, तोरी, उड़द और अखरोट। विभिन्न सार्वजनिक और निजी क्षेत्र के संगठनों की रिपोर्ट के तहत इस अवधि में गेहूं का डीएनए किया गया। हाल ही में अनुक्रमित काली मिर्च थोटुमुरियन जीनोम से अनुक्रम जानकारी 69,126 सरल अनुक्रम दोहराता (एसएसआर) की पहचान और लक्षण वर्णन के लिए उपयोग किया गया था। अनाज अमरैंथस के लिए, एसएसआर मार्कर्रों का विकास सार्वजनिक डेटाबेस का उपयोग करके शुरू किया गया और कुल 2,80,997 एसएसआर loci की पहचान की गई और 66,243 एसएसआर मार्कर्रों के लिए प्राइमर जोड़े उत्पन्न किए जा सकते थे और इनमें से 53,067 प्राइमर अद्वितीय थे। एनजीएस डेटा से हाइब्रिड असेंबली का उपयोग करके तोरी के एक ड्राफ्ट जीनोम को इकट्ठा किया गया था। पूर्वी तट से चावल का उपयोग (2243 परिग्रहण) 36plex एसएनपी परख के साथ किया गया और इसका उपयोग कोर विकास के लिए किया गया। एएटी, जीपीटी और पीपीडीके जीन के लिए सी 4–विशिष्ट जीन प्रतियां चावल के सभी अध्ययन किए गए जीनोटाइप में पत्तियों की तुलना में अनाज में काफी अंतर से व्यक्त की गई थीं। गेहूं में कुल उन्नीस विभिन्न जीनोमिक क्षेत्रों में 51 एमटीए / क्यूटीएल को अंकुरण स्तर पर चार अलग–अलग पैथोटाइप के प्रतिरोध के साथ जोड़ा गया, यानी 18 एमटीए (टी पैथोटाइप), 14 एसएनपी (462119), 7 एसएनपी (110 एस 119) और GWAS के माध्यम से 12 एसएनपी (238S119)। जीएम स्थिति की जांच के लिए या घटना की पुष्टि के लिए पांच फसलों के 27 खेप के कुल 67 नमूनों का परीक्षण किया गया। प्रौद्योगिकी को 2015 में DSS इमेजेटेक प्राइवेट लिमिटेड को हस्तांतरित किया गया, जिसे कंपनी द्वारा कपास, मक्का, चावल, सोयाबीन, गेहूं, कैनोला, सरसों सहित प्रमुख फसलों में जीएम घटनाओं की स्क्रीनिंग के लिए GMO स्क्रीनिंग और क्वांटिफिकेशन किट के रूप में लॉन्च किया गया।

पीजीआर जागरूकता / टीएसपी / एमजीएमजी / आउटरीच

मुख्यालय में प्रमुख फसलों पर तीन प्रक्षेत्र दिवसों में जननद्रव्य के उपयोग की सुविधा के लिए आयोजित किया गया। प्लांट एक्सप्लोरेशन एंड जर्मप्लाज्म कलेक्शन डिवीजन द्वारा 11 राज्यों के 2354 किसानों, और केवीके के 100 अधिकारियों, कृषि और बागवानी विभाग के फील्ड अधिकारियों, अरुणाचल प्रदेश सरकार के 100 अधिकारियों के बीच संरक्षण और कृषि प्रबंधन पर जागरूकता पैदा की गई। क्षेत्रीय केन्द्र अकोला ने आदिवासी उप–योजना के तहत एक कार्यशाला सह जागरूकता कार्यक्रम का आयोजन किया, जिसमें राज्य स्तरीय कृषि प्रदर्शनी (AGROTECH–2019) में भाग लिया और महाराष्ट्र में किसानों के बीच अनाज के प्रसार को लोकप्रिय बनाया। भवाली क्षेत्रीय केन्द्र ने TSP, एक प्रशिक्षण और 3 किसान प्रक्षेत्र दिवसों के तहत एक कृषि–जैव विविधता मेला–सह–संगोष्ठी का आयोजन किया। बेस सेंटर कटक ने आईसीएआर–एनआरआरआई के साथ चावल जननद्रव्य प्रक्षेत्र दिवस का सह–आयोजन किया, टीएसपी के तहत जैव विविधता मेला आयोजित किया और किसान मेले में ओडिशा के पीजीआर का प्रदर्शन किया। रांची बेस सेंटर में एक कुलथी जननद्रव्य प्रक्षेत्र दिवस का आयोजन किया गया। क्षेत्रीय स्टेशन शिलांग ने मेघालय और असम में टीएसपी के तहत दो कार्यशालाओं का आयोजन किया। शिमला स्टेशन पर, कृषि विज्ञान केंद्र (KVK) तबू–द्वितीय के सहयोग से एक पीजीआर जागरूकता कार्यक्रम टैबू, लाहौल और स्पीति हिमाचल प्रदेश में पीपीवी और एफआरए के साथ किसानों की किस्मों के पंजीकरण की सुविधा के लिए आयोजित किया गया। त्रिशूर क्षेत्रीय केन्द्र ने किसानों के साथ एक जर्मप्लाज्म एक्सचेंज डे और किसानों के साथ आम की विविधता के दिन का आयोजन किया। इसके अलावा, वायनाड जिले के आदिवासी इलाकों में तीन प्रशिक्षण सह रोपण सामग्री वितरण कार्यक्रम भी आयोजित किए गए।

अन्य गतिविधियां

PGR नीति नियोजन इकाई ने PGR प्रबंधन मुद्दों पर विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय स्तर पर नीति निर्माताओं को इनपुट

प्रदान किए। एग्रीकल्चरल नॉलेज मैनेजमेंट यूनिट (AKMU) ने इन्फोग्राफिक्स के साथ भरा चरित्र चित्रण डेटा तक पहुंचने के लिए एक ऑनलाइन एप्लिकेशन विकसित किया। एकेएमयू द्वारा ट्विटर के माध्यम से पीजीआर गतिविधियों के बारे में जानकारी प्रसारित करने के प्रयास ने 1.9 लाख छापे (पिछले वर्ष की तुलना में 146% वृद्धि) को आकर्षित किया है, जो NBPGR की भूमिका को लोकप्रिय बनाता है। PGR पोर्टल, NBPGR का प्रमुख वेब–आधारित सूचना पोर्टल, 2019 में प्रति माह औसतन 4200 विचारों के साथ कई देशों से एक्सेस किया गया था। ICAR-NBPGR ने 2019 के दौरान विभिन्न हितधारकों के लिए 11 प्रशिक्षण और 2 संगोष्ठियों का आयोजन किया। इसके अलावा, 13 वैज्ञानिक और 17 तकनीकी और प्रशासनिक कर्मचारियों को विभिन्न संगठनों द्वारा प्रदान किए गए विभिन्न प्रशिक्षण कार्यक्रमों से गुजरना पड़ा। संस्थान के वैज्ञानिक और तकनीकी कर्मचारियों ने संबद्ध अनुसंधान क्षेत्रों में वर्तमान विकास पर बढ़त हासिल करने के लिए एक साझा मंच के माध्यम से वैज्ञानिक अपडेट साझा करने के लिए 2019 के दौरान 129 सेमिनार/संगोष्ठी/सम्मेलन/कार्यशालाओं में भाग लिया था। इसके अलावा, संस्थान के 15 वैज्ञानिक कर्मचारियों ने 2019 के दौरान 21 विदेशी प्रतिनियुक्तियों के लिए काम किया। 2019 के दौरान, अद्वितीय लक्षण वाले 105 जर्मप्लाज्म विभिन्न कृषि–बागवानी फसलों की 40 प्रजातियों से पंजीकृत थे। दो M.Sc. और चार पीएच.डी. पी जी स्कूल IARI के 58 वें दीक्षांत समारोह में छात्रों को डिग्री प्रदान की गई। वर्तमान में, नौ M.Sc. सहित कुल 29 छात्र। और बीस पीएच.डी. रोल पर हैं वर्ष के दौरान, 4 पदोन्नति, एक स्थानांतरण, 11 सेवानिवृत्ति सभी कर्मचारी श्रेणियों में प्रभावित हुईं। वैज्ञानिक कर्मचारियों को 17 पुरस्कार दिए गए। सहकर्मी–समीक्षा किए गए शोध लेख (121), किताबें (8), पुस्तक अध्याय/मैनुअल अध्याय (84), टीवी वार्ता (07), रिपोर्ट (3), प्रशिक्षण मैनुअल (7), पीजीआर रिपोर्टर के रूप में शोध आउटपुट का प्रसार/नोटिस /ब्रोशर (9) और ई–प्रकाशन (4)।

EXECUTIVE SUMMARY

The significant achievements during 2019 by ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) on various PGR aspects *viz*., plant exploration and collection of germplasm; germplasm exchange; plant germplasm quarantine; germplasm characterization and evaluation; *ex-situ, in-situ* and *in-vitro* conservation of germplasm; DNA fingerprinting, genomic resources' generation and GM detection; under 21 institutionally funded programs and 39 externally funded projects are summarized hereunder:

Plant exploration and collection of germplasm

In 2019, a total of 34 explorations was undertaken across the country wherein 2,169 accessions of various agri-horticultural crops, crop wild relatives (CWR) and other economic species were collected from 104 districts located in 20 states of India. Of these, 707 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 14 explorations conducted. A total of 458 herbarium specimens (including 61 unrepresented taxa) was processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Biosystematic studies revealed the occurrence of 13 species (16 taxa) of *Trichosanthes* (excluding *Gymnopetalum*) in the country. New and extended distribution of some *Trichosanthese* spp. has been reported and diagnostic keys for identification of all the Indian taxa were completed.

Akola station undertook three explorations and a total of 257 accessions of vegetables, legumes, and other crops were collected from the selected districts of Maharashtra and Karnataka. At **Bhowali**, 81 accessions of various crops were collected from Arunachal Pradesh, Uttarakhand and Uttar Pradesh. Three explorations were undertaken by the **Cuttack** base centre, and 211 accessions of various crops were collected from Odisha and West Bengal. 152 accessions of multiple crops were collected in a collaborative exploration undertaken by **Hyderabad** RS, and The Jodhpur station conducted an exploration trip from catchment area of Chambal river in UP, MP and Rajasthan and 30 accessions of local landraces were collected. Two exploration program were undertaken by the **Ranchi** base centre in Jharkhand and Bihar to collect accessions of minor fruits (43 access.), vegetables and millets (50 access.). Two explorations were conducted by **Shillong** station, one in Meghalaya and another in Mizoram for collection of 171 germplasm. Two explorations were undertaken by **Shimla** station and resulted in the collection of 121 germplasm of various agri-horticultural crops from Meghalaya and Uttarakhand. At **Srinagar** station, an exploration on faba bean in was done in Kashmir, and 28 diverse accessions were collected. **Thrissur** station conducted three explorations and collected 409 samples of germplasm from North Sikkim and Nicobar.

Germplasm exchange

In 2019, 89,418 accessions (1,93,395 samples) were imported which included 55,926 accessions (56 ,570 samples) of germplasm and 33 492 entries (1,36,825 samples) of CGIAR nurseries for trials. Several trait-specific seed/planting material were also imported during the year. Additionally, 11,117 samples of different crops were supplied to national users for utilization in various crop improvement programmes under MTA. Further, 66,097 samples were supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing. A total of 2,599 samples were exported to different countries under collaborative research projects. Also, a supply of 7273 samples of ICRISAT mandate crops (FAO designated accessions) and 38540 samples of CIMMYT Maize trials/nurseries was facilitated to different countries.

National Supply

HQ, New Delhi supplied 4,863 accessions of various crops to 85 indenters for their use in crop improvement. **Akola** supplied 1,169 accessions of

various crops for research purposes to 39 user agencies within India. A total of 276 accessions of multiple crops was supplied to different indenters under MTA from **Bhowali**. At **Cuttack**, a set of 126 accessions of various crops were supplied to three ICAR-institutes. A total of **933** germplasm accessions was provided to 24 SAUs/ICAR institutes against 23 indents by **Hyderabad** station. At **Jodhpur**, during *Kharif* 2019, 1358 accessions of different crops; 236 accessions of wheat mini core, 35 accessions of Indian mustard and 15 accessions of fenugreek, ten accessions of ber and 24 acc. of pomegranate, during *Rabi* 2019-2020 were characterised/evaluated. A total of 254 accessions of Horsegram (*Macrotyloma uniflorum* Lam) and accessions of Jackfruit and Tamarind was characterized and evaluated at **Ranchi**. A total of 176 accessions of various crops was supplied to indentors as per MTA by **Shillong** station. At **Srinagar** station, 40 accessions of different crops were supplied to different indenters for research purpose. A total of 1,250 accessions in various species/taxa were supplied to 20 user agencies under MTA by **Thrissur** Station.

Plant germplasm quarantine

A total of 1,18,751 samples of imported germplasm accessions of various crops were processed for quarantine clearance at **HQ**, New Delhi. Of the 1,689 infested/ infected/ contaminated samples, 1,565 were salvaged through physicochemical methods. The remaining samples could not be salvaged and hence rejected. A total of 1,478 samples of exotic germplasm of different legume crops imported from different countries/ sources were grown in post-entry quarantine (PEQ) greenhouses, and the harvest of the plants free from viruses was released to the indenters. Forty-one post-entry quarantine inspections were carried out at various indenter's sites during 2019. A total of 2768 samples of various crops were processed for export, and 15 Phytosanitary Certificates were issued. Quarantine processing of 20 samples of imported transgenic planting material revealed infection with *Bipolaris oryzae and Fusarium verticillioides* in 19 samples of *Oryza sativa* from USA and infected samples were salvaged; absence of terminator gene was ensured; all samples were salvaged before release and PEQ inspection undertaken. Under seed health testing, 334 samples were found infected out of 10,997 samples received from Division of Germplasm Conservation ,and a total of 18 samples were rejected as they could not be salvaged. A total 2,715 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids, and 178 samples were found infested while visual infestations of insect-pests were recorded in 949 samples. A total 1,127 samples were found infested by various insect-pests, and 953 were salvaged while 174 were rejected. Besides, 136 samples were received from TCCU for seed health testing before/ after cryo-preservation, of which seven samples were found infected with different fungi, and all were salvaged. Additionally, in **Hyderabad** station, 53,296 samples (26, 552 imports; 23,904+2840 exports) were processed for quarantine clearance. 49 phytosanitary certificates were issued. Import samples (20,925) infested/ infected with pests/pathogens were salvaged and released (20,269). Quarantine services were extended to 98 organizations in South India. Post-entry quarantine inspection was conducted on 16,371 samples of different crops at Hyderabad.

Germplasm characterization and evaluation

During 2019, a massive number of accessions (14,149) of agri-horticultural crops were characterised, evaluated, regenerated and multiplied at **HQ**. For evaluation against biotic stresses, 58 promising wheat accessions, 18 accessions of wild brinjal germplasm along with six accessions of *S. melongena*, four promising accessions of *Solanum incanum* and 762 accessions of pulses were screened/validated. Under abiotic stresses,893 accessions comprising wheat (443), barley (220) and lentil (150) were evaluated against drought and mung bean (80) against heat stress. Quality parameters for 1,239 accessions comprising different crops *viz*., rice (180), wheat (100), barley (286), maize (45), linseed (218) and fruit tree (37) were studied. In medicinal and aromatic plants, 189 accessions were evaluated for various phytochemical constituents. Under CRP on

Agrobiodiversity, a total of 2,650 accessions comprising rice (1,022), wheat (917), chickpea (300) and okra (411) was evaluated at AICRP centres/ hotspots for biotic and abiotic stresses.

At **Akola**, a total of 2,336 accessions in Rabi (457) and Kharif (1,879) accessions of various crops were characterized and evaluated. Also, at Akola 1,081 germplasm accessions of different crops were multiplied and regenerated. About 375 accessions of various *Rabi*, *Kharif* (688), vegetable (66) and fruit crops (95 accessions) crops were multiplied for seeds, characterized and evaluated at **Bhowali**. **Cuttack** base centre characterized a set of 3798 accessions of various crops and crop wild relatives apart from 425 accessions of rice, wild *Oryza* species, *Ocimum* spp., *Hibiscus sabdariffa* for different morpho-agronomic traits in. At **Hyderabad**, a total of 716 accs. of different agri-horticultural crops were sown for field characterization/ evaluation/ screening/ multiplication/ rejuvenation. Further, 15 varieties of Amaranths and 120 accessions of various cereals, millets, pulses were characterized and evaluated during the year in externally funded projects. Characterization of 63 different accessions of various crops was done at **Shillong** for different agro-morphological traits. At **Shimla**, a total of 1361 germplasm accessions of various field crops was characterized and evaluated against important traits of interest. At **Srinagar** station, 228 germplasm accessions of three crops were characterized for their agro-morphological traits. A total of 490 germplasm were characterized in Thrissur.

Ex-situ conservation of germplasm

A total of 31,455 accessions of germplasm, including regenerated germplasm, varieties to be notified, released cultivars and trait-specific registered germplasm of various crops were received for long-term conservation in the National Genebank. These were processed following the genebank standards, adding 12,255 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 4,43,921. Of the conserved accessions, 4,203 were new, and 8,052 accessions were received after regeneration. Monitoring of germination and seed quantity in stored germplasm (9573 accessions) and distribution (56,481) for characterisation/ evaluation/regeneration/research were the other priority activities. The germplasm supplied includes those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). Upgradation / Modernization of National Genebank was done, and so far 11 LTS and three MTS modules have been commissioned.

Germplasm in MTS & FGB

A total of 20,838 accessions of various crops/ species germplasm are being maintained under controlled conditions in the MTS of the Regional Station at **Akola**. A total of 11,316 accessions are being conserved in **Bhowali** MTS, and 1,251 accessions are maintained in field gene banks. At **Cuttack**, 519 accessions comprising M&AP, horticultural crops, tuber/aroid crops and various CWR are being maintained in the FGB, and 1,430 voucher specimens are preserved in the herbarium. At **Jodhpur**, 423 germplasm accessions of horticultural plants are being maintained in a field gene bank, and 43085 accessions of agri-horticultural crops are being conserved at the station in the MTS facilities. At **Ranchi**, a total of 617 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank. In **Shillong**, a total of 2,155 accessions of agri-horticultural crop germplasm are maintained at MTS. In addition to these crops, in field gene bank has 528 accessions maintained. RS-**Thrissur** has a germplasm holding of 9,057 accessions of various crops/ perennial horticultural plants and their wild relatives of which 7,182 are in the MTS and 1875 in the FGB.

In-vitro and cryo conservation of germplasm

Cultures of 1,886 accessions of 145 plant species of different horticultural crops were conserved in the *In Vitro* Active Genebank at ambient and at low temperature, with subculture duration ranging from 2-24 months. A total of 13,896 accessions of agri-horticulture species were conserved as seeds,

embryonic axes, pollen and genomic resources in the cryogenebank. New accessions (21) added *in vitro,* and a total of 533 new accessions of different crops and wild species were cryostored in the form of seeds, embryonic axes, pollen and genomic resources. In vitro multiplication and conservation protocols were refined in some crops and varying degrees of success was achieved in cryopreservation experiments using vitrification, encapsulation-dehydration, encapsulation-vitrification, droplet vitrification and V- and D-cryoplate techniques in other crops. *In vitro* cryobanking was done in 56 accessions of seven crops. Cryopreserved accessions revealed a high level of genetic similarity in profiles of cryopreserved and regenerated plantlets and their respective controls in *Allium* spp. (using 30 SSR markers) and *Gentiana kurroo* (using 30 SSR and 39 ISSR markers). A total of 533 accessions were cryostored as seeds, embryonic axes, pollen and genomic resources and dormant buds.

DNA fingerprinting, genomic resources generation and GM detection

Total of Ninety-two samples of sixteen agri-horticultural crops, namely, chilli, cotton, cowpea, finger millet, foxtail millet, mungbean, paddy, pearl millet, pigeonpea, sesame, soybean, sponge gourd, urdbean, walnut and wheat were DNA profiled during the period under report from various public and private sector organisations. The sequence information from the recently sequenced black pepper Thottumurian genome was used for identification and characterization of 69,126 Simple Sequence Repeats (SSRs). For grain Amaranthus, development of SSR markers was initiated using public databases and a total 2, 80,997 SSR loci were identified, and primer pairs could be generated for 66,243 SSR markers, and 53, 067 primer pairs out of these were unique. A draft genome of *Luffa acutangula* was assembled using hybrid assembly from NGS data. Rice accessions from East coast (2243 accessions) were genotyped with 36plex SNP assay and used for core development. The C_4-specific gene copies for *aat*, *gpt*, and *ppdk* gene were significantly differentially expressed in grains as compared to leaves, across all studied genotypes of rice. In wheat a total of 51 MTAs/QTLs in nineteen different genomic regions were found to be linked with resistance to four different pathotypes at the seedling stage, i.e., 18 MTAs (*T* pathotype), 14 SNPs (*46S119*), 7 SNPs (*110S119*) and 12 SNPs (*238S119*) through GWAS. A total of 67 samples of 27 consignments of five crops were tested for checking the GM status or for event confirmation. The technology was transferred to DSS Imagetech Private Limited in 2015, which was launched as GMO Screening and Quantification Kit by the company for the screening of GM events in major crops including cotton, maize, rice, soybean, wheat, canola, mustard

PGR awareness/TSP /MGMG/Outreach

As a part of outreach activities, the institute organized 5 field days and 26 MGMG program/TSP/ exhibition/visists/PGR awareness-cum- biodiversity fair programmes. At **HQ** Three germplasm field days on major crops were organized to facilitate germplasm utilization. Awareness on conservation and on-farm management of indigenous plant genetic resources was created among 2,354 farmers of 11 states, and >100 officials of KVKs, field functionaries of the department of agriculture and horticulture, Government of Arunachal Pradesh by Plant Exploration and Germplasm Collection Division, **New Delhi**. RS **Akola** organized a Workshop cum Awareness programme under Tribal Sub-Plan, participated in State level Agriculture Exhibition (AGROTECH- 2019) and popularised grain amaranth among farmers in Maharashtra. **Bhowali** station organized one Agro-biodiversity fair-cum-seminar under TSP, one training and 3 Farmer's Field Days. Base centre **Cuttack** co-organized rice germplasm field day with ICAR-NRRI, organized a biodiversity fair under TSP and exhibited PGR of Odisha at Kisan Mela. Horsegram Germplasm Field Day was organized at **Ranchi** base centre. The Regional Station **Shillong** organized two workshops, under TSP at Meghalaya and Jorhat, Assam. At **Shimla** station, one PGR awareness programme in collaboration with Krishi Vigyan Kendra (KVK) Taboo-II was organized at Tabo, Lahual & Spiti Himachal Pradesh to facilitate the registration of Farmers' Varieties with PPV&FRA. **Thrissur** station

organized a Germplasm exchange day with farmers and a mango diversity day for outreach with farmers. Besides, three training cum planting material distribution programmes in tribal hamlets of Wayanad district were also organized.

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 to access characterization data replete with infographics. AKMU's endeavor to disseminate information on PGR activities via Twitter has attracted as many as 1.9 lakh impressions (146% increase compared to last year) popularizing the role of NBPGR. The PGR Portal, NBPGR's principal web-based information portal, was accessed from many countries with an average number of >4200 views per month in 2019. ICAR-NBPGR organized 11 trainings and 2 symposia for various stakeholders during 2019. Apart from this, 13 scientific and 17 technical and administrative staff underwent various training programmes imparted by various organizations. Scientific and technical staff of the institute had participated in 129 seminars/symposia/ conferences/workshops during 2019 to share scientific updates through a common platform to gain an edge on current development in allied research areas. Besides, 15 scientific staff of the Institute underwent for 21 foreign deputations during 2019. During 2019, 105 germplasm with unique traits were registered belonging to 40 species of various agri-horticultural crops. Two M.Sc. and four Ph.D. students were awarded degree in 58th Convocation of P G School IARI . Currently, a total of 29 students including Nine M.Sc. and Twenty Ph.D. are on rolls During the year, 4 promotions, one transfer, 11 retirements were effected across all staff categories. The scientific staff were bestowed with 17 awards. Dissemination of research outputs in the form of peer-reviewed research articles (121), books (8), book chapters/ manual chapters (84), tv talks (07), reports (3), training manuals (7), PGR reporter/notices/ brochures (9) and e- publications (4).

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.

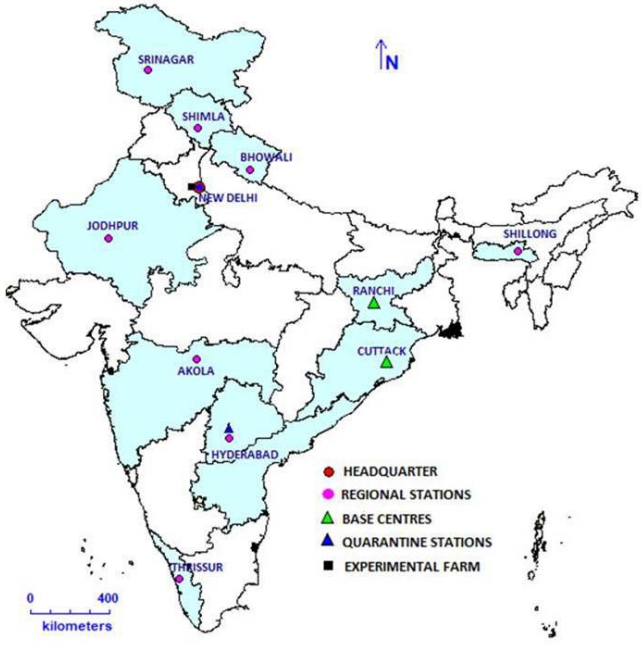


Fig. 1. NBPGR network of regional stations and base centres

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, 2019 was 314 comprising 123 scientific, 72 technical, 47 administrative and 61 supporting staff.

National genebank

The National Genebank, ICAR-NBPGR, New Delhi was established to conserve national heritage of

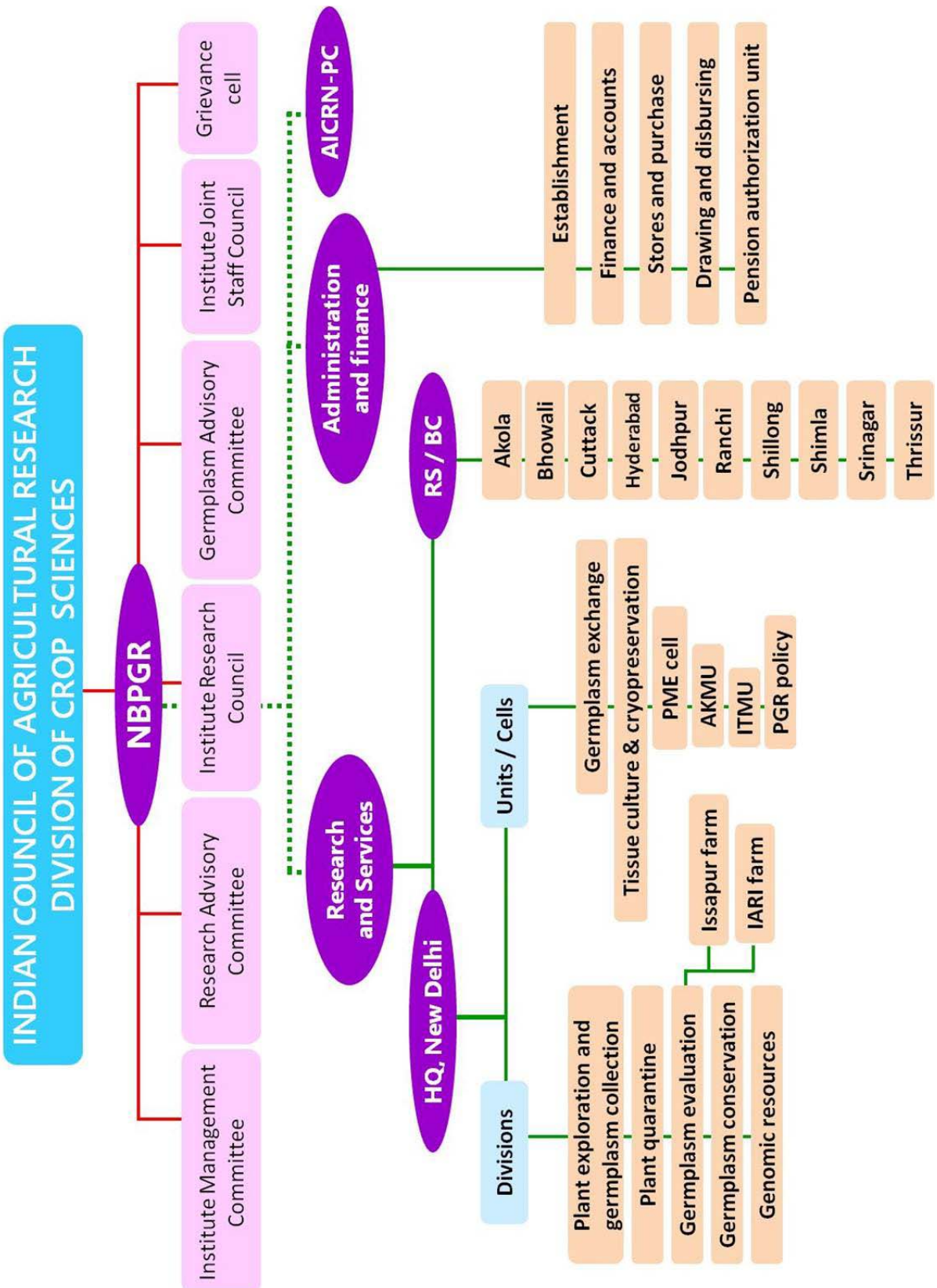


Fig. 2. Organogram of ICAR-NBPGR

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

The National Genebank facility commissioned in 1997 has 13 modules, each with a storage capacity of 50,000 to 76,000 samples depending upon the size of seeds. One of these modules is used for medium term storage of active germplasm collections and the rest for long- term storage. Its cryopreservation facility contains six liquid nitrogen tanks (cryo-tanks), each containing 1,000 litres of liquid nitrogen. These six cryo-tanks have a capacity to store 0.25 million samples. Thus, the National Genebank has a total capacity to store 0.85 to 1.25 million samples. New modules have been commissioned for upgradation of the NGB.

Indian national plant genetic resources system (INPGRS)

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

All India coordinated research network on potential crops

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

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

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

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

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

International collaboration

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

regions sponsored by FAO and Bioversity International are organized by ICAR-NBPGR.

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

Training programmes and information services

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

Library and documentation services

NBPGR has a dedicated library on plant genetic resource management and is being used by all staff and students regularly. The library maintained its designated services and activities of acquisition of books and journals, exchange of literature, development of library collection database, circulation, reference services and documentation. NBPGR library is one of the members of ICAR-CeRA Consortium that facilitates online access to the journals and databases from regional stations as well. Newspaper clipping services on PGR and its related subjects were provided to readers regularly. During the year under report, 75 books related to various aspects of PGR management and agriculture were added to the library collections through purchase and exchange basis. Library procured 37 journals including 21 international journals and 16 Indian through subscription for the use at the Headquarter and different regional stations. Out of 21 International journals, ten are online only and six online as well as printed journals, which are accessible to scientists and technical personnel at their desktop. A monthly list of new arrivals were also circulated to readers at the headquarters and regional stations. Bureau's publications were provided to over 298 different organizations in India and in return, library has received 410 publications as gratis from various national and international organizations

Post-graduate teaching programme

Since academic session 1997, Bureau has been undertaking post-graduate teaching in plant genetic resources leading to M.Sc. degree affiliated to Post Graduate School, IARI, New Delhi. From the academic session 2004-2005, Ph.D. degree programme was started by the Post Graduate School, IARI, New Delhi. Two M.Sc. and four Ph.D. students were awarded degree in 58th Convocation of P G School IARI. Currently, a total of 29 students including Nine M.Sc. and Twenty Ph.D. are on rolls.

Extension services for PGR awareness

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

Funds allocated and expenditure incurred during the financial year 2019-20

Unified Budget 2019-20 (Rs. In Lakh)

A - Non-Recurring (Capital)	**B.E. 2019-20**	**R.E. 2019-20**	**Expenditure**
Works - Office Building	300.00	303.15	303.13
Equipments	619.73	469.03	468.94
Information Technology	20.00	9.10	9.07
Library Books & Journals	21.00	2.12	2.11
Vehicles & Vessels	23.00	7.85	7.83
Furniture & Fixtures	8.50	8.75	8.73
Total (A)	***992.23***	***800.00***	***799.81***
B - Recurring (Revenue)	**B.E. 2019-20**	**R.E. 2019-20**	**Expenditure**
Establishment Charges - Regular	4139.37	4450.75	4450.67
Wages - Regular	65.00	99.25	99.21
Pension & Other Retirement Benefits - Regular	4128.00	3220.00	3220.00
Domestic TA/Transfer TA	45.00	48.60	48.58
Research Expenses	120.00	135.60	135.59
Operational Expenses	176.45	188.40	188.31
Infrastructure	500.00	583.90	583.89
Communication	10.00	8.20	8.20
Equipments, vehicles & others	40.00	31.00	30.99
Office Building	250.00	285.00	284.99
Residential Building	50.00	15.30	15.29
Minor Works	5.00	5.25	5.24
Others (excluding TA,)	90.00	115.95	115.79
HRD	15.00	7.20	7.16
Publicity & Exhibitions	4.00	1.60	1.52
Guest House - Maintenance	1.00	0.20	0.16
Others Miscellaneous	35.00	23.80	23.75
Total (B)	***9673.82***	***9220.00***	***9219.34***
Total (A+B)	***10666.05***	***10020.00***	***10019.15***
Tribal Sub-Plan (TSP)	60.00	60.00	51.67
NEH	250.00	74.11	74.02
SCSP Capital	107.50	0.00	0.00
SCSP General	430.00	430.00	429.70
G. Total (A+B+NEH+TSP+SCSP)	**11513.55**	**10584.11**	**10574.54**
AICRN - PC 2018-19	**B.E.2019-20**	**R. E.2019-20**	**Expenditure**
Grant-in-Salaries	249.74	249.74	249.74
Grant-in-General	90.00	100.00	99.91
TSP	35.00	35.00	35.00
NEH	60.00	45.00	45.00
Total	**434.74**	**429.74**	**429.65**
CRP on AB 2018-19	**B.E.2019-20**	**R. E.2019-20**	**Expenditure**
Grant-in-Capital	12.36	12.36	12.11
Grant-in-General	350.00	350.00	349.97
Total	**362.36**	**362.36**	**362.08**

DIVISION OF PLANT EXPLORATION AND GERMPLASM COLLECTION

1

Summary: In 2019, a total of 34 explorations were undertaken across the country wherein 2,169 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 104 districts located in 20 states of India (Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal). Of these, 707 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 14 explorations conducted. A total of 458 herbarium specimens (including 61 unrepresented taxa) were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Biosystematic studies revealed occurrence of 13 species (16 taxa) of *Trichosanthes* (excluding *Gymnopetalum*) in country. New and extended distribution of some *Trichosanthes* spp. has been reported and diagnostic keys for identification of all the Indian taxa were completed. Biosystematic studies of *Allium*, *Amaranthus* and *Luffa* are in progress. Geo-referencing and mapping of 5,806 indigenous accessions of black gram (*Vigna mungo*) was done. Awareness on conservation and on-farm management of indigenous plant genetic resources was created among 2,354 farmers of 11 states, and >100 officials of KVKs, field functionaries of the department of agriculture and horticulture, Government of Arunachal Pradesh.

1.1 Plant exploration and germplasm collection

In the year 2019, a total of 34 explorations (involving 28 collaborators) were undertaken and 2,169 accessions of different agri-horticultural crops comprising 1,379 accessions of cultivated and 790 of wild species were collected from 104 districts covering 20 states of India. The states include Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal. These collections captured diversity in 439 species; cultivated (1379 acc.; 64%) and crop wild relatives (790 acc.; 36 %) in various crop- groups (Fig. 1.1). Maximum accessions were collected in vegetables (711) followed by fruits and nuts (385) and pulses (306). Emphasis was given on collecting germplasm from various diversity-rich, remote and tribal inhabited, disturbed and under-explored areas mainly in Andaman and Nicobar Islands, Arunachal Pradesh, Gujarat, Jammu & Kashmir, Mizoram, Nagaland, Sikkim and Uttarakhand. A total of 910 collected accessions were sent to Germplasm Handling Unit (GHU) for conservation, while the remaining accessions were sent for multiplication

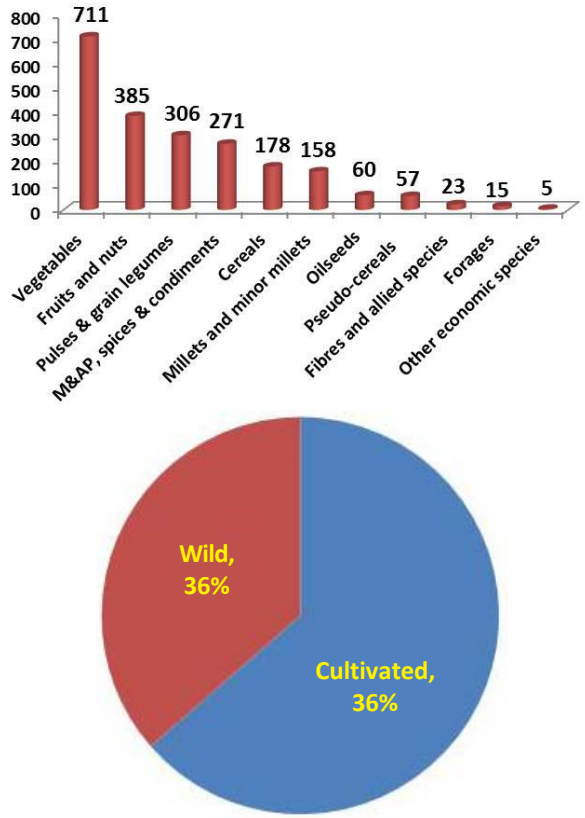


Fig. 1.1: Germplasm accessions collected across different crop-groups and ratio in cultivated *Vs* CWRs

and maintence in National Active Germplasm Sites (NAGS). Status of germplasm collected in explorations conducted by ICAR-NBPGR and its regional stations/ base centres is given below (Table 1.1 & 1.2).

Table 1.1: Explorations undertaken and germplasm collected in year 2019

Headquarters & Stations	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	3	160	97	257
Bhowali	3	17	59	76
Cuttack	3	96	115	211
Hyderabad	1	144	8	152
New Delhi (HQ)	14	622	85	707
Ranchi	2	73	3	76
Shillong	3	95	117	212
Shimla	1	19	22	41
Srinagar	1	28	-	28
Thrissur	3	125	284	409
Total	**34**	**1379**	**790**	**2169**

Maximum accessions were collected in vegetables (711) followed by fruits & nuts (385) and pulses (306).

Table 1.2: Details of germplasm collected in different crop groups in the year 2019

Crop-group (accs.)	Crop/wild species (accessions)
Cereals (178)	*Brachypodium pinnatum* (2), *Brachypodium sylvaticum* (6), *Coix lacryma-jobi* (15), *Elymus duthiei* (1), *E. longearistatus* (2), *E. nutans* (4), *E. semicostatus* (1), *E. sikkimensis* (1), *Hordeum vulgare* (9), *Hordeum vulgare* var. *nudum* (2), *Oryza nivara* (5), *O. rufipogon* (7), *O. sativa* (97), *O. sativa x O. rufipogon* (1), *O. sativa* var. *spontanea* (1), *Triticum aestivum* (10), *T. aestivum* ssp. *sphaerococcum*(1), *Zea mays* (13)
Pseudo-cereals (57)	*Amaranthus caudatus* (4), *A. dubius* (6), *A. hypochondriacus* (15), *Amaranthus* tricolor (9), *Chenopodium album* (7), *Fagopyrum esculentum* (6), *F. tataricum* (10)
Millets and minor millets (158)	*Avena sativa* (1), *Brachiaria brizantha* (1), *B. mutica* (1), *Echinochloa colona* (3), *E. cruspavonis* (1), *Eleusine coracana* (30), *E. indica* (6), *Panicum sumatrense* (10), *Paspalum dilatatum* (1), *Pennisetum glaucum* (12), *P. pedicellatum* (2), *Setaria italica* (15), *S. pumila* (1), *S. sphacelata* (1), *S. verticillata* (3), *Sorghum bicolor* (69), *S. halepense* (1)
Pulses/Grain legumes (306)	*Cajanus cajan* (84), *C. scarabaeoides* (7), *Cicer arietinum* (1), *Lens culinaris* (3), *Macrotyloma uniflorum* (12), *Phaseolus vulgaris* (24), *Pisum sativum* (1), *Rhynchosia suaveolens* (1), *Rhynchosia* sp. (1), *Vigna aconitifolia* (4), *V. angularis* (9), *V. angularis* var. *nipponensis* (3), *V. glabrescens* (1), *V. marina* (4), *V. mungo* (31), *V. mungo* var. *silvestris* (1), *V. radiata* (34), *Vigna* sp. (2), *V. trilobata* (1), *V. trinervia* (2), *V. umbellata* (20), *V. unguiculata* (44), *V. unguiculata* subsp. *sesquipedalis* (16)
Oilseeds (60)	*Arachis hypogaea* (1), *Brassica rapa* var. *brown sarson* (1), *B. rapa* var. *toria* (1), *B. juncea* (2), *Glycine max* (20), *Guizotia abyssinica* (8), *Perilla frutescens* (17), *Ricinus communis* (1), *Rorippa elata* (1), *Sesamum indicum* (8)
Fibres and allied species (23)	*Cannabis sativa* (1), *Corchorus aestuans* (3), *C. capsularis* (2), *C. fascicularis* (1), *C. olitorius* (2), *Crotalaria juncea* (1), *C. pallida* (2), *C. retusa* (1), *C. verrucosa* (1), *Hibiscus cannabinus* (1), *H. sabdariffa* (5), *Thespesia lampas* (1), *Sesbania cannabina* (1), *S. sericea* (1)

Crop-group (accs.)	Crop/wild species (accessions)
Fruits and nuts (385)	*Actinidia callosa* (1), *Aegle marmelos* (36), *Artocarpus chama* (2), *A. chaplasha* (5), *A. communis* (1), *A. gomezianus* (2), *A. heterophyllus* (1), *A. lacucha* (9), *A. peduncularis* (5), *Baccaurea ramiflora* (2), *Bentinckia nicobarica* (1), *Buchanania lanzan* (17), *B. splendens*(1), *Bursera serrata* (4), *Calamus erectus* (1), *Carissa carandas* (9), *Carica papaya* (1), *Cayratia trifolia* (1), *Cerbera manghas* (1), *Chaenomeles cathayensis* (2), *Choerospondia saxillaris* (1), *Cissus repens* (2), *Citrus x aurantiacum* (1), *Citrus aurantifolia* (2), *C. indica* (2), *C. limon* (3), *Citrus x limon* (3), *C. macroptera* (2), *C. medica* (2), *C. reticulata* (6), *Cordia grandis* (1), *C. subcordata* (1), *Cornus capitata* (1), *Corylus ferox* (1), *Cotoneaster microphyllus* (3), *Decaseermum parviflorum* (1), *Dillenea pentagyna* (1), *Dimocarpus longan* (3), *Diospyros lotus* (1), D. melanoxylon (2), *D. undulata* (1), *Diploknema butyracea* (1), *Docynia indica* (2), *Dracontomelon dao* (1), *Duchesnea indica* (1), *Elaeagnus angustifolia* (1), *E. floribundus* (1), *E. latifolia* (1), *E. parvifolia* (1), *Eriobotrya lotus* (1), *Feronia limonia* (6), *Ficus roxburghii* (1), *Fragaria vesca* (1), *Garcinia cowa* (2), *G nervosa* (3), *G pedunculata* (1), *G speciosa*(9), *Gardenia tubiflora*(1), *Gnetum gnemon* (3), *Grewia asiatica* (1), *G calophylla* (1), *Haematocarpus validus*(1), *Hippophae salicifolia* (2), *Holboellia latifolia* (3), *Jasminum elongatum* (1), *Juglans regia* (4), *Knema globularia* (2), *K. laurina* (1), *K. malayana* (2), *Limonia acidissima* (1), *Livistona jenkinsiana* (2), *Maclura cochinchinensis* (1), *Madhuca longifolia* (1), *Malpighia glabra* (1), *Malus domestica* (6), *M. sikkimensis* (1), *Mangifera camptosperma* (2), *M. nicobarica* (2), *Manilkara littoralis* (2), *Morinda citrifolia* (1), *Morus alba* (1), *Musa acuminata* (14), *M. balbisiana* (2), *M. balbisiana* var. *andamanica* (1), *M. indandamanensis* (3), *M. kattuvazhana* (2), *M. rosacea* (1), *M. sikkimensis* (1), *Myrica esculenta* (2), *Orophea katschallica* (1), *Parthenocissus semicordata* (1), *Passiflora edulis* (3), *P. suberosa* (1), *Persea Americana* (1), *Persea avocado* (4), *Phyllanthus emblica* (3), *Phytolacca acinosa* (1), *Pinanga manii* (1), *Pithecellobium dulce* (2), *Prinsepia utilis* (1), *Prunus armeniaca* (4), *P. cornuta* (1), *P. domestica* (3), *P. jacquemontii* (2), *P. mira* (2), *P. nepalensis* (3), *P. persica* (2), *Psidium guajava* (1), *Punica granatum* (1), *Pyracantha crenulata* (1), *Pyrus communis* (3), *P. pashia* (11), *P. pyrifolia* (4), *Rhus chinensis* (2), *Ribes alpestre* (2), *R. griffithii*(1), *R. himalense* (1), *R. orientale* (3), *Rosa macrophylla*(2), *R. sericea* (3), *Rubus acuminatus*(1), *R. alexeterius* (1), *R. andersonii* (1), *R. biflorus* (2), *R. calycinus* (1), *R. ellipticus* (2), *R. lineatus* (2), *R. macilentus* (1), *R. moluccanus* (1), *R. nepalensis* (1), *R. niveus* (2), *R. paniculatus* (1), *R. pentagonus* (1), *R. rugosus* (3), *R. splendissimus* (1), *Sambucus adnata* (1), *Schleicheraoleosa* (4), *Sorbus aucuparia* (1), *S. cuspidate* (1), *S. microphylla* (2), *Spondiasdulcis* (1), *S. mombin* (1), *Syzygium claviflorum* (2), *S. cumini* (10), *S. flosculiferum* (1), *S. gratum* (1), *S. jambos* (2), *S. parvifolium* (1), *S. zeylanicum* (1), *Tamarindus indica* (8), *Toddalia asiatica* (1), *Triphasia trifolia* (1), *Vaccinium glaucoalbum* (1), *Vanilla albida* (1), *V. andamanica* (4), *Ziziphus horsfieldii* (2), *Z. xyloplora* (1)
Vegetables (711)	*Abelmoschus angulosus* (2), *A.caillei* (3), *A. esculentus* (20), *A. crinitus* (1), *A. ficulneus* (13), *A. manihot* ssp. *tetraphyllus* var. *tetraphyllus* (20), *A. mizoramensis* (12), *A. moschatus* (3), *A. tetraphyllus* (4), *A. tetraphyllus* var. *pungens* (1), *A. tuberculatus* (1), *Allium carolinianum* (2), *A. cepa* (2), *A. chinense* (1), *A. fasciculatum* (3), *A. hookeri* (3), *A. humile* (1), *A. jacquemontii* (1), *A. prattii* (1), *A. proliferum* (1), *A. stracheyi* (4), *A. tuberosum* (2), *A. victorialis* (1), *A. wallichii* (7), *Alocasia cucullata* (1), *A. indica* (2), *A.macrorrhiza* (3), *Amorphophallus bulbifer* (1), *A. hirsutus* (1), *A. muelleri* (2), *Basella alba* (4), *Benincasa hispida* (12), *B. hispida* var. *pruriens* (1), *Blumea balsamifera* (1), *Brassica juncea* var. *rugosa* (5), *B. rapa* (4), *Canna indica* (9), *Canavalia cathartica* (2), *C. gladiata* (2), *Capsicum annuum* (35), *C. frutescens* (1), *Celosia argentea*(1), *Coccinia grandis* (8), *C. indica* (2), *Colocasia esculenta* (17), *Colocasia* sp. (2), *Cucumis callosus* (2), *C. hystrix* (1), *C. melo* (1), *C. melo* var. *flexiosus* (1), *C. melo* var. *agrestis* (19), *C. sativus* (24), *C. sativus* var. *hardwickii* (20), *Cucurbita ficifolia* (1), *C. maxima* (11), *Cucurbita moschata* (4), *C. pepo* (1), *Cyamopsis tetragonoloba* (1), *Dioscorea alata* (10), *D. bulbifera* (8), *D. esculenta* (1), *D. glabra* (9), *D. nummularia* (1), *D. pentaphylla* (1), *D. piscatorum* (2), *D. serpenticola* (6), *D. spinosa* (1), *Diplocyclos palmatus* (2), *Ipomoea aquatica* (1), *I. batatas* (1), *Lablab purpureus* (17), *Lagenaria siceraria* (18), *Luffa acutangula* (36), *L. acutangula* var. *amara* (4), *L. hermaphrodita* (8), *L. cylindrica* (58), *Lycopersicon esculentum* (1), *Momordica charantia* (12), *M. charantia* var. *muricata* (9), *M. cochinchinensis*(1), *M. dioica* (1), *M. subangulata* sub sp.renigera (4), *Moringa oleifera* (39), *Mukia maderaspatana*

1.2 Explorations undertaken and germplasm collected by NBPGR Headquarter

During the reporting period, 14 explorations were undertaken in parts of Arunachal Pradesh, Assam, Bihar, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Nagaland, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh. A total of 707 accessions (cultivated: 622 and wild species: 85) of different agri-horticultural crops were collected (Table 1.3).

Table 1.3: Explorations undertaken by the ICAR-NBPGR, Headquarter (2019)

Crops collected	Districts, state and period	Number of accessions			Collaborating Institute/SAU
		Cultivated	Wild	Total	
Paddy, lab-lab bean & others	Tirupur, Dindigul, Theni (Tamil Nadu), 28 Jan.-06 Feb., 2019	33	-	33	TNAU, Coimbatore
Seed spices (coriander, ajwain)	Guna, Shivpuri (Madhya Pradesh), 1-9 March, 2019	54	-	54	ICAR-NRCSS, Ajmer
Chironjee, under-utilized fruits	Chandrapur, Wardha, Yavatmal, (Maharashtra), 6-15 May, 2019	-	24	24	
Multi-crops	Uttarkashi (Uttarakhand), 11-21 Oct., 2019	43	5	48	
Tropical minor fruits	Faizabad, Varanasi (Uttar Pradesh), 23 Sept.-30 Oct., 2019	16	9	25	NDUA&T, Faizabad
Tuber crops & rice	Cachar (Assam),14-22 Oct., 2019	44	3	47	ICAR-CTCRI, Thiruvanathapuram
Multi-crops	West Siang,Siang, Shi-Yomi (Arunachal Pradesh), 12-22 Nov., 2019	58	6	64	
Round gourd	Dholpur, Swaimadhopur, Karauli (Rajasthan), Bhind, Morena, Sheopur (MP), Etawah (UP), 19-30 Aug, 2019 and 12-22 Nov., 2019	37	-	37	ICAR-IIVR, Varanasi
Multi-crops	Upper Subansiri, Lower Subansiri (Arunachal Pradesh), 19-30 Aug, 2019 and 12-22 Nov., 2019	38	8	46	ICAR-NEH, RC, Basar
Multi-crops	Zunhaboto, Nagaland,1-10 Dec., 2019	59	6	65	ICAR-IARI, New Delhi
Vegetables	Sidhi, Singrauli, Anuppur (MP) & Balia, Deoria, Basti, Mirzapur (UP), 4-12 Nov., 2019	41	8	49	ICAR-IGFRI, Jhansi
Multi-crops (rice, minor millets)	Dang, Navsari and Tapi (Gujarat), 14-23 Nov., 2019	89	12	101	HRMS, Waghai, KVK, NAU, Navsari
Cucurbits & leafy vegetables	Bhagalpur, Munger (Bihar) & Sahibganj (Jharkhand)14-26 Nov., 2019	82	4	86	ICAR-IIVR, Varanasi
Exploration under externally funded project					
Pulses	Almora, Bageshwar, Chamoli, Rudraprayag, Tehri (Uttarakhand) 1-20 Oct., 2019	28	-	28	DBT-NIPGR, New Delhi
TOTAL		**622**	**85**	**707**	

1.2.1 Agricultural crops

I. Landraces of rice and sorghum from Tamil Nadu

A total of 32 accessions comprising of rice (18), sorghum (4), lablab bean (7), and others (3) were collected from parts of Coimbatore, Tirupur, Dindigul and Theni districts of Tamil Nadu. In rice, *Kichali samba, Senthalazhi nel/Malaiarusi nel, Thuyamalli, Kuzhiyadichan, Kattuyanum, Thuyamalli, Swarna moosori, Mappillai samba, Sevvapukavuni, Karrupukavuni, Karungkuruvai;* in sorghum, *Karuncholam, Sen cholam* and *Vellai cholam;* in little millet, *Kadai kanni* (considered as highly drought tolerant millet); and in lablab bean, *Kodiavarai, Kozhiavarai, Kuthumochai, Kozhikalavarai, Pattaiavarai, Vellai mochai, Kundu muthuavarai and Kadalai mocha avarai* with unique traits were some interesting landrace collections from the surveyed region.

II. Landraces of rice, millets and other crops from Gujarat

In an exploration to parts of Dang, Navsari and Tapi districts of Gujarat, 102 accessions of 30 crops, species of wild relatives comprising rice (35) followed by finger millet (12), little millet (9) and sorghum (5) were collected. The notable collections include 27 landraces of rice like *Ambe more, Bangadu, Chahpure, Chimansal, Chirli, Colin, Dangi, Desi dangi, Dobadia, Dodadkiya, Dudh-malai, Dumania, Hari, Jeera bhat, Kabrudolo, Kajalheri, Kala bhat, Kala dangar, Khadsi, Krishna kamod, Lal dhanhar, Lal kada, Phutte, Prabhavati, Sathiya* and *Tulsia bhat* with variability for grain colour (white, brown, black, spotted), awn and awnless, grain size and shape (small to long and round), kernel colour (white, red and black), leaf-blade colour, scented and non-scented grain, early and late maturity (60-120 days), plant height (dwarf to very tall plant); in finger millet for grain colour (white and red grain), panicle (compact

Fig. 1.1. Drought tolerant sorghum landraces: *'Karuncholam'* with black and *'Sencholam'* with red seeds, collected from rain-fed areas of Tamil Nadu

Fig. 1.2. *'Senthalazhi nel'*: A primitive rice landrace from Tamil Nadu

Fig. 1.3. Variability in paddy grains from Gujarat

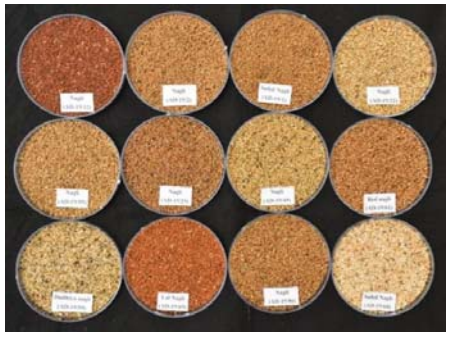


Fig. 1.4. Variability in foxtail millet from Gujarat

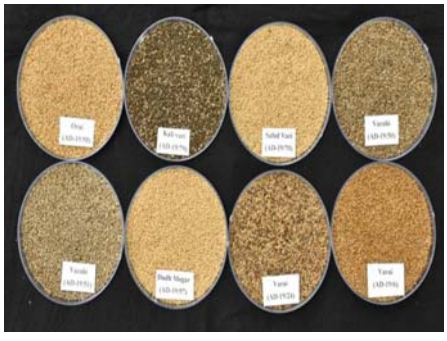


Fig. 1.5. Variability in little millet from Gujarat

and semi open), plant height (dwarf, medium and tall plant); in little millet i.e. grain colour (white, green and brown seeded), grain size (small, medium and bold seeded), panicle (open and compact /dense type), varied panicle length, yield (low to high yield); in sorghum, grain colour (white, brown and black), grain size (bold and medium size), panicle (compact and diffused); in cowpea, seed colour and size (pale small, golden bold, mottled dark brown). *Triticum aestivum* ssp. *sphaerococcum* (endemic Indian dwarf wheat) having high number of tillers (20-22), 100-110 days maturity, 23 seeds/ear, 20-24 q/ha yield, non-sticky and soft chapatti making quality from Dhat village under Vyara block of Tapi district was a distinct collection.

III. *Canna indica*, rice and mustard from Cachar, Assam

Fourty-seven accessions comprising of *Canna indica* (9), *Oryza sativa* (10), *Brassica juncea* (7), *Alocasia indica* (4), and 16 others including wild species were collected from Cachar district of Assam. Good variability among rice landraces (*Biren dhan, Chanmuni dhan, Kali jira, Lal bahadur, Masuri dhan, Mokta dhan, Satuki* and *Taposheel*) was observed for maturity, plant height, panicle colour, grain husk colour, size, shape, kernel colour, scented/non-scented types, uses etc. Variability in different traits was recorded. Landraces like *Kalijira* and *Taposheel* are used during rituals and festivals. The tribals use the leaves of "Sugandhmanthiri" (*Homalomena aromatica*) - a wild and kitchen garden medicinal plant in the form of chutney, the stalk cooked with dal/curry and the rhizome used and traded in perfumery industry. *Canna indica* rhizome is used in production of starch, for making noodles, while farmers of this region grow it for ornamental flower only.

IV. Pulses from parts of Uttarakhand

A total of 28 accessions comprising of *Vigna umbellata* (10), *Glycine max* (4), *Eleusine coracana* (4), *Macrotyloma unifloram* (3), and others (7) including landraces of ricebean namely *Rains, Rayans, Naurangi, Pili rains, Lal rains, Hara mass, Bhura mass* and *Gurunsh* were collected from parts of Almora, Bageshwar, Chamoli, Rudraprayag and Tehri districts of Uttarakhand. Variability was observed in ricebean for maturity (early and late), plant height, seed shape, size and colour; in finger millet head type (open and closed). *Cannabis sativa* locally called "bhang" grown in the kitchen garden was also collected. Its roasted seeds are consumed as bhujiya and added in chutney particularly during winter season.

Fig. 1.6. Grain variability in rice germplasm from Assam

Fig. 1.7. Fruit variability in Chili germplasm from Assam

Fig. 1.8. *Canna indica*: a local source of starch from Assam

Fig. 1.9. Seed variability in ricebean germplasm from Uttarakhand

V. Multi-crop germplasm from remote areas of Arunachal Pradesh

Sixty-four germplasm accessions of cereals, millets and pseudocereals including nine landraces of rice (*Aamker, Axi, Roing, Day, Laldhan, Panikheti, Noginaamo, Naminama*); maize (7), buckwheat (5), french bean (5), chilli (4), soybean (3), fingermillet (3), mustard (3), perilla (3) and 22 others crops / species were collected from upper part of West Siang, Siang, Shi-Yomi districts of Arunachal Pradesh. Some difficult areas like Aalo, Kaying, Pidi, Payum, Tato, Monigong, Mechuka, Yomcha and Nari circle/blocks especially were surveyed. Variability was observed in French bean, maize, chilli and in rice for grain colour, seed/ fruit shape and size. Farmers in these areas are cultivating mostly local landraces in *jhum* fields under rainfed condition, while rice and vegetables are being grown in irrigated fields. Now the farmers have started practicing settled agriculture as many of the *farmlands/jhums* have been converted into orchards of orange, banana, pineapple, kiwi fruit, pear, peach, plums, black cardamom, rubber plant and palm oil tree.

In another exploration, forty-six germplasm samples comprising soybean (9), paddy (4), coix (4), finger millet (3), ricebean (3), and others (21) were collected from Upper Subansiri and Lower Subansiri districts of Arunachal Pradesh. Upper Subansiri is one of the country's 250 most backward districts and also less explored for crops diversity. These districts have distinct ethnic culture affiliated with Tagin, Galo, Apatani and Nyishi tribes. Local beer popularly known as 'Apong' (prepared from rice and fingermillet) is among the most common way of relaxing among the tribes. Good variability was observed in soybean for seed size and colour, plant type (erect & unbranched, trailing and branched; cowpea for seed colour; in rice bean for seed size; in coix for grain size and colour; in finger millet for closed and open heads. Good diversity was observed among wild leafy vegetables (*Clerodendrum glandulosum, Corchorus olitorius, Zanthoxylum rhetsa, Solanum nigrum, Spilanthes clava, Pouzolzia hirta*, etc.), mostly grown in kitchen garden for own consumption and sale in local markets to income generation. A rare germplasm considered as close wild relative of adzuki bean, namely *Vigna angularis* var. *nipponensis* was also collected from Lower Subansiri district.

Fig. 1.10. Variability in soybean from Arunachal Pradesh

Fig. 1.11. *Sauropus androgynus* 'Insulin plant' -a wild edible fruit from Arunachal Pradesh

VI. Multi-crop germplasm from Zunheboto, Nagaland

A total of 65 accessions comprising of *Perilla frutescens* (9), *Oryza sativa* (7), *Vigna umbellata* (6),

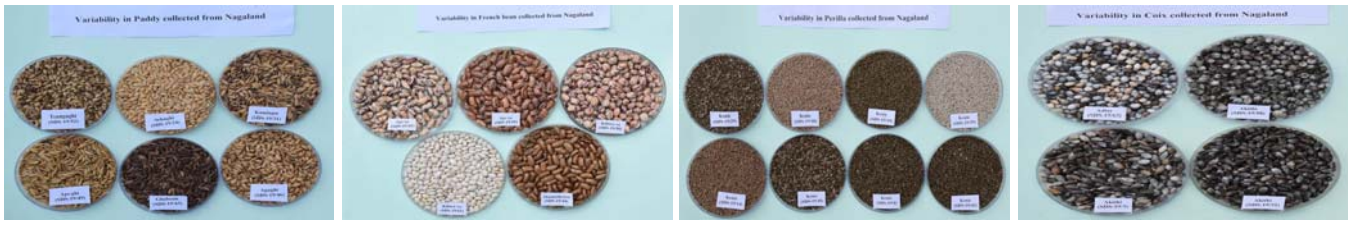


Fig. 1.12. Variability in germplasm of paddy, French bean, perilla and coix from Nagaland

Setaria italica (5), *Glycine max* (3), *Coix lacryma-jobi* (3), *Capsicum annuum* (3), *Cucumis sativus* (3), *Sesamum indicum* (3), *Phaseolus vulgaris* (3), *Solanum aethiopicum* (3), *S. torvum* (3) and others (14) were collected from remote areas like Tsiesema, Kietabi, Zunheboto Littami, Susutami, VK Town, Mokokchung, Tichipami and Kholeboto areas of Nagaland. Variability in ricebean, fox-tail millet and coix was observed for maturity, plant height, seed shape, size and colour and for maturity, plant height, seed shape, size and colour in rice landraces namely- *Sekughi, Kumlupu, Ghaboan, Apaghi, Ajo-ghi* and *Tsungughi.*

VII. Germplasm from Panchgain valley of Uttarakhand

Panchagain valley is named after a group of five villages (Liwadi, Rala, Kasla, Fitari and Regcha) located in the remote north western part of Uttarkashi district. Upper reaches of valley remains covered with snow from December to April. The valley is rich in local crop diversity and traditional culture. Due to the remoteness of valley, the inhabitants are cultivating only local landraces of amaranth, french bean, potato, chenopods, barley, buckwheat and perilla during *kharif* and wheat is the only crop grown in *rabi* season under rain-fed condition in villages situated above 1800 m. During survey, a total of 47 germplasm samples of wheat (6), buckwheat 'phafra' (5), amaranth 'marsha' (7), finger millet 'koda' (5), chenopods 'bathu'(3), adzuki bean 'dhaulans' (4) french bean 'rajmah' (3), and others including wild economic species (14) were collected. Good variability was observed in amaranth (*Amaranthus hypochondriacus* and *A. caudatus*) for panicle (red & light yellowish creamy) and grains (black and yellowish); in French bean for grain colour, size and shape. Three types of buckwheat (*ogla*, *phafar*and *chawbri*) were included variable collections.

1.2.2 Horticultural crops

I. Tropical underutilized fruits from Maharashtra

A total of 24 germplasm samples of underutilized fruits comprising of 'Chironjee' *Buchanania lanzan* (17), 'Beal' (*Aegle marmelos*) (4), 'Jungle jalebi' (*Pithecellobium dulce)* (2), with variability in fruit and nut size, early and late maturing types in

Fig. 1.13. Interaction with the local farmers of Panchgain valley

Fig. 1.14. Harvesting of amaranth- grown as a main crop for food and forage

Fig. 1.15. *Sorbus cuspidata* 'Mol': an important wild edible fruit of valley

Fig. 1.16. Harvesting of coriander for green seeds

Fig. 1.17. Green seeds coriander ready for sale

Chironjee and seed size in Jungle jalebi were collected from forests of Bhandara, Nagpur, Wardha, Chandrapur districts of Vidarbha region of Maharashtra. In surveyed area, majority of the local people were not aware about commercial value of chironjee, hence early picking of fruits, felling/lopping of trees in forest was not observed. However, the fruits and trees were highly damaged by monkeys in most of the areas. An accession of *Luffa acutangula* var. *amara* was also collected.

II. Seed spices from Madhya Pradesh and Rajasthan

The diversity in germplasm of seed spices was explored in Ashok Nagar, Guna, Gwalior and Shivpuri districts of Madhya Pradesh and Bara district of Rajasthan. A total of 53 accessions comprising of *Coriandrum sativum* (39) including some named landraces (*Kumbhraj, Mithi dhana, Kudi dhana, Deshi dhana, Dhana and Ramela*), 'ajwain' (*Trachyspermum ammi* -7), kalaunji (*Nigella sativa*-3) and others (4) were collected. The collected germplasm had good variability in seed shape (round, oval), size (small, large) and colour (brown, light brown, green, dark green, parrot colour) and 100 seed weight (0.97-1.65 g). It was observed that the farmers located in Ashok Nagar, Guna and Shivpuri districts of Madhya Pradesh were selling matured, dried coriander with green colour which is used to impart flavour in beverage industry. To retain the green colour and aroma in mature seeds, the local farmers have developed an indigenous method for drying of coriander seed. In this method, the plants are cut before sunrise and covered by cellophane sheet for 1-2 days and shade dried. *Kumbhraj, Mithi dhana* and *Kudi dhana* are most preferred landraces used for green coriander. Generally the light green and dark green processed seed are fetching significantly higher price in local mandi because of presence of high aroma in seeds in comparison to yellow seed one.

III. Potential fruits from eastern Uttar Pradesh

Twenty-five samples of potential fruits comprising karonda (09), aonla (02), Phalsa *Grewia asiatica* (01), bel (01), ber (01), and others (11) were collected from Faizabad and Varanasi districts of Uttar Pradesh. In these districts, karonda is common on boundary of fields, marginal and wasteland where cropping is not feasible. Good variability in morphological and biochemical characters of karonda *viz*. fruit colour (deep red, pink, pink white and green), fruit shape (oblong and round), fruit length (15-25 mm), fruit diameter (12-20.56 mm), fruit weight (3-10 g), leaf length (37-58 mm), flower fragrance (mild to strong), fruit pulp colour (white, pink, red and dark red), seed colour (white and black), number of seed/ fruit (3-6), TSS (3-9.5 °B), acidity (0.9-1.8 pH) and vitamin C (10-28 mg/100g) was observed. In Chirai village of Varanasi district, 30-40 years old karonda orchard is fetching good income to its farmer. The fruits are considered of better quality because of having attractive maroon colour, fruit weight (10 g), no. of seed/ fruit (4), TSS (9.5°B), acidity (1.10 pH) and vitamin C (28mg/100g). Spineless bel from Jaunpur, scented flowered ber (*Ziziphus*) having higher pulp to stone ratio (M/

Fig. 1.18. A unique collection having maroon fruit in karonda (*Carissa carandus*) from UP

Fig. 1.19. Variability in karonda (*Carissa carandus*) from eastern UP

V) from Mirzapur/Vindhyachal hill; deep black coloured fruit and pulp with TSS (8.5 °B) in fox grape (*Cayratia trifolia*) were some interesting germplasm collections.

IV. Diversity in cucurbits and other crops in parts of central India

Forty-nine accessions mainly landraces of *Luffa*, ash gourd, pumpkin (15), niger (6), rice landraces (5) namely *Lal dhan, Sirohi dhan, Jeera phool* and four other species, along with associated ethno-botanical information were collected from remote areas of Sidhi, Singrauli, Shahdol and Anuppur district of Madhya Pradesh. The collections were made mainly from the tribal farmer's fields and kitchen gardens. Variabilty in shape and size of fruits was observed in sponge gourd, bottle gourd and local maize for cob size. Niger locally called as *'Ramtilla'* was growing as a minor oilseed crop for main use in

Fig. 1.20. *Oryza rufipogon* a wild relative of rice growing in a pond from MP

Fig. 1.21. Gond tribal women sharing seeds of *Cucurbita moschata 'Kumada'* for conservation from MP

Fig. 1.22. Bajaara tribal separating calyx and stem of *Hibiscus sabdariffa* for edible and fibre use in MP

cooking oil. Lesser known crops used for local consumption and utilization, such as red calyx of *Hibiscus sabdariffa* used in preparation of 'chutney' and mature seeds of chakwat (*Cassia tora*) being used for pharmaceutical purposes, were some interesting information recorded from the area.

V. Cucurbits germplasm collected from parts of Bihar and Jharkhand

A total of 86 samples in cucurbitaceous vegetables comprising of *Luffa cylindrical* (24), *Luffa acutangula* (17), *Cucumis sativus* (6), *Trichosanthes cucumerina* (5), *Benincasa hispida* (4), *Lagenaria siceraria* (4), *Momordica charantia* (4), *Cucurbita moschata* (3), and others (19) were collected from parts of Bhagalpur, Munger districts of Bihar and Sahibaganj district of Jhrakhand. Good diversity was observed and collected in fruit size, shape and colour in *Luffa, Momordica, Lagenaria* and *Cucurbita moschata*. Diverse germplasm was collected in *Cucumis, Coccinia and Trichosanthes*. In most of the vegetable growing areas farmers purchase seed every year instead of retaining seeds of previous years. Majority of the cucurbits are grown in Daulat Chak, Pannu Chak, Naki Haveli, Abhaipur, Antichak, Lalban, Navgachhia, Peerpainthi, Olapur, Ammapur, Madhuban areas of the surveyed districts.

Fig. 1.23. Fruit variability in sponge gourd from Jharkhand

VI. Round gourd from parts of Uttar Pradesh, Madhya Pradesh and Rajasthan

Round gourd (*Benincasa fistulosa*) was poorly represented in genebank, hence a crop-specific exploration was conducted in parts of Dholpur, Sawai Madhopur and Karauli districts of Rajasthan; Bhind, Morena, Sheopur districts of Madhya Pradesh and Etawah district of Uttar Pradesh. Thirty seven samples of local landraces of round gourd were collected with good variability in fruit shape (flat to round), size (small to large), and colour (light green to dark green). Generally farmers prefer seeds of local landraces for raising next year crop. In Dholpur, Etawah, Bhind and Morena districts, the crop is grown during *kharif* season (July to Sept), while in Sheopur, Sawai Madhopur and Karauli districts in summer season (March to June). Some special features observed in fruits of local landraces are hairs/trichomes on their skin and mild smoky taste, which is not seen in hybrid varieties. The immature, tender and light green fruits are used as a cooked, boiled, and fried vegetable and are pickled or candied. The seeds after removing seed coat are roasted or fried and eaten as a snack.

1.3 On-farm crop diversity conservation

To repatriate the plants diversity eroded and promote horizontal spread in villages for *on-farm* conservation in Uttarakhand, the *kharif* crops/ landraces (*Chwari dhan, Chakrata local rajma, Panchgain local rajma,* foxtail millet and *Kala Bhatt*) were distributed for cultivation in 18 villages and in rabi crops, seeds of Meshre wheat landrace was distributed to 14 farmers of nine villages in Dehradun, Tehri and Uttarkashi districts of Uttarakhand. About 60% farmers have sown keen interest in cultivation and conservation of reintroduced crops in selected villages. In rabi season, the seed of *Meshre* wheat landrace was also distributed to 12 farmers of seven villages to promote *on-farm* conservation and management in Dehradun and Uttarkashi districts. A workshop on "O*n-farm* conservation awareness' was also organised at village-Jadi, Chakrata, Dehradun, Uttarakhand, and >125 tribal farmers participated in this programme.

1.3.1 Survey on wild rice habitat in Eastern Uttar Pradesh

Wild rice is found mostly in wetlands, ponds and their periphery, and now facing threat of extinction due to encroachment and loss of habitat. A survey

Fig. 1.24. Multiplication and *on-farm* conservation of wheat landrace (*Mensre*) in farmer's field at Tarli, Koruva and Pokhari villages

was undertaken in parts of Ballia, Basti, Deoria, Gorakhpur, Kushinagar, Mau, Sant Kabirnagar districts of eastern Uttar Pradesh to locate the habitats of wild rice species suitable for their long-term protection and *in-situ* conservation. During survey, more than 20 taals (ponds), wetland sites were visited and local people contacted to record information about the taals. It was observed that most of the Taals/ponds and river banks were flooded by heavy rains received during current year. Due to which, both population of wild rice and local rice landraces were flashed out in and around visited areas. Despite the losses due to flood, good population of *Oryza rufipogon (Tinni/ Tinna)* was observed in Lahura deva Taal, Jagdispur areas in district Sant Kabirnagar and Chandu Taal (Pakshi Vihar), Nagar Bazar, area in district Basti. Whereas, the population of another wild rice species *O. nivara* (Tinna/ Jharanga) was found at several places in periphery of Taal/wetlands and adjoining shallow lands/or farmer's fields. Different type of aquatic flora and birds were observed in the visited sites. The local people harvest the wild rice for consuming as cereal during fast and the straw is used as fodder and also as fuel. Most of the lands in and around taals are owned by private farmers hence undertaking long term *in-situ* conservation of wild rice is difficult.

1.4 National Herbarium of Cultivated Plants

This year, 458 herbarium specimens, 32 seed samples and economic products were added to the National Herbarium of Cultivated Plants (NHCP), making total collection of 24,123 herbarium specimens (representative of 4,330 species belonging to 1,538 genera and 267 families), 3107 seed samples and 739 economic products. Herbarium specimens (165) of *Artocarpus teysmannii, Diospyros undulata, Homalomena aromatica, Cucumis melo, Momordica cochinchinensis, Curcuma cannanornsis, Trichosanthes cucumerina, Iris kumaonensis* and *Litsea cubeba* were added from explorations to Andaman & Nicobar Islands, Assam, Arunachal Pradesh, Haryana, Kerala, Meghalaya, Mizoram, Chandigarh, Rajasthan, Tamil Nadu, Uttar Pradesh and parts of Uttarakhand. Other collections included as herbarium specimens of *Allium*, *Cucumis*, *Ocimum, Lens, Lathyrus, Lepidium* and *Basella* (38; experimental fields of IARI); seeds of *Cordia myxa* and *C. gharaf* from Gujarat, and *Echinochloa stagnina* from Arunachal Pradesh and *Pereskia bleo* from Meghalaya were added as seed samples; and dried fruits of *Canarium strictum, Nypa fruticans, Pandanus leram* and *Ziziphus nummularia* from Andaman & Nicobar Islands, Arunachal Pradesh and Rajasthan; dried roots/rhizomes of *Nardostachys jatamansi* and *Withania somnifera* from Haryana as economic products. Identification services were provided (23) and authentication certificates (18) issued to students and researchers for material taken up for experimental study.

Digitization of NHCP: A total of 568 specimens/ taxa belonging to crop genepools were authenticated and digitised including 61 taxa (Table 1.4) unrepresented added as specimens and digital images to the NHCP, resulting into a total of 8,977 digitised images. The digital images of reference herbarium specimen(s) were placed in respective database. The herbarium digital resource has been uploaded on NBPGR webpage (www.nbpgr.ernet.in›nhcp) for access to users.

Table 1.4: Unrepresented taxa added in NHCP during 2019

Family	Taxon	Locality	*W/C
Acanthaceae	*Peristrophespeciosa* Nees	Himachal Pradesh	W
	Pseuderanthemum reticulatum (W. Bull) Radlk.	Delhi	C
Amaryllidaceae	*Zephyranthes rosea* Lindl.	Himachal Pradesh	W
Apocynacae	*Cerbera odallam*L.	Kerala	C
Araceae	*Typhonium blumei* Nicolson &Sivad.	Delhi	W
	Typhonium diversifolium Schott	Uttarakhand	W
	Anaphyllum beddomei Engl.	A & N Islands	W
Asteraceae	*Erigeron multicaulis* DC.	Himachal Pradesh	W
	Gnaphalium coarctatum Willd.(= *Gamochaeta coarctata* (Willd.) Kerguelen)		C
	Gaillardia pulchella Fougeroux		W
	Gnaphalium affine D. Don		
	Carpesium divaricatum Siebold& Zucc.	Arunachal Pradesh	W
Begoniaceae	*Begonia aborensis* Dunn	Arunachal Pradesh	C
Campanulaceae	*Codonopsis pilosula* (Franch.) Nannf.	Arunachal Pradesh	W
Convolvulaceae	*Ipomoea quamoclit* L. (=*Quamoclitpennata* (Desr.) Bojer)	Himachal Pradesh	W
	Dichondra micrantha Urb.	Andaman & Nicobar	W
Ebenaceae	*Diospyros undulata* Wall. ex G. Don	Andaman & Nicobar	W
Euphorbiaceae	*Phyllanthus virgatus* G. Forst. (=*Phyllanthus simplex* Retz.)	New Delhi	C
	Phyllanthus polyphyllus Willd.	Kerala	C
Fabaceae	*Millettia peguensis* Ali	Delhi	W
	*Lathyrus clymenum*L. (=*L. articulatum* L.)	Himachal Pradesh	W
	Lathyrus sylvestris L.		C
Fagaceae	*Lithocarpus dealbatus* (Hook. f. & Thomson ex Miq.) Rehder	Meghalaya (Received for identification)	W
Flacourtiaceae	*Flacourtia sapida* Roxb.	Himachal Pradesh	W
Grossulariaceae	*Ribes uva-crispa* L. (=*Ribes grossularia* L.)	Himachal Pradesh	W
	Ribes rubrum L.		
Juglandaceae	*Engelhardtia spicata* Leschen ex Blurr	Himachal Pradesh	W
Lamiaceae	*Scutellaria barbata* D. Don	New Delhi	W
	Hyssopus lophanthoides Buch.-Ham. ex D. Don	Arunachal Pradesh	W
Malvaceae	*Sida fallax*Walp.	Uttar Pradesh	W
Melastomataceae	*Memecylon umbellatum* Burm. f.	Kerala	W
	Oxyspora paniculata (D. Don) DC.	Arunachal Pradesh	W
Meliaceae	*Dysoxylum gotadhora* (Buch.-Ham.) Mabb.	Arunachal Pradesh	W
Menispermaceae	*Tinospora crispa* (L.) Hook.f. & Thomson	China (Received for identification)	W
Moraceae	*Artocarpus teysmannii* Miq. (=*Artocarpus peduncularis* Kurz)	Andaman & Nicobar	W
Myristicaceae	*Knema laurina* (Blume) Warb.	Meghalaya	W
Oleaceae	*Forsythia suspense* (Thunb.) Vahl	Himachal Pradesh	W
	Jasminum fluminense Vell.	Kerala	W
	Jasminum coarctatum Roxb. (=*Jasminum rottlerianum* Wall. ex DC.)		W
Onagraceae	*Epilobium parviflorum* Schreb.	Himachal Pradesh	W
Parmeliaceae	*Evernia prunastri* (L.) Ach. (=*Lichen prunastri*L.)	Assam	W

Family	Taxon	Locality	*W/C
Polygonaceae	*Fagopyrum dibotrys* (D. Don) Hara *Persicaria chinensis* (L.) H. Gross	Himachal Pradesh Arunachal Pradesh	W W
Proteaceae	*Grevillea robusta* A. Cunn. ex R.Br.	Himachal Pradesh	C
Pteridaceae	*Onychium japonicum* (Thunb.) Kze.	Himachal Pradesh	C
Ranunculaceae	*Thalictrum javanicum* Blume	Himachal Pradesh	W
Rosaceae	*Malus sikkimensis* (Hook.f.) Koehne *Docynia indica* (Wall.) Decne. *Rubus rugosus* Sm. *Sorbus acuparia* L.	Himachal Pradesh Arunachal Pradesh	W W
Rubiaceae	*Uncaria sessilifructus* Roxb. *Luculia gratissima* (Wall.) Sweet	Arunachal Pradesh	W
Solanaceae	*Tubocapsicum anomalum* (Franch. &Sav.) Makino *Solanum campylacanthum* Hochst.	Arunachal Pradesh Tanzania	W W
Sterculiaceae	*Sterculia lanceolata* Cav.	Arunachal Pradesh	W
Taxodiaceae	*Cunninghamia lanceolata* Hook.	Himachal Pradesh	C
Tiliaceae	*Grewia elastic* Royle	Himachal Pradesh	W
Urticaceae	*Pouzolzia hirta* Blume Ex Hassk.	Arunachal Pradesh	C
Verbenaceae	*Clerodendrum laevifolium* Blume *Clerodendrum sahelangii* Koord. ex Bakh.	Uttarakhand Haryana	W W
Vitaceae	*Cayratia pedata* (Lam.) Gagnep.	Kerala	C

*Wild (W)/Cultivated (C)

1.5 Biosystematic studies

Biosystematics studies were undertaken during explorations in natural habitats in Andaman & Nicobar Islands (South Andaman, Little Nicobar, Great Nicobar), Jammu & Kashmir (Kashmir Province), West Bengal (central districts), Meghalaya (Ri-Bhoi), Arunachal Pradesh (Dibang Valley), Madhya Pradesh and Rajasthan. Observations made after consolidating studies of field specimens and various herbaria, are given below:

Biosystematic studies concluded in *Allium*, *Luffa Trichosanthes* and *Amaranthus* showed occurrence of 13 species (16 taxa) of *Trichosanthes* (excluding *Gymnopetalum*) in country. New and extended distribution of some *Trichosanthes* spp. has been reported and diagnostic keys for identification of all the Indian taxa were completed. Areas where explorations and study was undertaken in natural habitats in Andaman & Nicobar Islands (South Andaman, Little Nicobar, Great Nicobar), Jammu & Kashmir (Kashmir Province), West Bengal (central districts), Meghalaya (Ri-Bhoi), Arunachal Pradesh (Dibang Valley), Madhya Pradesh and Rajasthan. In genus *Cucumis*, less-known group in *Cucumis melo* (38 accessions) were studied for fruit and floral morphology and identified distinct characters in subsp. *melo* and subsp. *agrestis.* Based on the morphological, cytological and molecular findings a less-known vegetable melon 'Arya' oriniginally collected from Rajasthan and adjoining parts of Haryana was identified to be closely related to snake melon (*Cucumis melo* subsp. *melo* var. *flexuosus*) than snap melon and muskmelon. Identification key was developed in common melon for field use.

1.6 Diversity mapping in *Vigna mungo*

Geo-referencing and mapping of 5,806 accessions of black gram (*Vigna mungo*) collected from various parts of country was done (Fig. 1.25). Mapping of assembled diversity has shown that Himachal Pradesh (514) followed by Maharashtra (466), Madhya Pradesh (450), Uttar Pradesh (365), Chhattisgarh (298), Uttarakhand (289), Jharkhand (287) and Andhra Pradesh (267) were extensively explored states. Whereas under explored areas of

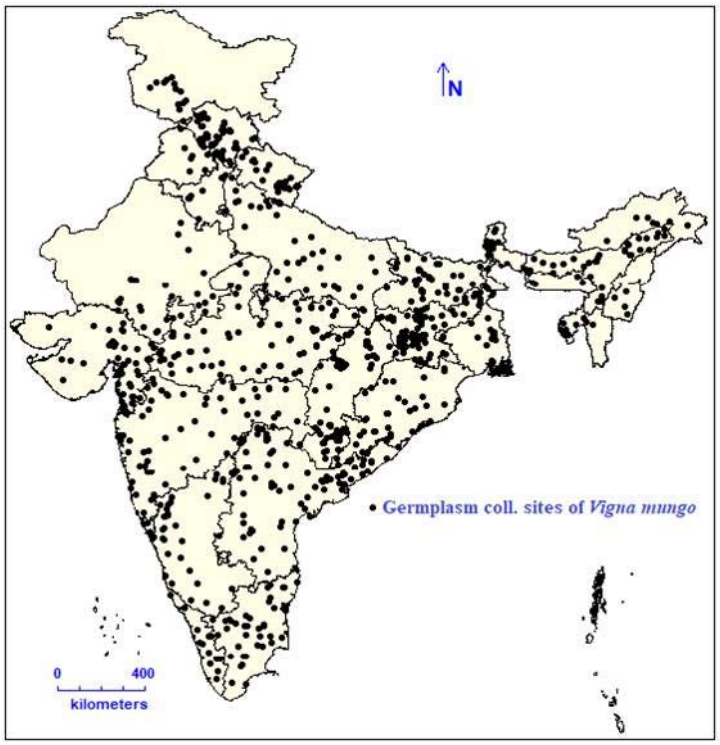


Fig. 1.25. Germplasm collection sites of blackgram

black gram identified for future collection are: Arunachal Pradesh (Anjaw, Changlang, Lower Dibang valley, Upper Dibang valley, Upper Siang, West Siang, East and West Kameng); Nagaland (Mon and Tuensang), Gujarat (Chhota Udaipur, Surat, Tapi); Odisha (Kandhamal, Rayagada and Kalahandi) and Sikkim (East, South and West) as gaps for collection.

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

PGR/DPEGC-BUR-DEL-01.00: Exploration for collection of germplasm of agri-horticultural crops, maintenance of herbarium and biosystematics and ethno-botanical studies (**SP Ahlawat**)

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

PGR/DPEGC-BUR-DEL-01.01: Exploration for collection of genetic resources of agricultural crops and their wild relatives (**SP Ahlawat**, KC Bhatt, RS Rathi, DP Semwal, Soyimchiten, S Nivedhitha, Resmi Raj, *Ravi Kishore Pamarthi, NS Panwar* and *OP Dhariwal*)

PGR/DPEGC-BUR-DEL-01.02: Exploration for collection of genetic resources of horticultural crops and their wild relatives (**KC Bhatt**, RS Rathi, DP Semwal, S Nivedhitha, NS Panwar and OP Dhariwal)

PGR/DPEGC-BUR-DEL-01.03: National Herbarium of Cultivated Plants (NHCP), establishment, maintenance, build-up and taxonomic studies on crop plants (**Anjula Pandey,** K Pradheep**,** S Nivedhitha, *Ravi Kishore Pamarthi* and *Rita Gupta*)

PGR/DPEGC-BUR-DEL-01.04: Geo-informatics for assessment of diversity distribution in agri-horticultural crops (**DP Semwal**, KC Bhatt, Anjula Pandey, N Sivaraj, Soyimchiten, *Ravi Kishore Pamarthi* and *NS Panwar*)

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

GERMPLASM EXCHANGE AND POLICY UNIT 2

Summary: During 2019, 89,418 accessions (1,93,395 samples) were imported, which included 55,926 accessions (56 ,570 samples) of germplasm and 33 492 entries (1,36,825 samples) of CGIAR nurseries for trials. A total of 11,117 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, 66, 097 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing. Analytical inputs provided are as per requirements of the policy makers for negotiations and formulations of policies at various national and international levels on issues related to PGR management.

2.1 Import of plant genetic resources

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

Germplasm accessions procured	:	55,926 accessions (56,570 samples)and processed
CGIAR nurseries for trials	:	33,492 entries (1,36,825 samples)
No. of countries involved	:	27
No. of Import Permits issued	:	690
Resource generated	:	Rs 1,02,57,457/-

2.1.1 Cereals

Aegilops tauschii (50) from Germany, (150) from UK; *Hordeum vulgare* (19) from Australia, (459) from M orocco, (120) from Netherlands, (1535) from USA; *Oryza alta* (3), *O. australiensis* (1), *O. brachyantha* (4), *O. glumaepatula* (1), *O. grandiglumis* (1), *O. granulata* (1), *O. latifolia* (3), *O. minuta* (3), *O. nivara* (5), *O. officinalis* (16), *O. rufipogon* (5) all from Philippines; *O. sativa* (34) from Brazil, (60) from Colombia, (1160) from Germany, (4) from Malaysia, (2948) from Philippines, (2) from Thailand, (312) from USA, (8) from Vietnam and *O. sativa* ssp. *japonica* (19) from USA; *Triticum aestivum* (29) from Australia, (1) from Japan, (176) from Mexico and (5) from UK, *Triticum aestivum* subsp. *aestivum* (23), *Triticum* sp. (264), *Triticum spelta* (2) all from Mexico, *Triticum sphaerococcum* (20) from Bulgaria, (28) from Germany and *Triticum turgidum* subsp. *durum* (10) from Mexico; *Zea mays* (27) from Argentina, (24) from Australia, (141) from Brazil, (14286) from Chile, (1) from Egypt, (100) from France, (100) from Indonesia, (14) from Italy, (73) from Kenya, (1276) from Mexico, (5259) from Philippines, (506) from South Africa, (5009) from Thailand, (3067) from USA, *Zea nicaraguensis* (6), *Zea perennis* (1) both from Mexico, were imported.

2.1.2 Millets

Eleusine coracana (603) from Kenya, (198) from Zimbabwe; *Pennisetum glaucum* (111) from Kenya, (117) from Niger and (3) from USA; *Sorghum bicolor* (72) from Australia, (832) from Kenya, (8) from USA, (3556) from Mali and (68) from Zimbabwe, were imported.

2.1.3 Grain legumes

Cicer arietinum (2) from Turkey, (71) from USA, *C. echinospermum* (1), C. *oxyodon* (1) both from USA,

C. reticulatum (2) from Turkey, (1) from USA; *Macrotyloma uniflorum* (1) from USA; *Pisum sativum* (4) from UK; *Vigna unguiculata* subsp. *sesquipedalis* (104), Vigna *unguiculata* subsp. *unguiculata* (110) from Taiwan, were imported.

2.1.4 Oilseeds

Arachis hypogaea (2) from Uganda; *Brassica napus* (8) from France and (1) from Switzerland; *Carthamus tinctorius* (278) from USA; *Glycine max* (1) from Czech Republic and (1122) from USA; *Helianthus annuus* (7) from USA; *Linum aristatum* (3) from USA, *L. austriacum* (2) from Poland; *L. bienne* (4) from Netherlands; *L. grandiflorum* (1), *L. hudsonioides* (2), *L. lewisii* (2) all from USA, *L. perenne* (1) from UK, (2) from USA, *L. subteres* (1) from USA and *L. usitatissimum* (1) from Netherlands; *Ricinus communis* (133) from USA, were imported.

2.1.5 Forages

Chrysopogon zizanioides (1) from USA; *Dicanthelium oligosanthes* (1) from USA, were imported.

2.1.6 Vegetables

Abelmoschus caillei (14) from Taiwan, *A. esculentus* (53) from Taiwan and (801) from USA, *A. manihot* (1), *A. moschatus* (9) both from Taiwan; *Allium cepa* (40) from USA; *Brassica oleracea* (1) from Netherlands and (1) from USA; *B. oleracea* var. *botrytis* (108) from USA, *B. oleracea* var. *capitata* (2) from Japan, (23) from Netherlands and (16) from USA; *Capsicum annuum* (11) from Korea, (220) from Netherlands, (118) from Taiwan, (11) from Thailand and (342) from USA; *C. baccatum* (2) from Taiwan, *C. baccatum* var. *pendulum* (1), *C. chinense* (1) both from USA; *Citrullus lanatus* (2) from Thailand and (3) from USA; *Cucumis melo* (3) from USA, *C. sativus* (28) from Netherlands, (56) from Spain and (4) from USA; *Cucurbita moschata* (34) from Thailand and *C. pepo* (2) from Taiwan; *Daucus carota* (29) from USA; *Lagenaria siceraria* (2), *L. sphaerica* (1) both from USA; *Luffa acutangula* (3) from Thailand and *L. aegyptiaca* (119) from Vietnam; *Momordica charantia* (36) from Philippines, (29) from Taiwan and (823) from Thailand; *Raphanus sativus* (59) from USA; *Solanum arcanum* (6), *S. chilense* (15), *S. chmielewskii* (2), *S. corneliomulleri* (2), *S. galapagense* (4), *S. habrochaites* (9), *S. huaylasense* (1) all from USA, *S. lycopersicum* (6) from Czech Republic,(186) from Israel, (652) from Netherlands, (115) from Taiwan, (438) from USA, *S.pennellii* (13), *S. peruvianum* (3), *S. pimpinellifolium* (13) AND *S. sitiens* (1) all from USA, were imported.

2.1.7 Fruits & ornamentals

Actinidia arguta (1), *A. chinensis* (26) both from USA; Carica *papaya* (8) from USA; *Celosia argentea* (3) from UK; *Cosmos bipinnatus* (11) from UK. *Citrus aurantium* (1) from USA, *Citrus limon* (10) from South Africa, (9) from USA, *C. limonia* (1) from USA, *Citrus* sp. (2) from South Africa and (4) from USA; *Musa* spp. (1) from Ethiopia; *Persea americana* (2) from Kenya, (5) from South Africa and (13) from USA; *Plectranthus scutellarioides* (20) from UK; *Poncirus trifoliata* (3) from USA; *Vasconcellea goudotiana* (2), *V. monoica* (1), *V. parviflora* (1), *V. pubescens* (2), *V. quercifolia* (1), *V. stipulata* (1) all from USA, were imported.

2.1.8 Medicinal and Aromatic plants

Cannabis sativa (1) from Romania, (3) from Spain and (2) from USA, were imported.

2.1.9 Spices

Trigonella astroites (1), *T. glabra* (2), *T. macrorrhyncha* (1), *T. orthoceras* (3) all from Australia; *Trigonella* sp. (7); *T. spinosa* (3), *T. spruneriana* var. *spruneriana* (3) all from USA, were imported.

2.1.10 Beverages

Coffea canephora (12) from France and (1) from Thailand, were imported.

2.1.11 Potential crops

Fagopyrum esculentum (31), *F. tataricum* (56) both from USA, were imported.

Fig. 2.1. Buckwheat accessions imported from USA established at RS, Shimla

2.1.12 Tuber crops

Ipomoea batatas (2) from Peru; *Solanum tuberosum* (6) from Canada, (1) from Denmark, (15) from Ireland, (3) from Peru, (9) from UK and (41) 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 2019 are indicated below.

Table 2.1: Trait specific seed/planting material imported in 2019

Crop/EC No./Country	Specific Traits	Distribution
Paddy		
EC1000383/ Philippines	NERICAs: Shorter duration, tolerance to specific biotic and abiotic stresses, stable yield.	IGKV, Raipur
EC1000384-1000386/ Philippines	High and stable yield and tolerant to drought, cold, iron toxicity and salinity	IGKV, Raipur
EC1000387/ Philippines	Orylux 6 aromatic variety with good market potential	IGKV, Raipur
EC1001394-1001446/ Philippines	High yielding cultivars and hybrids	IARI, ND
Wheat		
EC972065-972390/ Germany	Wheat DH lines for screening against rust resistance	ICAR-NBPGR
EC976846/ Japan	Japanese wheat landrace Nobeoka Bozu moderately resistant to Fusarium head blight	ICAR-NBPGR
EC1009520-1009548/ Australia	Heat stress experimental lines from Australia	ICAR-NBPGR
EC1009717-794 / Germany; EC1024094-4113/ Bulgaria	Wild wheat lines (*Aegilops tauschii*); *Triticum sphaerococcum*	ICAR-IARI, ND
Maize		
EC977839-977867/ Mexico	Maize lines resistant to stem borer especially fall army worm	ICAR-NBPGR
EC979442-450 / Mexico	Lines for Silage	ICAR-NBPGR
EC979451-54 / Mexico	Stem borer tolerant	ICAR-NBPGR
EC979455-58 / Mexico	Water logging tolerant lines	ICAR-NBPGR
EC1008219-246 / USA	Resistant to south- western corn borer (*Diatraea grandiosella*), fall armyworm (*Spodoptera frugiperda*), and southern corn rust (*Puccinia polysora*)	ICAR-IIMR, Ludhiana
Chickpea		
EC1023944-949/ USA	Susceptible and resistance lines to five races of fusarium wilt	IIPGR, ND

Crop/EC No./Country	Specific Traits	Distribution
Pea		
EC978214-217/UK	Powdery mildew resistant lines	PAU, Ludhiana
Linseed		
EC993390-91 / Netherlands EC993429-30/ Poland	Wild sp. *Linum humile, Linum angustifolium, Linum austriacum*	ICAR-NBPGR
Soybean		
EC978204-978213/ Japan	Landraces of soybean –Senbon, Hepipipqingrang, Southern prolific, Zairaishu, Hachikoku misao, Oushobu waswbon, Shirosaya, Karikachi	ICAR-NBPGR
EC1026157	Variety Polanka	ICAR-NBPGR
Chilli		
EC994252-994258/ Taiwan	Restorer and maintainer lines in Chilli from Taiwan	SDAU, Krushinagar
Tomato		
EC1000250/ USA	Wild species *Solanum chmielewskii*)	ICAR-NBPGR
Cucumber		
EC1024114-117/USA	high carotene lines	ICAR-NBPGR
Avocado		
EC1027328	Dwarf variety Gwen	K J B Agro , The Nilgiris
EC1027330	Cold tolerant avocado variety Fuerte	K J B Agro, The Nilgiris
EC1027329, 331-340	Improved varieties- Hass, Bacon, Zutano, Reed, Pinkerton, Duke 7, Sharwill, Ettinger, Lam hass, Toro canyon	K J B Agro , The Nilgiris
Citrus		
EC978218-22 / South Africa	Improved cultivars- Less seeded, small core, flesh pale-greenish yellow, juice with high acidity	Mahyco, Jalna
EC976849-976857/USA	Improved varieties in Citrus	ICAR-NBPGR
EC977512 / USA	Standard sour orange (*Citrus aurantium*)	ICAR-NBPGR
Kiwi fruit		
EC977548 - EC977574/ USA	Improved cultivars with High TSS content, yellow flesh, Glabrous fruit	ICAR-NBPGR
Papaya		
EC993394/ USA	New species -*Vasconcellea monoica*	ICAR-NBPGR
Buckwheat		
EC977202-288	Large and small seeded diploid and triploid varieties –Winsor royal, Pennline 25, Pennquad, Penn line 18, Perfectura, Aomori	ICAR-NBPGR
Potato		
EC1001459-1001464/USA	Potato varieties Sage Russet, Blazer Russet, Mountain Gem Russet, Gem Star Russet, Premier Russet, Defender, high yielding , resistant to powdery scab, early to mid-season maturity	Centre of Advanced Research in Plant Tissue Culture, Anand

Fig. 2.2. a. Citrus variety Lisbon (EC978219) from South Africa b. Avocado variety Hass (EC1027329) from USA

2.2.1 Export under collaborative research projects

Total of 2,599 samples including, 1,899 samples under Indo- African collaborative research project on stress tolerant orphan legumes, 211 samples comprising of six stress tolerant legume crops namely, *Dolichos* (50), mungbean (50), horse gram (50), cowpea (9), pigeonpea (2) and mothbean (50) were exported to 9 African partners namely Burkina Faso, Ghana, Kenya, Mali, Namibia, Niger, Nigeria, Tanzania and Uganda; 700 samples of wheat (350 to Bolivia and 350 to Bangladesh) under ICAR-CIMMYT Project; 16 samples-rice (4) to Japan, *Moringa* (12) to New Zealand; for training purpose - Taro (20) and kokum (16) to Belgium, were exported with approval from National Biodiversity Authority (NBA).

Also, facilitated supply of 7,273 samples of ICRISAT mandate crops (FAO designated accessions) to different countries and 38,540 samples of CIMMYT Maize trials/nurseries.

2.3 National supply of plant genetic resources

The seed and planting material of diverse agri-horticultural crops were supplied to ICAR institutes/ coordinated projects, agricultural universities and other users in India. Based on specific requests received 11,117 samples were supplied under the MTA. The crop wise samples and the recipient institutes are listed in Table 2.2. In addition a total of 66,097 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

Table 2.2: National supply of seed/planting material to recipients during 2019

Crop group/crop	No. of samples	Recipient Institute
Cereals (2,628)		
Barley	580	CSIR-CSIO, Chandigarh; MDU, Rohtak; CCSHAU, Hisar; VPKAS, Almora; IIWBR, Karnal; NIN, Hyderbad
Maize	77	Bhartisdan University; IIMR, Ludhiana; Maharashtra State Seed Corporation, Akola; Loyola Aacdemy of Degree & OG College, Secunderabad
Rice	328	NRRI, RS Hazaribagh; IARI, ND; PAU, Ludhiana; UAS, Mandya; Rasi Seeds; Panjab University , Farmers (Niod Kumar, Bhairab Saini, Soumik Banerjee)
Triticale	9	Shreeoswal Seeds and Chemical Ltd, Neemuch
Teosinte	53	IIMR, Ludhiana; GBPUAT, Pantnagar
Wheat	1,581	Bundelkhand University, Jhansi; IARI, ND; Nuziveedu Seeds; Univ. of Delhi; SKUAST (J), VPKAS, Almora; UAS, Dharwad; BRD (PG) College, Deoria; CCS HAU Hisar; CSKHPKV, Kangra; JNKVV, Powerkheda; Shreeoswal Seed and Chemical Ltd, Neemuch; IARI RS Shimla; Central Univ. of Haryana; CCSMU, Meerut
Millets (201)		
Fingermillet	150	MDU, Rohtak
Little millet	1	ANGRAU, RARS Nandyal
Pearlmillet	3	BIABSM, Baronda, Raipur
Brown top millet	43	ANGRAU, RARS Nandyal
Italian millet	4	ANGRAU, RARS Nandyal

Crop group/crop	No. of samples	Recipient Institute
Grain legumes (5026)		
Jackbean	10	SKLTSHU, Hyderabad
Chickpea	956	IARI, ND; Bundelkhand Univ., Jhansi; Rani Laxmibai CAU, Jhansi
Cowpea	720	KAU, Kollam; Rani Laxmibai CAU, Jhansi ; SKLTSHU, Hyderbad; BS Konkan Krish Vidyapeeth, Dapoli; Hamdard University, Delhi; IIPR, Kanpur; CCSHAU, Hisar; AAU, Anand
Dolichos bean	329	IIHR, Bengaluru; KAU, Thrissur; UAS, Dharwad; College of Hort., Chickmagalaur
Frenchbean	342	Dr YSRHU, Tadepalligudan; UAS, Dharwad; SKLTSHU, Hyderabad; LPU, Phagwara
Lentil	796	IIAB, Ranchi; NIPGR, Delhi; BCKV Nadia; UBKV, Cooch Behar; IIPR, Kanpur; IARI RS, Kota
Mungbean	151	NIPGR, Delhi; UAHS Shimoga; KAU, Thrissur; Rani Laxmibai CAU, Jhansi; LPU, Phagwara
Pea	348	CSKHPKV, Palampur; IARI RS, Kota; PAU, Ludhiana; IAS, Jhansi; NIPGR, Delhi
Pigeonpea	904	TNAU, Coimbatore; NIPB, ND;
Rice bean	322	ICAR RC NEH, Umiam; KAU, Thrissur
Urdbean	140	Annamalai University, Chidambram; NIPGR, Delhi; Rani Laxmibai CAU, Jhansi
Vigna sp.	8	ILS, Bhubneshwar
Oilseeds (530)		
Crambe	4	ICAR-NBAIR
Eruca sativa	4	ICAR-NBAIR
Eruca vesicaria	4	ICAR-NBAIR
Lepidium	4	ICAR-NBAIR
Linseed	51	AMU, Aligarh; Jamia Hamdard, Delhi
Mustard	463	Central Univ. of Haryana, Mahendragarh; Tierra Agrotech Pvt Ltd, Gurgaon; Seed Works Private Ltd., Telangana; University of Hyderabad; GBPUAT, Pantnagar; Amity University, Noida; Shreeoswal SEED & chemical Ltd, Neemuch
Vegetables (1753)		
Bitter gourd	132	AAU, Anand;ANGRAU Tirupati; VNR Seeds
Bottle gourd	70	ILS, Bhubneshwar; SVBPUAT, Meerut; KAU, Vellayani
Brinjal	239	Rajmata VijayrajeScindia KVV, Mandsaur; SKLTSHU; CSKHPKV, Palampur;PJSTSAU, Hyderabad; TNAU, Virudhnagar; KAY, Kasargod; Dr PDKVV, Akola
Carrot	46	ACSEN Hy Vegetables, Gurugram; SKUAST-K
Chilli	349	SKLTSHU, Telangana; IARI, ND; SKUAST-K; UAHS, Mudigree; CCSHAU; SKLTSHU, Hyderabad
Cucumber	131	OUAT, Bhubneswar; IARI, ND; BCKV, Kalyani; IARI,ND; Kittu Rani College College of Hort. Arabhavi; UAHS, Bgalkot; PAU, Ludhiana; KAU, Thrissur
Musk melon	10	PAU, Ludiana
Okra	112	AAU, Anand; Loyola Academy of Dgree and PG College, Secunderabad; VNR Seeds; CCSMU, Meerut; SVBPUAT, Meerut
Onion	20	ACSEN Hy Veg. Pvt Ltd.Gurugram; UAHS, Shimoga
Cauliflower	165	ACSEN Hy Veg. Pvt Ltd. Gurugram; IARI, ND
Tomato	479	College of Hort., Mudigree; VNR Seeds, Hyderbad; NBAR; SVBPUAT, Meerut; KAU, Thrissur; TBGRI, Padole; Mata Grjri College, Fategarh; LPU, Phagwara; IARI, ND; TNAU, Madurai
Medicinal and Aromatic plants (160)		
Aloe	70	VCSG Univ. of Forestry, Tehri; Amity University, Noida
Artemisia annua	2	University of Allahabad, UP
Andrographis	35	Jamia Hamdard, Delhi; SKUAST-J
Catharanthus	1	University of Delhi
Gilbe	5	Jamia Hamdard, Delhi
Mimosa pudica	24	PAU, Ludhiana

Crop group/crop	No. of samples	Recipient Institute
Mucuna	3	Uka Tarsadia University, Tawadi
Ocimum	6	University of Delhi
Physalia	1	University of Jammu
Plumbago	13	DTU, Delhi
Potential Crops (451)		
Amaranth	209	UAHS, Shimoga, IISER, Tirupati; Rani Laxmibai CAU, Jhansi
Buckwheat	60	University of Kashmir, Hazratbal
Chenopodium	182	NEHU Shillong; UAS, Bangalore; CSSRI, Karnal
Fruit crops (114)		
Artocarpus	6	SVBPUAT, Meerut
Apricot	23	CITH, Srinagar
Grapes	32	IARI, ND
Musa	12	SVBPUAT, Meerut
Peach	10	CITH, Srinagar
Plum	10	CITH, Srinagar
Tagetes minuta	13	HC&RI, Coimbatore
Parthenocissus quinquefolia	8	IARI, ND
Fibres (224)		
Cotton	224	CICR, Nagpur
Forages (6)		
Desmodium	2	NBAIR
Oat	4	CCSHAU, Hisar
Tubers (24)		
Potato	24	PAU, Ludhiana

2.4. PGR Policy

Analyzed the agenda items and prepared for India's position for:

2.5. International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)

- 9th meeting of the ad hoc open-ended working group to enhance the functioning of the multilateral system of access and benefit sharing (OWG- 9), June 16-21, 2019, Rome
- Informal meetings of OWG from January 14-15, 2019 at Costa Rica and March 25-27, 2019 at Ethiopia. Deliberations were on Draft revised Standard Material Transfer Agreement; Enforceability of the revised SMTA; Adapting the coverage of the Multilateral System; and Proposal for a Growth

Fig. 2.3. Dr S Archak at ITPGRFA OWG 9 meeting, at FAO, Rome, 16- 21 June 2019

Fig. 2.4. Dr S Archak at ITPGRFA OWG Informal meeting-2, Addis Ababa, Ethiopia, 25 -27 March 2019

- To advise on India's position on the changes proposed in ABS under ITGRFA, a discussion meeting of revised SMTA and expanding coverage of MLS was organised on May 24, 2019
- Stakeholders preparatory meetings at ICAR
- 8th Session of the Governing Body Meeting during November 11 -16, 2019 at Rome

Fig. 2.5. Asia region delegates worked with good coordination, understanding and cohesiveness during GB8

Asia Regional Preparatory Meeting for the Eighth Session of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was organized from October 8 to 10, 2019. The meeting was attended by 34 participants from 13 countries. FAO office in India provided for the logistic support. Dr Trilochan Mohapatra, DG, ICA & Secretary, DARE gave opening remarks. Sh Ashwani Kumar, Joint Secretary (Seeds) and national focal point of India for the International Treaty welcomed the participants. The meeting was organized to prepare the position of Asia group on the agenda items specifically the expansions of Annex 1 crops and revision of SMTA.

Fig. 2.6. Asia Regional Preparatory Meeting for the GB8 of ITPGRFA, New Delhi, 8 – 10 October 2019. Participants from 13 countries and two from the Treaty Secretariat participated in the meeting

2.6. Commission on Genetic Resources for Food and Agriculture (CGRFA)

- Agenda of the 17th Regular Session of the Commission on Genetic Resources for Food and Agriculture (CGRFA)

2.7. Convention on Biological Diversity

- Consultation on draft guidelines on access to biological resources and associated knowledge and equitable sharing of benefit regulations
- National report on compliance to the Cartagena Protocol
- Contributed to the fourth National Report under the Cartgena Protocol on Bio-safety
- Country programming framework for year 2019-22
- Biodiversity Finance Plan prepared under BIOFIN Project
- Consultation meeting on implementation of Biological Diversity Act 2002
- Consultation meet with experts on Digital Sequence Information
- Comments/ inputs/ views were provided for the agenda under consideration by NBA for Meeting of Expert Committee Meetings on ABS held during 2019
- Also, provided inputs to MoEF&CC regarding Aichi Target 9: By 2020, invasive alien species

and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their

2.8. Issues related to Biosecurity

- Sections where revision was needed were identified in Plant Quarantine (Regulation of Import into India) Order 2003
- European Union requirements for accreditation of seed production units for export of seeds from India to EU. Draft report was presented by the EU audit team and discussions ensued.
- SAARC Regional Consultative meeting in Nepal on Seeds without borders as follows:
- In continuation of providing advisory in 2018, 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.
- Undertook country specific, pathway-based generic PRA following crops facilitating import of these crops for the first time by ICAR-NBPGR:

Plant Species	Category of plant material	Country
Oats *(Avena sativa)*	Seed	Poland
Sea buckthorn (*Hippophae rhamnoides*)	Rooted plants	Russia
Hemp (*Cannabis sativa*)	Seed	USA
Rice (*Oryza sativa*)	Straw and grain with husk	Thailand
Cyamopsis tetragonoloba	Seeds	USA
Bamboo (*Guadua angustifolia*)	Rooted plants	Colombia
Ginseng (*Panax ginseng*)	Seed	China
Guria grass (*Chrysopogon zizanoides*)	Seed	USA
Radish (*Raphanus sativus*)	Seed	Czech Republic
Tomato (*Solanum lycopersicum*)	Pollen	Netherlands
Musa spp.	Leaf lamina	Ethiopia
Bottle gourd (*Lagenaria* sp.)	Seed	USA
Steinchisma spathellosum	Seeds	Argentina
Avocado (Persea americana	Plants	Kenya
Ryegrass (Lolium sp.	Seed	Italy
Wax gourd (Benincasa hispida	Seed	USA
Indian round gourd (*Benincasa fistulosa*)	Seed	USA
Fenugreek (*Trigonella* sp.)	Seed	Australia
Saw Palmetto (*Serenoa repens*)	Rooted seedling	USA
Niger (*Guizotia abyssinica*)	Seed	USA
Tuberose (*Polianthes tuberosa*)	bulbs	USA
Plectranthus scutellariodes	Seed	UK

Plant Species	Category of plant material	Country
Cosmos bipinnatus	Seed	UK
Lablab purpureus	Dried leaf	UK
Muhlenbergia reverchonii	Seed	USA
Saccharum alopercuroides	Seed	USA
Cucurbita pepo	Seed	Vietnam
Corkwood tree (Duboisia myoporoides, D. leichardtii and D. hopwoodi)	Unrooted and rooted tissue culture plantlets	Australia
Wild goat grass (Aegilops taushii)	Seed	Germany
Wheat (Triticum sphaerococcum)	Seed	Germany

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

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

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

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

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

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

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

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

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

DIVISION OF PLANT QUARANTINE 3

Summary: A total of 1,18,751 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 (1,689) comprised insects (265), nematodes (320), fungi (960), viruses (96) and weeds (48) including several exotic pests. Of the 1,689 infested/ infected/ contaminated samples, 1,565 were salvaged through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test. The remaining 138 samples could not be salvaged and hence rejected. In addition, one sample of maize was rejected due to heavy insect infestation. A total of 1,478 samples of exotic germplasm of different legume crops imported from different countries/ sources were grown in post-entry quarantine (PEQ) greenhouses and the harvest of the plants free from viruses was released to the indenters. Forty one post-entry quarantine inspections were carried out at various indenter's sites during this period. A total of 2,768 samples of various crops were processed for export, of which two infected samples were salvaged, 15 samples contaminated with 05 types of weed species were salvaged, and 15 Phytosanitary Certificates were issued. Quarantine processing of 20 samples of imported transgenic planting material revealed infection with *Bipolaris oryzae and Fusarium verticillioides* in 19 samples of *Oryza sativa* from USA and infected samples were salvaged; absence of terminator gene was ensured; all samples were salvaged prior to release and PEQ inspection undertaken. Under seed health testing, a total of 10,997 samples were received from Division of Germplasm Conservation, of which 334 samples were found infected with different fungal pathogens including virus (26). A total of 18 samples including rice infected with *Tilletia barclayana* (3), wheat infected with *T. indica* (11 samples), foxtail millet infected with *Ustilago crameri* (3) and one sample each of barley due to *Ustilago hordei* and little millet due to *Macalpinomyces sharmae* were rejected as they could not be salvaged. A total of 2,715 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 178 samples were found infested while visual infestation of insect-pests was recorded in 949 samples. A total of 1,127 samples were found infested by various insect-pests. Out of total 1,127 infested samples, 953 were salvaged by X-ray radiography (162), cold treatment (694) and mechanically (97) while 174 samples could not be salvaged hence rejected. In addition of 136 samples received from TCCU for seed health testing before/ after cryo-preservation, seven samples were found infected with different fungi, and all were salvaged.

3.1 Import quarantine

3.1.1 Quarantine examination: A total of 1,18,751 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 (Fig. 3.1). Of the import samples, 5,349 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids.

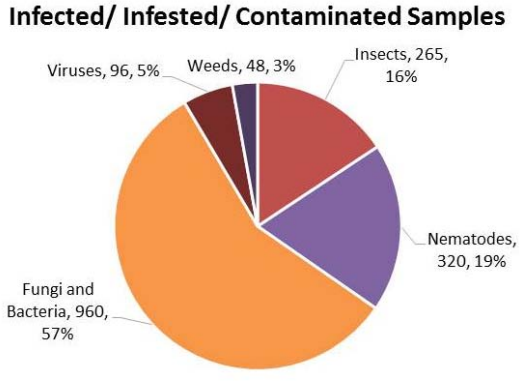


Fig. 3.1. Infected/ infested/ contaminated samples detected through quarantine examination

Of these, 265 samples were found infested with insects/ mites, including 224 with hidden infestation; 320 samples infected with nematodes, 960 infected with fungi, 96 with viruses and 48 with weeds (Fig. 3.1). The photographs of some of the quarantine weeds are given in Fig 3.2.

Convolvulus erubescens | *Galium tricornutum* | *Echinochloa crus-pavonis* | *Helianthus petiolaris*

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

3.1.2. Salvaging of infested/ infected/ contaminated germplasm: Of the total 1,689 infested/ infected/ contaminated samples, 1,561 were salvaged by various disinfestation/ disinfection techniques/ treatments like mechanical cleaning to remove damaged/ abnormal seeds, soil clods, plant debris, etc., fumigation with ethylene dichloride-carbon tetrachloride (EDCT) mixture at 320 mg L^{-1} for 48 h or Aluminium Phosphide fumigation (Phosphine at 2 g cu m^{-1} for 72 h) at 30°C under normal air pressure against insect infestation and hot water treatment (HWT) at 52°C for 30 minutes for various seed-borne bacterial pathogens and nematodes and X-ray screening for hidden insect infestation, pesticidal dip/ spray for vegetative propagules. Out of 265 insect infested samples, 264 were salvaged, by X-ray radiography (224), aluminium phosphide fumigation /Ethylene dichloride Carbon tetrachloride fumigation (24) and mechanical cleaning (11), while one maize sample from Thailand was rejected due to heavy insect infestation. In order to prevent the introduction of new strains/ biotypes of the associated fungal pathogen intercepted, 916 infected samples were salvaged by various disinfection techniques/ treatments such as fungicidal seed treatment and ethyl alcohol wash, and remaining 44 infected samples were rejected.

The rice samples infected with nematode were salvaged by hot water treatment. The rooted samples of *Persea americana* infected with nematodes were salvaged by root-dip treatment of 0.25 percent formalin for 10 min. A total of 48 samples contaminated with weed seeds were salvaged by mechanical cleaning.

These rejected samples included 28 samples of rice, from Brazil (17), China (8) and Philippines (1) due to *Tilletia barclayana*; two samples of barley from Morocco due to *Ustilago hordei*. In addition, nine samples of maize from USA and seven samples of pepper from The Netherlands rejected due to pesticide treatment. Total 14 *in vitro* samples of banana were also rejected due to mechanical damage and fungal contamination. A total of 79 samples comprising *Glycine max* (59) from USA; *Solanum lycopersicum* (17) from the Netherlands; *Capsicum annuum* (2) from the Netherlands and *Zea mays* (1) from Thailand were rejected due to viruses of quarantine significance for India.

3.1.3. Prophylactic treatments: A total 14,250 seed samples were subjected to fumigation with aluminium phosphide (Phosphine at 2 g per cubic metre for 72 hrs)/ Ethylene dichloride- Carbon tetrachloride at 320 mg/litre for 48 hrs and 1,483 vegetative propagules were given pesticidal dip/ spray treatment against pests and 3,830 samples of paddy were given mandatory prohpyalctic hot water treatment. In order to prevent the introduction of new strains of tobamoviruses through seeds, all the introduced germplasm samples of chilli (286) and tomato (596) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate (Fig 3.3).

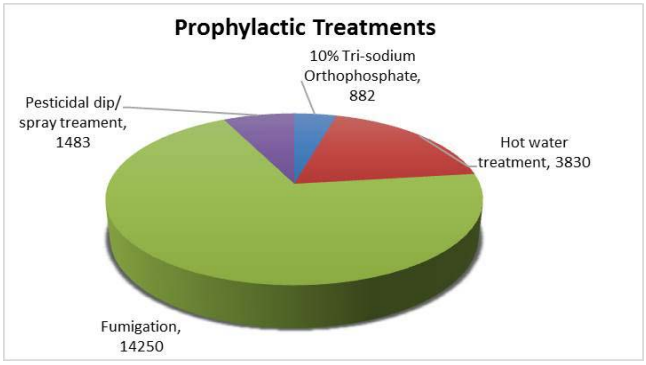


Fig. 3.3. Prophylactic treatments of introduced germplasm samples

3.1.4 Growing out test for detection of viruses: A total of 985 samples of exotic germplasm comprising *Glycine max* (357), *Phaseolus* spp. (412), *Pisum sativum* (1), *Vigna radiata* (200), *V. unguiculata* (5) and *V. subterranea* (10) were grown in PEQ greenhouses at Headquarters. Also 493 accessions of soybean comprising 200 accessions grown at PAU Ludhiana; 293 accessions grown at ICAR-NBPGR Regional Station, Hyderabad were inspected.. The plants showing virus-like symptoms were tested by electron microscopy, reverse-transcription PCR and enzyme-linked immunosorbent assay (ELISA). A total of 79 samples comprising *Glycine max* (59) from USA were rejected due to viruses of quarantine significance for India. The harvest from only healthy plants of different accessions was released to the indenters. Also, *Solanum lycopersicum* (17) from the Netherlands; *Capsicum annuum* (2) from the Netherlands and *Zea mays* (1) from Thailand were rejected due to viruses of quarantine significance for India. The various categories of pest interceptions are presented in Table 3.1.

Table 3.1: Pests intercepted in the exotic germplasm during 2019

Pests	Host	Source/ Country
Insect		
*Bruchus tristis**	*Lathyrus sativus*	Lebanon
*B. ervi**	*Lens culinaris*	Lebanon
*B. dentipes**	*L. sativus, Vicia faba*	Lebanon
Cadra cautella	*Zea mays*	Thailand
Lasioderma serricorne	*Daucus carota*	USA
Rhizopertha dominica	*Hordeum vulgare*	Morocco
	Oryza sativa	Philippines, Brazil
	Z. mays	Philippines
Sitophilus oryzae	*H. vulgare*	Morocco
	O. sativa	Philippines
Sitotroga cerealella	*Z. mays*	Thailand
	O. sativa	Philippines
Tribolium castaneum	*Z. mays*	Philippines
Immature stages of bruchid	*Vigna unguiculata*	Mali, Niger
	Vicia faba	Lebanon
Fungi and Bacteria		
Alternaria alternata	*Momordica charantia, Z. mays*	Thailand
	Raphanus sativus	USA
A. brassicae	*H. vulgare*	Morocco
A. brassicicola	*Brassica oleracea* var. *botrytis, B. oleracea, R. sativus*	USA
A. padwickii	*O. sativa*	Philippines
	Daucus carota	USA
A. radicina	*B. oleracea* var. *capitata*	USA
Bipolaris bicolor	*Triticum aestivum*	Australia
B. halodes, B. hawaiiensis	*O. sativa*	USA
B. maydis	*Z. mays*	Mexico
B. oryzae	*O. sativa*	Colombia
B. rostrata	*Z. mays*	Mexico, Philippines
	M. charantia	Thailand
	O. sativa	USA
B. sorokiniana	*H. vulgare*	Morocco
	M. charantia	Thailand
	Solanum lycopersicum	Israel
Cercospora kikuchii	*Glycine max*	USA
Claviceps purpurea	*H. vulgare*	Morocco
Colletotrichum capsici	*G. max*	USA
	M. charantia	Thailand
Epicoccum nigrum	*T. aestivum*	Australia
Fusarium sp.	*T. aestivum, Helianthus* sp.	Australia
Fusarium dimerum	*O. sativa*	Brazil, Philippines, USA
F. oxysporum	*Cicer arietinum*	Lebanon
	M. charantia	Thailand
	T. aestivum	Australia
	Z. mays	Mexico, Thailand
F. semitectum	*Cannabis sativa*	Romania
F. solani	*Cicer arietinum*	Lebanon
F. verticillioides	*Abelmoschus*	USA
	B. oleracea var. *capitate, C. baccatum* var. *pendulum, G. max*	

Pests	Host	Source/ Country
	Capsicum annuum	Taiwan, The Netherlands, USA
	Cicer arietinum, *T. durum*	Lebanon
	H. vulgare	Morocco
	M. charantia	Thailand
	O. sativa	Philippines, USA
	S. lycopersicum	Philippines, Taiwan. USA
	V. unguiculata	Mali
	Z. mays	Chile, France, Mexico, Philippines, Thailand, USA
F. verticillioides subglutinans	*C. arietinum*	Lebanon
Myrothecium roridum, *Phomopsis* sp.	*M. charantia*	Thailand
Nigrospora oryzae	*O. sativa*	Philippines
Phoma exigua, *P. herbarum*	*M. charantia*	Thailand
P. sorghina	*O. sativa*	Brazil, USA
Phomopsis phaseoli	*G. max*	USA
Puccinia carthami	*Helianthus* sp.	Australia
Stenocarpellum maydis	*Z. mays*	USA
Tilletia barclayana	*O. sativa*	Brazil, China, Philippines
Ulocladium consortile	*O. sativa*	USA
Ustilago hodei	*H. vulgare*	Morocco
Verticillium albo-atrum	*T. aestivum*	Australia
Xanthomonas campestris pv. *campestris*	*B. oleracea*	The Netherlands
Viruses		
[9]*Arabis mosaic virus*	*G. max*[c&]	Japan, USA
	V. unguiculata[c&]	Mali
Bean common mosaic virus	*G. max*[c&]	USA
	V. radiata	USA
Bean common mosaic necrosis virus	*V. unguiculata*	Mali
	V. radiata	USA
**Bean pod mottle virus*	*G. max*	USA
Bean yellow mosaic virus	*V. radiata*	USA
**Broad bean stain virus*	*G. max*	Japan, USA
Broad bean wilt virus	*C. annuum*	Taiwan
	V. faba	ICARDA (Lebanan)
**Cherry leaf roll virus*	*G. max*	USA
Cowpea mild mottle virus	*G. max*	USA
	V. unguiculata	Mali
Cucumber mosaic virus	*C. annuum*	Taiwan
	S. lycopersicum	The Netherlands
Grapevine fan leaf virus	*G. max*[c&]	Japan, USA
	V. radiata[c&]	USA
	V. unguiculata[c&]	Mali
Pea seed-borne mosaic virus	*V. faba*[c&]	ICARDA (Lebanan)
**Pepper mild mottle virus*	*C. annuum*	The Netherlands, Taiwan
**Pepino mosaic virus*	*C. annuum*	The Netherlands, Taiwan
	S. lycopersicum	The Netherlands
[9]*Red clover vein mosaic virus*	*V. faba*[c&]	ICARDA (Lebanan)
**Raspberry ringspot virus*	*G. max*	Japan, USA
	V. radiata	Afghanistan, USA
	V. unguiculata	Mali
Southern bean mosaic virus	*G. max*[c&]	USA
Soybean mosaic virus	*G. max*	Japan, USA
	V. radiata	USA
Tobacco ringspot virus	*C. annuum*	Taiwan
	G. max[c&]	USA
Tobacco streak virus	*C. annuum*	The Netherlands, Taiwan
	G. max	USA
	V. radiata	Afghanistan
Tomato black ring virus	*C. annuum*	Netherlands
	G. max[c&]	USA
**Tomato bushy stunt virus*	*C. annuum*	The Netherlands, Taiwan
	S. lycopersicum	The Netherlands
Tomato mosaic virus	*C. annuum*	The Netherlands, Taiwan
**Tomato ringspot virus*	*C. annuum*, *S. lycopersicum*	The Netherlands
	G. max	USA
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Brazil, China, Philippines, USA

Pests	Host	Source/ Country
Tylenchorhynchus sp. *Aphelenchus avenae*	*Persea americana*	Kenya
Weeds		
Atriplex patula	*Carthamus tinctorius*	USA
Centaurea cyanus	*Brassica napus*	Switzerland
**Convolvulus erubescens*	*C. arietinum*	Lebanon
[9]*E. crus-pavonis*	*O.. sativa*	USA
**Galium tricornutum*	*L. culinaris*	Lebanon
**Helianthus petiolaris*	*Helianthus annuus*	Australia
Heliotropium europeum	*H. vulgare*	USA

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

3.1.5 PEQ inspection at indenter's site: A total of 41 post-entry quarantine inspections (PEQI) were carried out at various indenters' sites during this period and a total of 16,186 germplasm were imported (Table 3.2). During PEQI, 10 plants of accession EC977291 of pepper from South Korea under IQ44/2019, three plants of accession EC949869, one plant each of accessions EC949882 and EC949884 of tomato from The Netherlands under IQ166/2019 were suspected for viral infection at Syngenta India Ltd, Aurangabad were uprooted and incinerated. A sample of wheat i.e. entry # 411 of 9th HPYT (ET221995) from Mexico under IQ 298/2018 infected with loose smut (*Ustilago segetum*) at M/s Ankur Seeds Pvt. Ltd., Nagpur, Maharashtra was uprooted and incinerated. Similarly, at M/s Sungro Seeds Pvt Ltd., Sonipat, 3 plants of accession EC967260 and one plant each of accessions EC967258, EC967261 and EC967263 and two plants of EC967257 of *Capsicum* from Taiwan under 355/2018 were uprooted and incinerated due to suspected viral infection.

In all, a total of 57 accessions of *Capsicum annuum, Momordica charantia, Solanum lycopersicum, Triticum aestivum, Vicia faba* and *Zea mays* were uprooted from 12 different locations due to virus-like symptoms, and destroyed during PEQ inspections.

3.2 Export quarantine

A total 2,768 samples of crops comprising *Arabidopsis* (153), *Vigna radiata* (450), *V. aconitifolia* (210), *V. unguiculata* (81), *Cajanus cajan* (258), *Lablab purpureus* (450), *Macrotyloma uniflorum* (450), *Triticum aestivum* (700), *Oryza sativa* (2), *Moringa oleifera* (12), *Colocasia esculenta* (1) and *Garcinia indica* (1) were exported to Burkina Faso, Ghana, Niger, Nigeria, Mali, Tanzania, Kenya, Uganda, Namibia, Germany, New Zealand, Bangladesh and Bolivia. Out of 2768 exported samples, 1911 were X-ray tested. Fifty-six samples of *V. radiata*, *V. aconitifolia*, *V. unguiculata*, *C. cajan*, *L. purpureus*, *M. uniflorum* and *T. aestivum* were found infested by immature stages of bruchid, *Callosobruchus maculatus*, *C. theobromae*, *C. analis* and *Rhizopertha dominica*. All 56 insect infested samples were salvaged by fumigation using aluminium phosphide (Phosphine at 2 g per cu.m. for 72 h)/ Ethylene dichloride Carbon tetrachloride at 320 mg/l for 48 h. Prophylactic treatment with fumigation was given to 2555 samples. One sample of wheat intended for export to Mexico was found contaminated with *Phalaris minor* seeds, and 11 samples of horsegram and three samples of moth bean intended for export to Ghana, Nigeria and Namibia were found contaminated with *Emex australis, Echinochloa crus-galli, Ipomoea purpurea* and *Vicia sativa*, respectively. Sixteen infected samples were salvaged, and a total 15 phytosanitary certificates were issued.

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

A total of 10,997 accessions of indigenously collected and/ or multiplied seed material were received through Division of Germplasm Conservation for seed health testing (SHT) before pest-free conservation in the National Gene Bank. As a result of SHT, 334 samples were found infected with different fungal pathogens including 26 mottled soybean samples and 1,127 samples infested by various insect-pests. A total of 262 samples were found infected with nematodes from fourteen different states of the country. A total of 49 samples

Table 3.2: Details of post entry quarantine inspections (PEQI) undertaken at indenters' site during 2019

S.No	IQ No.	Source country	Crop	Samples	Indentor's site
1.	310/2018	Lebanon	*Lathyrus sativus*	160	ICARDA, Amlaha
2.	311/2018	Lebanon	*Lens culinaris*	269	ICARDA, Amlaha
3.	312/2018	Lebanon	*Vicia faba*	186	ICARDA, Amlaha
4.	312/2018	Lebanon	*Vicia faba*	986	New Area, IARI, New Delhi
5.	283/18	Mexico	*Triticum aestivum*	253	ITC Pvt. Ltd., Sehore (MP)
6.	290/18	Mexico	*Triticum aestivum*	1,500	ITC Pvt. Ltd., Sehore (MP)
7.	294/2018	Mexico	*Triticum aestivum*	98	ITC Pvt. Ltd., Sehore (MP)
8.	402/18	Mexico	*Triticum aestivum*	50	ITC Pvt. Ltd., Sehore (MP)
9.	292/2018	Mexico	*Triticum aestivum*	1,343	Syngenta India Ltd, Karnal
10.	414/2018	Mexico	*Triticum aestivum*	330	Syngenta India Ltd, Karnal
11.	197/ 2018	USA	*Hordeum vulgare*	288	SAB Miller Pvt. Ltd., Farrukh Nagar, Haryana
12.	297/2018	Mexico	*Triticum aestivum*	876	Ajeet Seeds, Aurangabad, Maharashtra
13.	322/2018	Mexico	*Triticum aestivum*	1,352	Nirmal Seeds, Jalgaon, Maharashtra
14.	364/2018	Thailand	*Zea mays*	530	Monsanto India Ltd., Bengaluru
15.	298/2018	Mexico	*Triticum aestivum*	1,498	Ankur Seeds Pvt. Ltd., Nagpur, Maharashtra
16.	295/2018	Mexico	*Triticum aestivum*	590	Suraj Crop Science, Gandhinagar
17.	301/2018	Mexico	*Triticum aestivum*	1,232	Bioseeds Pvt. Ltd., Ludhiana
18.	291/2018	Mexico	*Triticum aestivum*	2,438	Nuzividdu Seeds Pvt. Ltd., Karnal, Haryana
19.	406/2018	Mexico	*Triticum aestivum*	50	Nuzividdu Seeds Pvt. Ltd., Karnal, Haryana
20.	354/2018	Taiwan	*Lycopersicum esculentum*	20	Sungrow Seeds Pvt Ltd, New Delhi
21.	278/2018	Taiwan	*Cucumis sativus*	3	SKUAS&T, Jammu
22.	299/2018	Mexico	*Triticum aestivum*	615	Rasi Seeds Private Ltd., Delhi
23.	27/2019	Taiwan	*Momordica charantia*	63	Ankur Seeds Pvt. Ltd., Nagpur Maharashtra
24.	305/2018	Nepal	*Artocarpus heterophyllus*	75	World Agroforestry Centre, Jhansi
25.	375/2018	Taiwan	*Solanum lycopersicum*	11	Noble Seeds Pvt. Ltd., Sonipat, Haryana
26.	391/2018	Taiwan	*Capsicum annuum*	22	Noble Seeds Pvt. Ltd., Sonipat, Haryana
27.	280/2018	Thailand	*Capsicum annuum*	4	Syngenta India Ltd, Aurangabad
28.	44/2019	South Korea	*Capsicum annuum*	5	Syngenta India Ltd, Aurangabad
29.	166/2019	The Netherlands	*Capsicum annuum*	39	Syngenta India Ltd, Aurangabad
30.	107/2019	Brazil	*Oryza sativa*	28	Savannah Seeds Pvt. Ltd., Gurgaon
31.	124/2019	USA	*Oryza sativa*	249	Savannah Seeds Pvt. Ltd., Gurgaon
32.	187/2018	Philippines	*Oryza sativa*	50	Savannah Seeds Pvt. Ltd., Gurgaon
33.	188/2018	China	*Oryza sativa*	7	Savannah Seeds Pvt. Ltd., Gurgaon
34.	279/2018	Brazil	*Oryza sativa*	27	Savannah Seeds Pvt. Ltd., Gurgaon
35.	395/2018	USA	*Oryza sativa*	76	Savannah Seeds Pvt. Ltd., Gurgaon
36.	61/2019	USA	*Oryza sativa*	60	Savannah Seeds Pvt. Ltd., Gurgaon
37.	124/2018	USA	*Glycine max*	150	RS, ICAR-NBPGR, Hyderabad
38.	49/2019	The Netherlands	*Solanum lycopersicum*	146	Syngenta India Ltd., Aurangabad
39.	187/2019	The Netherlands	*Solanum lycopersicum*	460	Syngenta India Ltd. Aurangabad
40.	355/2018	Taiwan	*Capsicum annuum*	18	Sungro Seeds Pvt Ltd., Sonipat
41.	311/2019	USA	*Daucus carota*	29	Somani Seeds Pvt Ltd., Sonipat
				16,186	

accessions of indigenously collected seed material and multiplied material at various centres were found contaminated with 24 types of weed seeds and all these samples were salvaged by mechanical cleaning. The details of pests detected are given in Table 3.3.

Table 3.3: Pests detected in material processed for National Genebank

Pests	Host	Source/ Collection site
Insects		
Bruchus lentis	*Lens culinaris*	New Delhi, Punjab, Kerala
B. pisorum	*Pisum sativum*	Uttar Pradesh
Callosobruchus analis	*Vigna mungo*	Karnataka
C. cajanus	*Cajanus cajan*	Andhra Pradesh, Uttar Pradesh, Bihar, Gujarat, Karnataka, Telengana
C. chinensis	*Glycine max*, *V. mungo*	New Delhi
	Lablab purpureus	Gujarat
	V. radiata	Tamil Nadu, Uttar Pradesh
	V. umbellata	Meghalaya
C. maculatus	*Cicer arietinum*	Chattisgarh, Andhra Pradesh
	Macrotyloma uniflorum, *V. angularis*, *V. umbellata*	New Delhi
	Phaseolus vulgaris	New Delhi, Kerala
	V. mungo	New Delhi, Telengana, Odisha, Karnataka
	V. radiata	Karnataka, Tamil Nadu, Kerala, Odisha, Telengana
	V. unguiculata	New Delhi, Odisha, Karnataka, Kerala
	V. unguiculata ssp. *sesquipedalis*	Kerala
C. phaseoli	*P. vulgaris*	Himachal Pradesh
	C.cajan	Meghalaya
Caryedon serratus	*Zea mays*	New Delhi
Corcyra cephalonica	*Arachis hypogea*	Rajasthan
Cryptolestes ferrugenius	*Oryza sativa*	Odisha, Uttrakhand
Immature stages of insects	*C. cajan*	New Delhi, Chattisgarh, Kerala, Karnataka, Uttar Pradesh, Madhya Pradesh
	Hibiscus sabdariffa	New Delhi
	L. purpureus	New Delhi, Maharashtra, Uttrakhand, Karnataka
	L. culinaris	New Delhi, Chattisgarh, Uttar Pradesh
	M. uniflorum	New Delhi, Chattisgarh
	Pisum sativum	Uttar Pradesh, New Delhi
	Prosopis cineraria, *V. aconitifolia*	Rajasthan
	Sesbania grandiflora	New Delhi
	V. mungo	New Delhi, Tamil Nadu, Odisha, Rajasthan, Andhra Pradesh, Uttar Pradesh, Karnataka
	V. radiata	Tamil Nadu, Telengana, Odisha, Andhra Pradesh, Uttar Pradesh, Karnataka, Uttrakhand, Jammu and Kashmir
	V. unguiculata	New Delhi, Telengana, Maharashtra, Uttrakhand
Lasioderma serricorne	*C. cajan*	Kerala
Oryzaephilus surinemensis	*Chenopodium* spp.	New Delhi
Pectinophora gossypiella	*Gossypium hirsutum*	New Delhi, Rajasthan, Maharashtra

Pests	Host	Source/ Collection site
Rhizopertha dominica	*O. sativa*	Odisha, Telengana, Kerala, Andhra Pradesh, Uttar Pradesh, Chattisgarh, Tamil Nadu
	Sorghum bicolor	Telengana, Tamil Nadu
	Triticum aestivum	Maharashtra, Tamil Nadu, Gujarat
	Z. mays	New Delhi
Sitophilus oryzae	*O. sativa*	Meghalaya, Odisha, Nagaland
	T. aestivum	New Delhi, Uttrakhand
	Z. mays	Rajasthan, Uttrakhand
S. zeamais	*Z. mays*	Uttrakhand
Sitotroga cerealella	*Avena fatua*	Punjab
	Coix lacryma-jobi	New Delhi, Meghalaya
	O. sativa	West Bengal, New Delhi, Odisha, Gujarat, Bihar, Chattisgarh, Haryana, Kerala, Goa, Karnataka, Telengana, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttrakhand, Nagaland, Manipur
	Sorghum bicolor	Kerala
	T. aestivum	New Delhi
	Z. mays	Rajasthan, Uttrakhand, Gujarat
Spermophagous albofaciatus	*Abelmoschus esculentus*, *Hibiscus sabdariffa*, *H. cannabinus*	Kerala
	H. sabdariffa	Telengana
	Urena sinuata	New Delhi
Tribolium castanium	*Arachis hypogea*	Rajasthan
	Cucumis melo	Karnataka
	G hirsutum	Punjab
	Helianthus annuus, *Jatropha curcas*	Telengana
	Nigella sativa, *T. aestivum*	New Delhi
	O. sativa	Odisha, Uttrakhand, Meghalaya, Kerala
	Sesamum indicum	Kerala
Pathogen		
Acremonium strictum	*Fagopyrum esculentum*	Himachal Pradesh
Alternaria alternata	*Lolium perenne*	Himachal Pradesh
A. brassicicola	*Daucus carota*	Uttar Pradesh
	Brassica oleracea var. *botrytis*	Delhi, Uttar Pradesh
	Triticum spp.	Delhi
	Raphanus sativus	Uttar Pradesh
A. padwickii	*O. sativa, Oryza* sp.	Odisha
Alternaria sp.	*Amaranthus* sp.	Karnataka
	Solanum nigrum	Delhi
Bipolaris bicolor	*Eleusine coracana*	Kerala
B. micropus	*E. coracana*	Maharashtra
	O. sativa, Sorghum bicolor	Kerala
B. nodulosa	*Poa annua*	Telangana
B. oryzae	*O. sativa*	Delhi, Karnataka, Kerala, Meghalaya, Nagaland, Odisha, Telangana, Uttarakhand
	E. coracana	Delhi
	C. annuum	Karnataka
B. rostrata	*Setaria italica*	Delhi
	P. glaucum	Madhya Pradesh
	O. sativa	Telangana
B. sorokiniana	*O. sativa*	Odisha
	P. glaucum	Telangana
	S. bicolor	Maharashtra
	S. italica	Delhi
Bioplaris sp.	*Abelmoschus esculentus*	Kerala
	Asparagus officinalis,	Delhi

Pests	Host	Source/ Collection site
	Capsicum annuum, *Triticum* spp., *R. sativus*	
	P. glaucum	Gujarat
Botryodiplodia theobromae	*Luffa acutangula*	Delhi
	L. aegyptiaca	Maharashtra
Cercospora kikuchii	*Glycine max*	Delhi, Madhya Pradesh
Cercospora sp.	*Clitoria ternatea*	Karnataka
Colletotrichum capsici	*Benincasa hispida*	Delhi
	F. esculentum	Himachal Pradesh
	C. annuum	Delhi, Karnataka
	A. esculentus	Kerala
	G. max	Madhya Pradesh
C. gloeosporioides	*Dioscorea glabra*	A&N Island
Curvularia lunata	*P. glaucum*	Telangana
Fusarium dimerum	*O. sativa*	Kerala
F. oxysporum	*A. esculentus*	Delhi, Kerala
	A. officinalis, *C. annuum*, *S. italica*, *Trichosanthes dioica*	Delhi
	Cicer arietinum	Rajasthan
	Momordica charantia	Kerala
	O. sativa	Odisha
	Citrullus lanatus	Karnataka
F. pallidoroseum	*C. annuum*, *Solanum nigrum*	Delhi
	Vigna umbellata	Himachal Pradesh
F. solani	*O. sativa*	Odisha
	S. italica	Delhi
Fusarium sp.	*C. ternatea*	Karnataka
	Vigna unguiculata ssp. *sesquipedalis*	Kerala
F. subglutinans	*Allium victoria*, *Trichosanthes* sp., *T lupinus*	Kerala
	Basella alba, *Carthamus tinctorius*, *Sesamum mulayanum*, *Setaria italica*, *Solenum melongena*, *Triticum* spp., *Vigna ungiculata*	Delhi
	C. annuum	Karnataka
	Cajanus cajan, *Linum usitatissimum*	Gujarat
	Corchorus sp.	Goa
	Cucumis melo, *L. acutangula*	Odisha
	Cucumis sativus	Maharashtra
	G. max	Madhya Pradesh
	L. siceraria	Delhi, Odisha
	L. perenne	Himachal Pradesh
	O. sativa	Delhi, Goa, Odisha, Uttarakhand
	P. glaucum	Telangana
	Ricinus cummunis	Tamil Nadu
	S. nigrum	Andhra Pradesh
	Sesamum indicum	Rajasthan
	Triticum aestivum	Haryana
	Zea mays	Maharashtra, Telangana
Macalpinomyces sharmae	*Panicum sumatrense*	Gujarat
Macrophomina phaseolina	*Sesamum mulayanum*	Delhi
Myrothecium roridum	*Trichosanthes quinquangulata*	A&N Island
Phoma exigua	*Coix lacyma-jobi*	A&N Island
Phoma sorghina	*Capsicum annuum*, *Echinochloa* sp.	Kerala
	Cenchrus setigerus, *Perilla frutescens*	Delhi
	Cucurbita spp.	Maharashtra
	O. sativa, *P. glaucum*	Telangana
	S. italica	Karnataka
	Solanum lasiocarpum	A&N Island
	Poa annua	Telangana
Phomopsis phaseoli	*Oroxylum indicum*	Delhi
Phomopsis sp.	*O. sativa*	Odisha
Rhizoctonia solani	*Phaseolus vulgaris*	Kerala
Tilletia barclayana	*O. sativa*	Odisha, Telangana
T. indica	*Triticum* spp	Delhi
Trichothecium roseum	*O. sativa*	Odisha
Ulocladium consortiale	*V. umbellata*	Karnataka
Ustilaginoidea virens	*O. sativa*	Delhi, Telangana
Ustilago crameri	*S. italica*	Delhi
U. hordei	*Hordeum vulgare*	Haryana
Verticillium albo-atrum	*Chenopodium album*, *Cucurbita pepo*	Delhi
	O. sativa	Odisha
	S. melongena	Maharashtra
Xanthomonas campestris	*Brassica juncea* pv. *campestris*	Odisha, Rajasthan
	B. oleracea var. *botrytis*	Delhi

Pests	Host	Source/ Collection site
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andhra Pradesh, Arunachal Pradesh, Chhattisgarh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Odisha, Tamil Nadu, Telangana, West Bengal
Weeds		
Anthemis cotula	*Lepidium sativum*	Madhya Pradesh
Asphodelus tenuifolius	*Eruca sativa*	Kerala,
Brassica tournefortii	*Nigella sativa*	New Delhi
Chenopodium album	*Linum usitatisimum, T. aestivum*	New Delhi, Rajasthan
Convolvulus arvensis	*L. usitatisimum, Macrotyloma uniflorum, Spinacia oleracea*	Maharashtra, Uttar Pradesh
Echinichloa colona	*Lufa hermaphrodita, O. sativa, Vigna mungo*	Karnataka, New Delhi, Uttarakhand
Echinichloa crus-galli	*Cucumis sativus, Fagopyrum esculentum, O. sativa, Panicum milliaceum*	Maharashtra, New Delhi, Odisha, Uttarakhand
Galium aparine	*Carthamus tictorius*	Telangana
Ipomoea purpurea	*Cajanus cajan,*	Gujarat, Uttar Pradesh
Ipomoea triloba	*Cajanus cajan,*	Gujarat
Lathyrus aphaca	*T. aestivum*	New Delhi
Lathyrus sativus	*Lablab purpureus*	Odisha
Malva parviflora	*Lufa aegyptiaca*	Kerala,
Medicago denticulata	*Lens culinaris, Nigella sativa*	Chattisgarh, New Delhi
Melilotus indica	*G max T. aestivum*	Madhya Pradesh, New Delhi
Parthenium hysterophorus	*Daucus carota*	New Delhi
Phalaris minor	*Lepidium sativum, Linum usitatisimum, T. aestivum*	Madhya Pradesh, New Delhi, Rajasthan, Uttar Pradesh
Phyllanthus niruri	*Carthamus tictorius*	Telangana
Polygonium lapathifolium	*Lens culinaris*	New Delhi
Rumex crispus	*Nigella sativa, T. aestivum*	New Delhi
Setaria viridis	*Lufa cylindrica, M. uniflorum*	Maharashtra, Odisha
Sorghum halepense	*Nigella sativa*	New Delhi
Vicia hirsuta	*Lens culinaris, Linum usitatisimum, Nigella sativa*	New Delhi, Uttar Pradesh
Vicia sativa	*Coriandrum sativum, Linum sitatisimum, Nigella sativa, Trigonella foenum-graecum*	New Delhi, Uttar Pradesh

Visual/ stereoscopic examination resulted in detection of fungal (64) and viral (26) pathogens in germplasm samples which included purple stain (*Cercospora kikuchii*) in 42 soybean samples from Indore (39), Ludhiana (2) and Cachar (1) and one cowpea sample from Panchmahal. In rice, kernel smut (*Tilletia barclayana*) detected in two samples of rice from Cuttack, Odisha (1) and West Godawri, Andhra Pradesh (1) and false smut (*Ustilagenoidea virens*) in 06 samples from Guntur (2), Kokrajhar, Johat, West Godawri and Theni (1 sample each). In wheat, Karnal bunt (*Tilletia indica*) was detected in 11 samples from New Delhi and in barley, covered smut (*Ustilago hordei*) was detected in one sample from Karnal and smut (*Macalpinomyces sharmae*) in one sample of little millet from Dangs, Gujarat. In foxtail millet, smut (*Ustilago crameri*) was detected in three samples from New Delhi. In coriander, seed gall (*Protomyces macrosporus*) was detected in two samples from Gwalior. Viral symptoms included mottled seeds in soybean (26) from Indore. Out of 64 samples infected with fungal pathogens, eighteen samples including two samples of rice infected with *T. barclayana*, 11 samples of wheat infected with *T. indica*, one sample each of barley due to *U. hordei* and little millet due to *M. sharmae* and three samples of foxtail millet due to

U. crameri were rejected. Blotter test revealed detection and identification of many seed-borne fungi in 265 accessions of various crop germplasm. The important fungi detected include *Acremonium strictum*, *Alternaria brassicicola*, *Bipolaris oryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsica*, *Fusarium oxysporum*, *Fusarium solani*, *Macrophomina phaseolina*, *Phoma exigua*, *Rhizoctonia solani*, *Verticillium albo-atrum.*

A total of 2,715 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 178 samples were found infested while visual infestation of insect-pests was recorded in 949 samples. A total 1,127 samples were found infested by various insect-pests. Out of total 1,127 infested samples, 953 were salvaged by X-ray radiography (162), cold treatment (694) and mechanically (97) while 174 samples could not be salvaged hence rejected. A total of 262 samples were found infected with nematodes from fourteen different states of the country.

In addition, 136 cryo-preserved samples or for cryo-preservation were received from TCCU for seed health testing. Nine samples were found infected with different fungi and all were salvaged. A toal 53 samples were X-rayed to detect any hidden infestation of insect pests. Four samples of *Cajanus cajan* (1) and *Sesbania grandiflora* (3) were found infested by immature stages of bruchids and salvaged by X-ray radiography.

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

A total of 82 *in vitro* accessions comprising *Dioscorea* (54) and *Rubus* (28) were tested for associated viruses. Out of 54 accessions of *Dioscorea* tested for *Dioscorea latent virus* (DLV) and *Yam mosaic virus* (YMV), one accession was found infected with DLV, remaining 53 are found free from DLV; and all 54 are found free from YMV. Out of 28 accessions of *Rubus* tested for ArMV, RBDV, RpRSV, SLRV, SMYEV and ToRSV, 4 accessions were found to be infected with RpRSV, SMYEV, TBRV and ToRSV and 24 were found free from 6 viruses tested.

3.5 Supportive research

3.5.1 Broken bones tree – a new host record of *Phomopsis phaseoli*: During seed health testing of broken bones tree (*Oroxylum indicum*) collected during 2018 from Kokrajhar, Assam with Latitude (N) 26° 36.960[1], Longitude (E) 89° 54.234[1], some fungal growth in the form of ostiolate black pycnidial fruiting bodies was observed on seed surface (i.e. PKG/18-34) using blotter test (Fig. 3.4a). Stereoscopic observation revealed extrusion of two types of hyaline and non-septate conidia, namely alpha (α) and beta (β) conidia in the form of a gelatinous cirrus (Fig. 3.4b). The characteristics associated with morphology of α and β conidia were

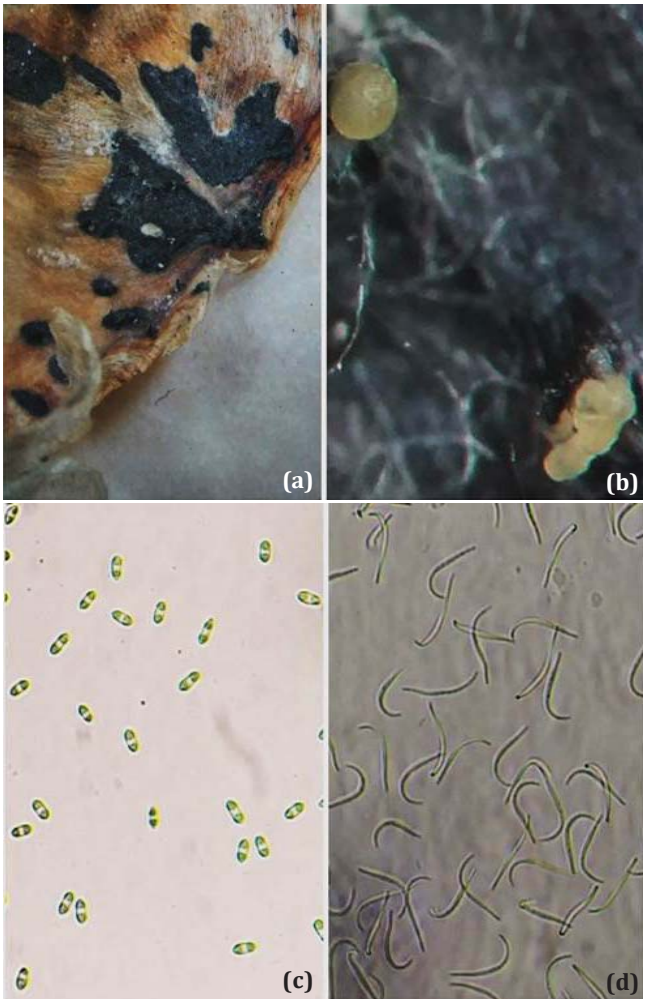


Fig. 3.4. *Phomopsis phaseoli* infected seed of broken bones tree showing fungal growth on surface (a), gelatinous cirrus (b) and morphology of α conidia (c) and β conidia (d)

observed during compound microscopic examination. The a conidia were aseptate, ellipsoidal and bi-guttulate measuring dimension 5-8 x 2-3 µm (Fig. 1c), whereas, b conidia were also aseptate and hyaline, but filiform, hooked and lack guttulae measuring dimension 18-20 x 1-2 µm (Fig. 3.4d) and the fungus was identified as *Phomopsis phaseoli* (Tel.: *Diaporthe phaseolorum*), which is a destructive pathogen causing severe yield losses in various host crops and the identity of the fungus was confirmed through ITS sequencing (NCBI Accession ID MT154253). The association of *P. phaseoli* with broken bones tree is a new host record.

3.5.2 Infection indexing and distribution profiling of seed-borne fungi of sorghum germplasm in India: Studies on infection indexing and distribution profiling of seed-borne fungi of sorghum germplasm from seventeen states of India revealed the presence of a total of 43 species belonging to 23 genera of fungi. Based on average infection index, *Fusarium verticillioides* (26.3 ±21.0), *Exserohilum rostratum* (21.3 ±17.9), *Alternaria alternata* (19.3 ±15.1), *Aspergillus flavus* (18.2 ±10.3), *Bipolaris sorghicola* (16.7 ±9.571), *A. niger* (14.4 ±7.4), *Fusarium semitectum* (15.4 ±10.7%), *Curvularia lunata* (11.5 ±8.5), *Colletotrichum sublineolum* (15.8 ±9.3) and *Phoma sorghina* (14.5 ±13.0) recorded as dominant species causing grain mould of sorghum in different agro-climatic zones of India and also affecting seed germination significantly. Among dominant species, *F. verticillioides*, *A. alternata* and *E. rostratum* were recorded with highest average infection index from Karanataka and *Aspergillus flavus* from Telangana representing Southern Plateau & Hills zone. Whereas, *A. niger, C. lunata F. semitectum*, *P. sorghina* and *C. graminicola* were recorded with highest infection index from Maharashtra representing 2 agro-climatic zones of the country i.e. Western Plateau & Hills and West-coast Plains & Ghats. The presence of so many pathogenic fungi with higher infection index in sorghum seeds from different agro-climatic zones indicates that there is urgent need to develop appropriate management strategies to reduce the risk of storage loss and mycotoxin production by these fungi.

3.5.3 Development of multiplex PCR for simultaneous detection of *Alternaria brassicae*, *Alternaria brassicicola* and *Xanthomonas campestris* pv. *campestris*: Alternaria leaf spots of oilseed brassicas caused by fungi, *Alternaria brassicae* and *A. brassicicola.* Black rot of crucifers caused by bacterium, *Xanthomonas campestris* pv. *campestris* are major limiting factors in oilseed brassicas across the world. A set of primers namely, AbeABC1F and AbeABC1R based on *ABC transporter* (*Atr1*) gene for *A. brassicae*, Aba28sF and Aba28sR based on SSR marker was developed for *A. brassicicola*, whereas, *rpf* region based primers namely, rpfH_F and rpfH_R were used for *X. campestris* pv. *campestris* for simultaneous and rapid detection of all three pathogens in a single reaction. The specific bands of 586 bp for *A. brassicae*, 201 bp for *A. brassicicola* and 304 bp for *X. campestris* pv. *campestris* were obtained in multiplex PCR assay (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 100 pg ml^{-1} of template DNA of all the three pathogens.

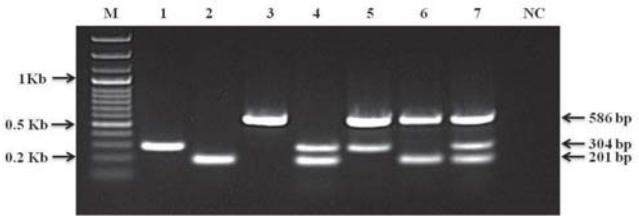


Fig. 3.5. Detection of *X. c.* pv. *campestris, A. brassicicola* and *A. brassicae* using multiplex PCR with three sets of specific primers. Lane M- 100 bp plus DNA ladder; Lane 1- *X. campestris* pv. *campestris* (304 bp), Lane 2– *A. brassicicola* (201 bp), Lane 3– *A. brassicae* (586 bp), Lane 4- *X. c.* pv. *campestris* + *A. brassicicola,* Lane 5- *X. campestris* pv. *campestris* + *A. brassicae*, Lane 6- *A. brassicicola* + *A. brassicae*, Lane 7- *X. c.* pv. *campestris* + *A. brassicicola* + *A. brassicae*, Lane NC- Negative control

3.5.4 Development of duplex PCR for simultaneous detection of *Alternaria padwickii* and *Bipolaris oryzae* infecting rice: *Alternaria padwickii* and *Bipolaris oryzae* are fungal pathogens causing stackburn and brown spot disease of rice, respectively and results in considerable yield losses across the world. A set of primers namely BoSP7-F and BoSP7-R designed from *B. oryzae* ATCC 44560

unplaced genomic scaffold scaffold_136 whereas ApEF-1F and ApEF-1R were designed from elongation factor 1 region of *A. padwickii*. The specific bands of 175 bp for *A. padwickii* and 325 bp for *B. oryzae* were obtained in multiplex PCR (Fig. 3.6). The detection sensitivity of the primer pairs were performed by dilution of genomic DNA and results revealed that it could detect up to 0.1 ng ml^{-1} of template DNA of both the pathogens.

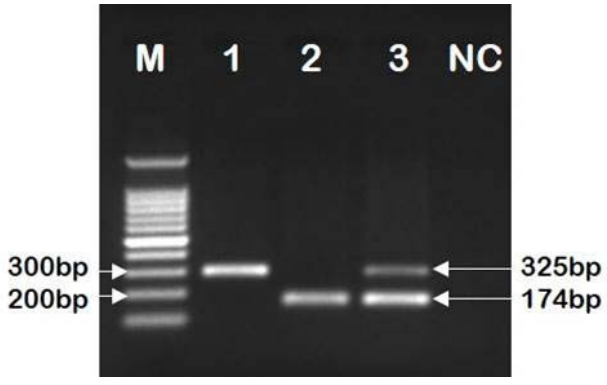


Fig. 3.6. Detection of *A. padwickii* and *B. oryzae* using multiplex PCR with two sets of specific primers. Lane M- 100 bp plus DNA ladder; Lanes 1- *B. oryzae*, 2– *A. padwickii*, 3– *B. oryzae*, and *A. padwickii*, lane NC- Negative control

3.5.5 Molecular identification and characterization of phytoplasmas associated with sesame phyllody in India: Nested PCR amplifications of 16S rRNA gene with the phytoplasma-specific universal primers P1/P7 and R16F2n/R2, respectively were used for identification of the phytoplasmas associated with sesame phyllody. Phytoplasma specific PCR amplicons of 1.8 kb and 1.25 kb were amplified only from symptomatic sesame plants and insect vector i.e. leaf hopper (*Orosius albicinctus*) samples using nested PCR (Fig. 3.7). Sequencing of the PCR amplicons and computer simulated restriction fragment length polymorphism analysis allowed classification of the phytoplasmas with 'Candidatus Phytoplasma asteris' (16SrI-B) group. The sequence homology of 99.8% with reference strain (GenBank accession: M30790) further confirmed this classification.

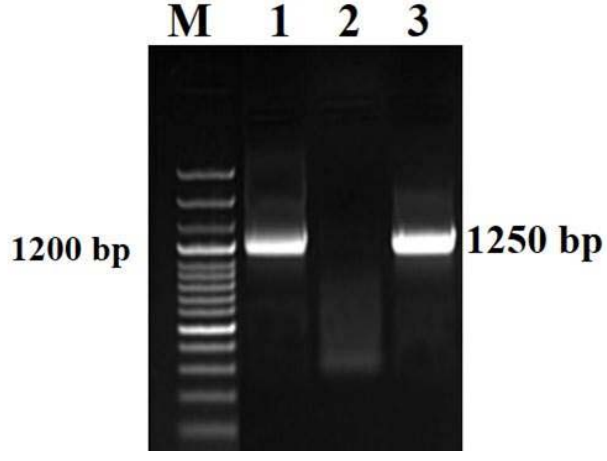


Fig. 3.7. Nested PCR of phytoplasma DNA amplification from sesame, and leafhopper with primer pair R16R2n/R16F2n. Lane M: Marker 100 bp plus DNA ladder, lane 1: Sesame phyllody infected leaf, lane 2: Negative control, lane 3: Leaf-hopper

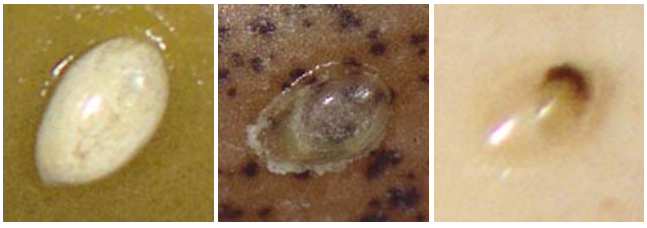
3.5.6 Screening of sesame germplasm against phyllody disease caused by Phytoplasma: A total of 306 accessions of sesame germplasm have been evaluated against phytoplasma under field conditions. Association of phyllody with phytoplasma has been confirmed using nested PCR. A total of 255 accessions were found free from phyllody. Also, transmission of phytolasma from sesame to *Catharanthus roseus* was successful using dodder and association of phytoplasma in *C. roseus* has been confirmed using nested PCR.

3.5.7 Screening of cowpea germplasm against yellow mosaic disease: A total of 3,703 accessions of cowpea were screened against yellow mosaic disease under natural field conditions. A total of 2,460 accessions were found highly resistant and are free from symptoms. A total of 500 accessions were found to be highly susceptible to yellow mosaic disease.

3.5.8 Screening of germplasm against *Bean common mosaic virus*: A total of 65 greengram accessions along with susceptible and resistant check were screened against BCMV under artificial conditions. Electron microscopy (EM) revealed the flexuous rod viral particles of 823nm. RT-PCR protocol was standardized for BCMV detection. Among the 65 accessions screened, 50 accessions were found to be immune, four accessions resistant, two accessions moderately resistant, three accessions susceptible and six accessions highly susceptible to BCMV. A total of 50 accessions were found to be immune to the BCMV, which did not show

any symptoms and EM, DAC-ELISA and RT-PCR also did not detect BCMV. Further, DAC-ELISA of seed coat and embryo of 65 accessions revealed the presence of BCMV in seed coat (27) and embryo (6) including 21 accessions found immune in the natural and artificial condition indicating susceptibility to BCMV. Therefore, 29 accessions were found to be immune to BCMV.

3.5.9 Effect of different pulses on the biology and relative growth rate of *Callosobruchus chinensis:* When *C. chinensis* fed on different pulses, different color pattern of egg, larva and pupa were noticed (Figs. 3.8- 3.10).



a. Green gram b. Lentil c. Cowpea

Fig. 3.8. Colour pattern of eggs of *C. chinensis* fed on green gram (a), lentil (b) and cowpea (c)

a. Green gram b. Lentil c. Cowpea

Fig. 3.9. Colour pattern of larva of *C. chinensis* fed on green gram (a), lentil (b) and cowpea (c)

a. Green gram b. Lentil c. Cowpea

Fig. 3.10. Colour pattern of pupa of *C. chinensis* fed on green gram (a), lentil (b) and cowpea (c)

The developmental period from egg to adult emergence and adult longevity of *C. chinensis* on green gram, lentil and cowpea was recorded. Incubation period ranged from 3.68 to 4.53 days on various pulses. Green gram recorded the longest period of larva (15.14 days) than cowpea (13.88 days). The pupal period ranged from 6.52 to 7.12 days. The average overall development period was highest on green gram (26.76 days). The female and male longevities ranged from 5.33 to 7.14 days and 5.00 to 6.14 days, respectively. Data on developmental period of various insect stages , longevity and oviposition periods was recorded and statistically analysed. Interaction data determined with the combined bootstrap test (P<0.05). Standard errors were predicted using 100000 bootstraps.

3.5.10 DNA bar code and amplification of cytochrome oxidase I gene from *Callosobruchus chinensis* and *C. maculatus:* *Callosobruchus chinensis* and *C. maculatus* got amplified by *COI* primer (Fig. 3.11). A band of approximately 710bp was obtained from them. To conclude the phylogenetic relationship between *C. chinensis* and other sequences of *C. chinensis* and *C. maculatus* and other sequences of *C. maculatus*, the COX gene region was analyzed. When alignment gaps were added, 682 bases of *C. chinensis* and 683 bases of *C. maculatus* were analyzed. DNA barcode for *C. chinensis* and *C. maculatus* were developed.

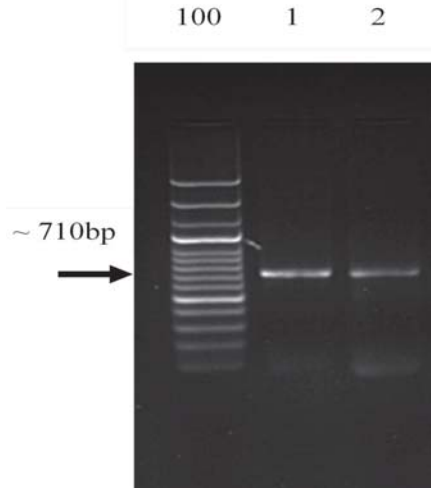


Fig. 3.11. COI 1 profiles of *Callosobruchus chinensis* (1) and *Callosobruchus maculatus* (2) analyzed with primer C1J 2183 and L2N 3014

3.5.11 Evaluation of non-edible oils against *Callosobruchus chinensis:* Hundred percent egg mortality was noticed in all non-edible oils such as *Pongamia glabra* oil, *Hydnocarpus wightiana* oil,

Madhuca longifolia oil, *Callophyllum inophyllum* oil, and *Azadirachta indica* oil compared to control (F = 6003.95; df = 5,18; P < 0.001). Similarly, all non-edible oils had ovipositional deterrence as compared to control (F = 126.140; df = 5,18; P < 0.001). All non-edible oils caused hundred percent larval (F = 6241.00; df = 5,18; P < 0.001) and adult mortality (F = 5525.82; df = 5,18; P < 0.001) than control.

3.5.12 Screening of vegetable crops for resistance to root-knot nematode, *Meloidogyne incognita:* To find the source of resistance against *M. incognita*, 350 accessions of various vegetable crops (table 1) were evaluated in pots filled with soil-sand mixture (500g). Each plant was inoculated with one thousand second stage juveniles of *M. incognita*. Plants were uprooted after 45 days of inoculation, root galls were counted and reaction of each accession assessed based on number of root galls induced. The plants with less than 10 galls per plant were considered as resistant. The details are as-

Crop	No. of accessions screened	Resistant accessions
Brinjal	200	IC253963A, IC260115
Okra	50	EC360927, EC360672
Cucumber	100	Nil

3.5.13 Nematicidal properties of *Flemingia procumbens* against *Meloidogyne incognita:* Nematicidal property was identified for the first time in root tubers of *Flemingia procumbens*, an underutilized native crop species grown in the tribal tracts of Khasi and Jaintia hills of Meghalaya, India. *In vitro* studies were conducted on second stage juveniles (J2s) of root-knot nematode, *Meloidogyne incognita,* which is a most economically important and commonly found nematode in cultivated fields. Powder extract of small, medium and large size tubers of *F. procumbens* was tested *in vitro* against J2s of *M. incognita*. All the three types of powder extracts were found effective and caused varied mortality in J2s of *M. incognita* in the range of 88-95%. The methodology developed is based on preliminary study and can be standardized for precision following further research investigations.

Fig. 3.12. Root galls on resistant brinjal accession IC253963A

Fig. 3.13. Root galls on susceptible brinjal variety Pusa Purple Long

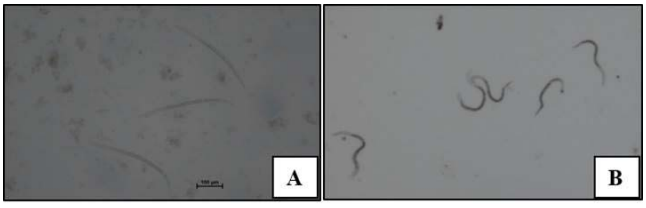


Fig. 3.14. Effect of Soh-phlong powder extract on J2s of *M. incognita*. A: Dead J2s in soh-phlong extract treatment. B: Live and active nematode in control treatment with active movement

3.5.14 Study of weeds problems in wheat germplasm: A phytosociological survey of weeds was conducted to check the severity of competition in wheat crop in New Delhi. A total of 20 weed species belonging to 18 genera and 11 families were recorded from the area under investigation. Two weed communities viz., *Phalaris-Emex-Avena* in Issapur and *Phalaris-Chenopodium-Avena* in Post Entry Quarantine Nursery (PEQN) were determined during this period. The dominant weed species among these communities were *Avena fatua, Chenopodium album, Cirsium arvense, Melilotus indica* and *Emex australis*. *Phalaris minor* was found as the most dominant and frequent weed species with IVI of 52.25 and frequency percentage of 87. The other weeds like *Asphodelus tenuifolius*, *Chenopodium murale, Cynodon dactylon, Cyperus rotundus, Lathyrus aphaca* and *Emex australis* were frequent with frequency percentage ranging from 42-58. *Emex australis* is proposed as a new emerging weed in wheat crop in the study area. This weed species has not been reported earlier as a weed in wheat crop.

3.5.15 Potential quarantine pests for India in solanaceous and cucurbitaceous vegetables: Information on insects, mites, fungi, bacteria, viruses, viroids phytoplasma and weeds of solenaceous and cucurbitaceous vegetables is being compiled on the parameters *viz.*, scientific name of the pest/

synonym(s), order/ family, pathway of introduction, host range, geographical distribution, economic losses/ physiological variation and phytosanitary risk.

3.6 Externally funded projects

3.6.1 National containment/ quarantine facility for transgenic planting material (DBT): With the approval of RCGM, 44 samples of imported transgenic planting material were received for quarantine clearance comprising of *Gossypium hirsutum* (20) from France for Bioseeds Pvt Ltd., Hyderabad; *Oryza sativa* (19) from USA for Punjab Agricultural university, Ludhiana; *Zea mays* (5) from the Phillipines for Syngenta India Pvt ltd., Pune and from USA for Monsanto Pvt Ltd., Bangalore. However, *Gossypium hirsutum* (20) from France for Bioseeds Pvt Ltd., Hyderabad has not been processed due to issue with number of samples. Therefore, 24 samples were processed for quarantine clearance and released to the indenters.

Seeds from imported consignment of transgenic *Zea mays* (3) from the Philippines for Pioneer Hibred Pvt. Ltd., Medak District were grown in the containment facility for 45 days for detection of seed-transmitted pests not detectable in the laboratory tests. On the basis of observations at regular intervals suspected leaf samples were tested in the laboratory for the presence of various pests. The plants were uprooted after 45 days of growing in the Containment Facility. These were disposed off in the presence of members of Institutional Biosafety Committee (IBSC) of ICAR-NBPGR as per biosafety guidelines of DBT.

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

Two post-entry quarantine inspections were undertaken for *Zea mays* from the Philippines grown at Syngenta Pvt Ltd., Aurangabad (04 samples). The crops were visually inspected for symptoms of pests/ diseases. Suspected infected leaf and soil samples were tested. *Z. mays* leaves showing virus-like symptoms were tested at ICAR-NBPGR against five viruses using ELISA. Further, samples were found to be free from exotic fungi, bacteria, viruses, nematodes and insect pests.

Ninteen samples of *O. sativa* from the USA were found infected with *Bipolaris oryzae and F. verticillioides* and infected samples were salvaged by giving fungicidal treatment with Bavistin and Dithane M45.

Maize leaves showing virus-like symptoms during growing in containment facility and PEQ inspection were tested against five viruses using ELISA. None of the samples showed the presence of five viruses tested.

Major pests which may accompany the seeds of *Gossypium hirsutum* from France; *Oryza sativa* from USA and *Zea mays* from the Philippines and not yet reported from India were listed by studying the available literature.

A total of 153 transgenic samples of *Arabidopsis thaliana* have been exported to USA for E.I Dupont India Pvt Ltd. Phytosanitary certificate was issued as per requirement of USA

3.6.2 Development of DNA barcode and multiplex PCR based diagnostics for detection of nationally important seed borne fungal pathogens of major pulse crops for safe exchange and conservation (DBT): Several gene specific primers were developed and used for amplification of gene specific regions of the major fungal pathogens for healthy germplasm exchange and conservation of pulse crops. The specific, highly sensitive and reliable conventional and real-time PCR assays were developed for diagnosis of the pathogens namely, *Alternaria alternata, Rhizoctonia solani and Fusarium oxysporum* f. sp. *ciceris* associated with the pulse crops.

Universal internal transcribed spacer (ITS) region based markers namely, BAA2aF & BAA2aR for *A. alternata* and BRS17cF & BRS17cR for *R. solani* were developed and amplified 400bp and 200bp species specific amplicons, respectively. Whereas, COX II region based marker FOCox1F & FOCox3R was developed for *F. oxysporum* f. sp. *ciceris* with

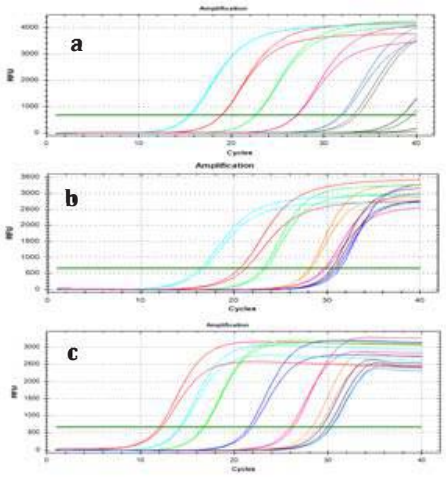


Fig. 3.15. Amplification plot generated by marker specific to genomic DNA of *Rhizoctonia solani* (a), *Alternaria alternate* (b) and *Fusarium oxysporum* f.sp. *ciceris* (c) at different concentrations (100 ng, 10 ng, 1 ng, 0.1 ng, 0.01 ng, 0.001 ng, 0.0001 ng)

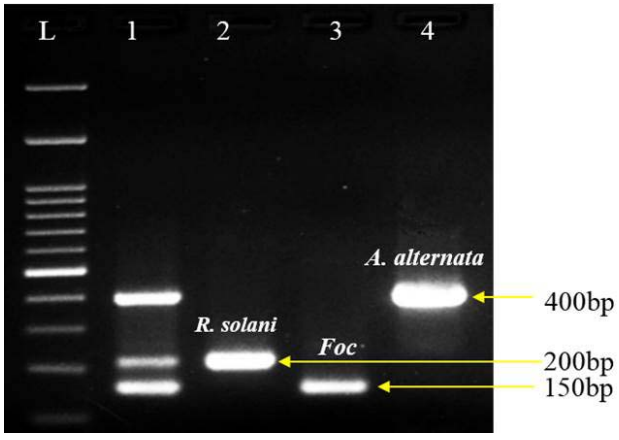


Fig. 3.16. Amplification of three different fungal pathogens using multiplex PCR using ITS based designed marker BRS17cF and BRS17cR for *R. solani*, BAA2aF and BAA2aR for *A. alternata* and COX II region based designed marker FOCox1F and FOCox3R for *F. oxysporum* f.sp. *ciceris*. Lanes L= Ladder, 1= *Rhizoctonia solani*, *F. oxysporum* f.sp. *ciceris* and *A. alternata* 2= *R. solani*, 3= *F. oxysporum* f.sp. *ciceris*, 4= *A.alternata*

amplicon size of 150 bp (Fig 3.15). All the markers proved to be highly specific and sensitive and are able to detect up to 0.0001 ng template DNA using qPCR (Fig 3.16). The highly sensitive, specific and reliable conventional and multiplex PCR assay was developed for diagnosis of these three pathogens simultaneously. Other gene sequences namely, small ribosomal subunit (SSU), large ribosomal subunit (LSU), b-tubulin, TEF-alpha are being used to design primers for development of molecular markers.

Research Programme (Code: Title, **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**, Meena Shekhar, 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** 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**, SP Singh, T Boopathi 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** 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**, Meena Shekhar, Kavita Gupta, Z Khan, Jameel Akhtar, T Boopathi, Bharat H Gawade, Pardeep Kumar, Raj Kiran, *Ashok Kumar Maurya* and *DS Meena*).

PGR/PQR-BUR-DEL-01.07: Quarantine processing of imported transgenic germplasm and supportive (**V Celia Chalam,** Kavita Gupta, Z Khan, Jameel Akhtar, *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, Meena Shekhar, V Celia Chalam, Kavita Gupta, MC Singh, SP Singh, Z Khan, T Boopathi, Bharat H Gawade, Pardeep Kumar, Raj Kiran, Veena Gupta, Sushil Pandey, Sandhya Gupta, *Ashok Kumar Maurya, DS Meena* and *Smita Lenka Jain*).

DIVISION OF GERMPLASM EVALUATION 4

Summary: During 2019, a total of 16,716 accessions of various agri-horticultural crops were characterized / evaluated/ regenerated and multiplied. For evaluation against biotic stresses, 58 promising wheat accessions were screened for Karnal bunt and Spot blotch disease under controlled conditon. 18 accessions of wild brinjal germplasm along with six accessions of *S. melongena* were evaluated for brinjal fruit & shoot borer (FSB). Four promising accessions of *Solanum incanum* were retested for fruit and shoot borer. In addition, 762 accessions of pulses/crops were evaluated for root-knot nematode resistance. Evaluation for abiotic stresses was undertaken in 893 accessions comprising wheat (443 acc.),barley (220 acc.) and lentil (150 acc.) against drought and mungbean (80 acc.) against heat stress. Quality parameters for 1,239 accessions comprising rice (180), wheat (100), barley (286), maize (45), linseed (218) and fruit tree (37) were studied. In medicinal and aromatic plants, 189 accessions were evaluated for various phyto-chemical constituents. Under CRP on Agro-biodiversity, a total of 2,650 accessions comprising rice (1,022), wheat (917), chickpea (300) and okra (411) were evaluated at AICRP centres/hotspots for biotic and abiotic stresses. Three germplasm field days on major crops were organized to facilitate germplasm utilization and 4,863 accessions of various crops were supplied to 85 indenters for its use in crop improvement.

4.1 Germplasm evaluation

4.1.1 Characterization and preliminary evaluation for agro-morphological traits: A total of 16,716 accessions comprising wheat (1,780), barley (688), maize (302), lentil (2,314), cowpea (4,433), ricebean (1,760), *Brassica* (784), sesame (696), linseed (2,567), pea (320), okra (411), brinjal (24), chilli (350),carrot (50), amaranth (100), fababean (40),*Chenopodium*(46) and *Ocimum* (51) were characterized for agro-morphological traits (Fig. 4.1) and promising accessions have been identified (Table 4.1). Indigenous wheat landrace (1,780 accessions) belonging to *T. aestivum*, *T. durum*, *T. dicoccum* species were grown for characterization and evaluation and good variability was recorded for phenology, plant height, biomass, tillers and spike traits. Entire collection of linseed germplasm (2,567 accessions) conserved at National Genebank was grown for characterization and preliminary evaluation based on agro-morphological and phenological traits (Fig. 4.2). Broad variability was recorded for plant height, flower colour, flower shape, corolla aestivation, capsule size and seed colour (Fig. 4.3). A core set of 688 barley accessions was developed from entire germplasm collection of 6,788 accessions characterized on the basis of 19 agro-morphological traits during *Rabi* 2016-2018 using CoreHunter3 software. The core constituted 521 six-rowed (*H. vulgare ssp. hexastichum)*, 157 two-rowed *(H. vulgare ssp. distichum)* and 10 wild

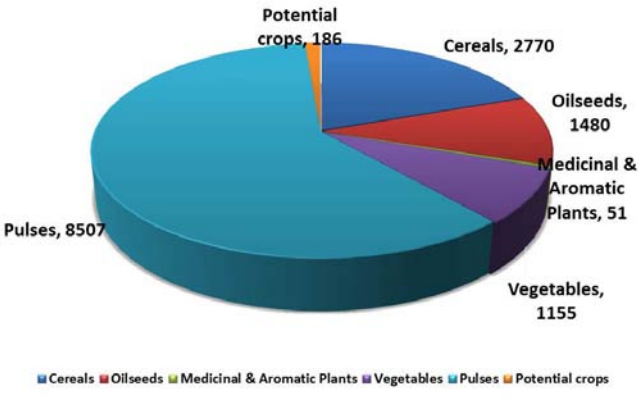


Fig. 4.1. Accessions characterized / evaluated in various crop groups during 2019

Fig. 4.2. Field view of characterization of linseed germplasm

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

Crop	Characters	Promising accessions
Wheat	Days to spike emergence (< 84)	IC0397815, IC0582729, IC0078990, IC0573157, IC0335973, IC0335976, IC0427140, IC0335964, IC0336014, IC0336026
	Grains per spike (> 80)	IC0281566, IC0260880, IC0356084, IC0315921, IC0595392, IC0406547, IC0260888, IC0539317, IC0539314, IC0279753
	1000 grain weight (>60g)	IC0298486, IC0402066, IC0381144, IC0554659, IC0539314, IC0396588, IC0402022, IC0539316, IC0329600
T. durum	Days to spike emergence (< 86)	IC0277754, IC0375867, IC0335932, IC0335938, IC0335952, IC0375878, IC0617422, IC0336001, IC0336013, IC0335941
	Grains per spike (> 67)	IC0614994, IC0539331, IC0138350, IC0539330, IC0138353, IC0138344, IC0138355, IC0138352, IC0138335, IC0138345
	1000 grain weight (>54g)	IC0321846, IC0138340, IC0614989, IC0277752, IC0277749, IC0138366, IC0128220, IC0321982, IC0384526, IC0128226, IC0138355
T. dicoccum	Days to spike emergence (< 94)	IC0335962, IC0277712, IC0277713, IC0545113, IC0545094, IC0138418, IC0402012, IC0402018
	Grains per spike (> 40)	IC0402020, IC0584049, IC0402012, IC0402018, IC0402043, IC0402019, IC0448026
	1000 grain weight (>40g)	IC0138418, IC0584049, IC0335962, IC0402019, IC0402020, IC0277713, IC0402012, IC0448026
Barley	Days to spike emergence (<60 days)	IC0138110, IC0138116, IC0138118, EC0578946, IC0137999, EC0578711, EC0578717, IC0113045, EC0362267, C0578792
	Days to maturity (<120 days)	EC0578370, IC0445542, IC0138109, IC0138114, IC0138110, IC0138115, IC0138116, IC0138119, IC0138120, IC0138121, IC0445928, IC0420720, EC0362237, IC0138294, IC328951
	Spike length (>12 cm)	IC0118656, IC0533203, EC578292
	Hundred-grain weight (>5.5 g)	IC0405269, IC0551372, EC0492252, EC0520242, IC0138120, IC0138111, IC0542197
Maize	Days to tassel (< 44)	IC0624767, IC0624766, IC0624765, IC0624910, IC0624911, IC0624912, IC253992, IC283431, IC0624908, IC0624916
	100 seed weight(> 31 g)	IC549904
	Plant height (<93 cm)	IC568703, IC253978, IC254010, IC254023, IC213120, IC254020, IC254017, IC254018, IC568701
	No. of ears/plant (>2)	IC200249, IC623955-1, IC656106, IC220226, IC253987, IC254014, IC624069-1
	Waxy type/high amylopectin	IC623954-1, IC623955-1, IC624018, IC624033, IC625138, IC625131
	Oil content(>6%)	IC623993, IC624054, IC623967, IC623978, IC624069-1, IC524524
	High resistant starch type (6.06%)	IC328587
Brassica juncea	Dwarf habit (<76 cm)	IC422028 , IC343199, EC766127 IC347947, IC491641
	Early maturing (<98days)	IC20167 (71), EC501610 (72), IC343199 (80), IC589691 (91), EC766320 (91), IC426386 (92),IC266266 (92), IC426394 (94)
	No. of silique on main branch (>81)	EC367885 (173.7), IC491077 (110), IC266810 (92)
	Seeds/siliqua (>30)	IC426322 (40), EC634284 (39), EC634281 (39), IC20167 (35)
	100 seed wt. (g)	IC491353,(6.7) IC491067,(6.6) EC766257 (6.6), EC766584 (6.5), EC766623 (6.3)
B. napus	Oil content (>43%)	IC422156 (44.0%), IC422172 (43.87%), IC422161 (43.42%), IC491485 (43.32%), IC491455 (43.29%)
	Dwarf habit (<99 cm)	IC4399682 (88.9), EC620098 (98.9 cm)
	Early maturity (<135 days)	IC 399682 (131), IC 399684 (132), EC 657036 (135)
	Seed/siliqua (>40)	EC338973 (24), IC657058 (23), IC620103 (23), EC271582(22.7)
	No. of silique on main branch (>90)	EC302448 (95), EC400804 (92), EC339016(91), EC339004 (90)

Crop	Characters	Promising accessions
Sesame	Capsule/plant(>150)	IC500789 (195), IC232271 (194), IC23309 (157), IC500847 (153)
	Seeds/ capsule (>65)	IC41945 (96), IC500996 (66), IC500944 (66)
	Capsule/nod (>5)	IC205312 (6), IC500968-1 (5)
	Locule no./capsule (>15)	IC132182 (20), IC204639 (18), IC43144-1 (16)
	Oil content (>50%)	IC43178-1 (55.61%), IC42999 (54.42%), IC43116 (54.39%), IC17476-1 (54.38%), IC54035 (54.09%), IC132489 (54.02%)
Linseed	Days to 50 % flowering (<60 days)	IC0096511, IC0096496, EC0012538, EC0000526, IC0267547, IC0096611, IC0096648, IC0118906, IC0498678, IC0096627
	Early maturity(<125 days)	IC0096490, IC0621688, IC0526057, IC0526058, IC0526064, IC0526102, IC0498426, IC0096725, IC0498473, IC0096499, IC0498928
	Tall plant height (>100 cm)	EC0718830, EC0718842, IC0526021, IC0526029, IC0526030
	Number of capsules/plant (>400)	IC0268341, IC0384577, IC0498567, IC0498588, IC0498598, IC0498722, IC0498756
	Primary branches/plant (>10)	IC0053298, IC0384577, IC0342142, IC0199754, IC0267676, IC0498466, IC0498722
	Seed yield/plant (>20 g)	IC0305055, IC0385765, IC0498787, IC0498722, IC0498537, IC0498549, IC0498574, IC0498778, IC0498794
Lentil	Early flowering (<50 days)	IC241532, IC241533, EC223238, EC223237A, EC78528, EC78477C, IC620659, EC955431
	Number of secondary branches (>52) & Pods/plant (>300)	IC118930, IC201716, NC60969, IC282828
	100 seed weight (> 6 g)	EC927418, EC499760
	Mechanical harvesting (Pod setting above 15cm from ground)	IC240885, IC240886, IC241144, EC267615, EC267697
	Erect type	IC201557, IC201580, IC366159, IC240885, IC240886, IC620659
	Number of pods/ cluster (>5)	IC241473(6-8),EC795516, ILL5588
	Rust resistant (Score 1)	EC 223235, EC 225452, IC 212688, IC 231785 and IC 241249
	Alternaria blight resistant	EC866132, IC267667, IC201778
	Nematode resistant	EC267631, IC560123
Cowpea	Early flowering (<35 days)	EC240917(26), EC240850 (32), EC366776, EC701965, EC724439, EC724452, IC20561, IC610398, IC548860
	Early maturity (< 60 days)	EC240917, EC240920, EC472253, EC458484, EC528382, EC517140, IC20561, IC610398
	Multiple pods (>4)	EC724658, EC724697, EC724700, EC769229, EC724054, EC725111, EC725120, EC242428-2
	Erect type	EC724365, EC12059, EC101997, EC240765, EC244396, EC240977-A, EC240664, GP290/03
	100 seed weight (>25 g)	IC599262 (30.74g), EC99573(28.30g), EC244164, EC99573, EC244080
	Narrow leaves	EC723682, EC723867, IC402099
	High pods/plant	IC73067, IC20886
	Long peduncle length (>35 cm)	EC284275(>50), EC394695 (45) EC244322, EC244203
	Fodder type	IC201077, IC202881, EC724744, EC724746, EC724374, EC240890
	Pubescent & bruchid resistant	EC762384
	Coil shape	EC725102
	Stay green	IC202701
	Nematode resistant	EC723870, EC724441, IC406512, IC550300
Chickpea	Erectness	IC244173, IC116431, EC267301
	Plant height (cm)	IC327373 (77.75), EC267301 (70.75), ICC3992 (68)
	High no. of primary branches/plant	ICC3905 (17.25), IC327373 (17.25)
	Pods/plant	IC327282 (271.25)
	100 seed weight (g)	EC412946 (30.6)
	Early flowering (days)	IC1176651 (88), IC327570 (88)

Crop	Characters	Promising accessions
Chilli	Earliness	EC772729, EC787141 (*C. chinense*)
	Flowers per inflorescence (>5)	EC769386, EC769423, EC772705
	Paprika type	EC772739, EC7727297, EC692287
	Resistant to ChilLCD	EC772732, EC772739 EC928983, EC769434, EC773729, EC920855, EC915030, EC769427, EC787141 (*C. chinense*)
	Resistant to ChilLCD, Mites,	EC769423, EC787119, EC769386, EC769388, EC771555, EC790590 (*C. tovari*), EC772791 (*C. baccatum* var. *pendulum*)
	Heat tolerance	EC772769 (*C. annuum* var. *grossum*)
	Climate smart genotype	EC692286, EC769448, EC772772
Pea	Earliness	IC356187, IC317547, EC598608
	High number of pods/Plant	EC269586, EC269578
	pod weight/plant	EC865999, IC427145, IC278701
	No. of seed /pod	EC387624, EC269301, IC346094
	1000 seed weight (>50g).	IC415499, EC598574, EC387634
Ricebean	Days to 50% flowering (days)	IC351514 (42), IC137161 (43), IC469197 (45), IC116118 (45), IC137156 (45), IC200064 (45), IC469177 (45), IC469185 (45), IC557727 (45), IC469185 (45), Ic469197 (45), IC351508 (45), IC298091 (45), IC341995 (48), IC469197 (48), EC10887-1 (48), EC114123 (48), EC269773 (48), IC129069 (48), IC129123 (48), IC137179 (48), IC146271 (48)
	Early maturity (days)	IC137161 (68), IC351514 (70), IC116118 (70), IC137156 (70), IC200064 (70), IC469177 (70), IC469185 (70), IC557727 (70), IC129069 (70), IC129123 (70), IC146271 (70),IC137179 (75), IC469185 (75), Ic469197 (75), IC351508 (75), IC298091 (75), IC341995 (75), IC469197 (75), IC469197 (75), EC114123 (75)
	Pod length (cm)	IC521177 (11.8), EC18565 (11.5), IC521146 (11.3), IC521063 (10.9)
	No. of grains/pod	IC521177 (12.3), IC521145 (11.7), IC521106 (11.3), IC521169 (11), IC520932 (10.3), IC520927 (10), IC520967 (10.7), IC521091 (10.7), IC521130 (10.7)
Grain amaranth	Inflorescence length (cm)	IC356046, IC444105, IC361327 (>78)
	No. of branches per plant	IC356046, IC436953, IC469837, IC279512, IC340823, IC317427, IC266812, IC436957, IC266778 (>8.00),
	Plant height (cm)Tak type	IC444105, IC356046, IC317427 (>120), IC356023, IC337341, IC469777, IC317549 (<56)
	Lateral spikelet length (cm)	IC356046, IC444105, IC266812, IC436974, IC279363, IC524215 (>51.00)
	Seed volume weight (g/ 10 ml)	IC469858, IC444099, IC506604, IC506605 (>7.00)
	Seed yield per plant (g)	IC436953, IC506611, IC506528, IC469858, IC506529, IC506520, IC506531 (>20.00)
Fababean (Grain)	Plant height (cm)	ET218765 (124.8)
	No. of pods per plant	ET218778 (40.60)
	No. of seeds per pod	ET218712, ET218770, ET218772, ET218764, ET218763, ET218766 (4.00)
	Pod length (mm)	ET218697 (14.8)
	Seed yield per plant (g)	ET218764, ET218786, ET218768, ET218775, ET218766 (>166.00)
Chenopodium	Days to 50% flowering	EC896120, EC896246, EC896202, EC896203 (< 81.00)
	Days to 80% maturity	EC896059, EC896110, EC896062, EC896203, EC896097, EC896115 (<118)
	No. of branches per plant	EC896208, EC896237 (>27)
	Inflorescence length (cm)	EC896115, EC896206, EC896108, EC896114 (>44.00)
	Plant height (cm)	EC896208, EC896059 (>182)
	Seed volume weight (g/10 ml)	EC896246, EC896271, EC896114, EC896203, EC896215 (>10)
	Seed yield per plant (g)	EC896206, EC896237, EC896209, EC896208, EC896098 (>37)

Fig. 4.3. Diversity in linseed flower structure and colour

Fig. 4.4. Core set of barley germplasm

Fig. 4.5. Partial field view of chickpea characterization at NBPGR, Experimental Farm, Issapur, New Delhi during *Rabi*, 2018-19

Fig. 4.6. Field view of an erect type genotype of chickpea (IC244173) suitable for mechanical harvesting

barley germplasm belonging to *Hordeum marinum and H. spontaneum.* The grain type was hulled in around 450 accessions. The core set was planted at Issapur farm during *Rabi* 2018-19 for evaluation for agro-morphological traits and seed multiplication (Fig. 4.4).

Chickpea variability for erect type accessions identified and suitable for mechanical harvesting are shown in Fig 4.5 and 4.6. In ricebean, variability was observed for days to maturity, pod colour, pod length, pod, thickness, seed size and colour (Fig 4.7 and 4.8). Similarly, maize germplasm recorded good variability for ear shape, ear size, kernel colour and kernel type (Fig 4.9) early maturing accessions were identified (Fig 4.10). Also, some *Brassica* accessions showed promising for multiple traits viz. IC343199, EC765483 for Dwarf (71cm) & Early maturing (80 days). Among chilli germplasm evaluated, three accessions namely EC769386, EC769423, EC772705 had more than 5 flowers per inflorescence and potential genotypes for high yielding. Germplasm accessions *viz.* EC692286, EC769448, EC772772 were categorised as climate smart ideotypes for cultivation in *Kharif* season having desirable plant type, fruit shape, fruit size and maturity (Fig 4.11).

Fig. 4.7. Partial field view of ricebean germplasm at New Area Farm, NBPGR, New Delhi

Fig. 4.8. Genetic variability in ricebean germplasm for inflorescence colour (a), pod length, thickness and colour during the near maturity stage (b) and seed size, shape and colour (c)

Fig. 4.9. Variability in maize germplasm for ear shape, ear length, kernel colour and kernel type

Fig. 4.10. Maize accessions with early maturity (IC0624767)

A core set of lentil germplasm was developed from entire genebank accessions to facilitate access, conservation, and utilization. Germplasm accessions (2,314) were evaluated in *Rabi* season of 2017 and 2018 at New Area Farm, ICAR, NBPGR, New Delhi (28.6374° N, 77.1548° E) (Fig. 4.12). Data were recorded for 28 morphological descriptors. The core sets were developed using the heuristic method by PowerCore Software. The proposed core collection comprised 170 accessions as representative of the total diversity present in the lentil collection. All the descriptor states for each descriptor in the entire collection were represented in the core set, indicating that the core set captured the allelic richness of the entire collection. Also, entries from each class intervals of continuous traits were assembled in the core, and range retention percentage were 99%. The Shannon diversity index and other validation parameters (MD%, VD%, CR% and VR%) of the core sets proved the maximization of diversity. This core set can be evaluated intensively for agronomic traits, economically important traits, including resistance to biotic and abiotic stresses to identify accessions with desirable traits for use in crop improvement research and genomic studies (Fig. 4.13).

A total of 4,433 accessions of cowpea including 713 acc. of IITA, Nigeria core set characterized for descriptor traits. Under DBT funded minor pulses project, 3720 accessions of cowpea was characterized at two locations, ICAR-NBPGR, New Delhi and UAS-Bengaluru (Fig. 4.14).

EC692286 EC769448

Fig. 4.11. Genotypes of chilli with desirable palnt type (Fruit shape & size)

Fig. 4.12. Field view of characterization of lentil germplasm

Fig. 4.13. Variability in seeds of lentil

4.1.2. Screening of germplasm for biotic stress resistance: Fifty-eight wheat accessions with no incidence of Karnal Bunt disease were grown for second year screening and validation under field condition at NBPGR farm and glasshouse condition at Division of Plant Pathology, ICAR-IARI, New Delhi for Karnal Bunt and Spot blotch diseases. Out of this, forty-five accessions were found tolerant to Karnal Bunt with less than 5% of KB disease incidence and 13 accessions (EC463396, EC576941, IC539317, EC576816, IC128151, IC144903, IC531524, EC10970, IC252419, IC443633, IC530086, IC529902, IC529052, IC530058) were found tolerant against spot blotch disease (double digit score <13).

Fig. 4.14.

A total of 762 accessions of various pulse crops, *viz*., cowpea (445), lentil (174), chickpea (143) were evaluated for resistant source to a species of root-knot nematode, *Meloidogyne incognita* in pots with artificial inoculation. Based on number of root-galls induced by nematode and its reproduction factor, four accessions of cowpea (EC723870, EC724441, IC406512, IC550300), two of lentil (EC267631, IC560123) and none of chickpea were found resistant to *M. incognita*.

In addition, among oilseed crops, *Brassica juncea* (34 acc.), *B. carinata* (13 acc.), *B. tournefortii* (5 acc.), *Lepidium* (26 acc.) were evaluated for white rust, alternaria blight and sclerotinia rot resistance. *B juncea* accessions, EC766164, EC766230 and IC20167 and *B. carinata* accessions, EC206641, EC206642, EC206651, IC341170 & IC555891 were found resistant to white rust with PDI=0.*B. juncea* accessions EC766164, EC766230 & IC20167 showed resistance to alternaria blight having disease severity percentage of <10%. The accessions EC766230 & IC 20167 also showed resistance to sclerotinia rot with PDI=0. In addition, about 30 accessions of *Eruca sativa* were evaluated for aphid resistance and IC310965, IC508406 found resistant to aphid (< 10 no. of aphids/ top 10 cm inflorescence). Accession, EC788230 had multiple disease resistance for White rust resistant (PDI=0), Sclerotinia rot resistant (PDI=0) and Alternaria blight (PDI= <10%) and EC787756 White rust resistant (PDI=0) & Sclerotinia rot resistant (PDI=0) alongwith agronomic features such as, Silique/main branch (96) & Seeds/silique (30); IC20167 forSeeds/silique (35), Early Maturing (71 days).

Also, total of 350 chilli accessions including 30 indigenous collections from Tripura and 318 exotic collections from National Gene Bank and two commercial checks varieties of chilli were screened against biotic stresses (Chilli Leaf Curl Disease) under natural field conditions during *Kharif*, 2019 at ICAR-NBPGR, Farm. Thirteen accessions viz., EC772732, EC772739 EC928983, EC769434, EC773729, EC920855, EC915030, EC769427 showed resistant reaction to Chilli leaf Curl Disease (ChiLCD), while accessions EC769427, EC787119, EC769386, EC769388, EC771555 did not reveal any infestation for white fly, yellow mites, thrips and aphids, so have multiple resistant to these biotic stresses. The germplasm line EC769427 was found promising against biotic stresses throughout the growing season, hence it was categorised as highly resistant line (Fig. 4.13).

Fig. 4.15. Chilli Leaf Curl Virus resistant (ChiLCD) line of chilli "EC769427"

Screening of lentil germplasm for *Alternaria* blight at BCKV, Kalyani: A set of 500 diverse germplasm have been screened for the pre-flowering blight-like disease at BCKV, Kalyani which is predominant in farmers field for last ten years at West Bengal. Fungal DNA isolation from ten randomly selected diseased plants followed by ITS sequencing using universal primer pair revealed cent percent similarity in NCBI database with single organism *Alternaria alternata*. Three popular varieties viz. WBL-77, Ranjan and Asha were kept as check for disease reaction comparison. Four hundred sixty-six genotypes survived till flowering and scoring was made using 1-9 scale. Bases on two-year field data, only three lines, EC866132, IC267667, IC201778, established as the tolerant lines against Alternaria blight attack at the pre-flowering stage. Selected lines are being validated in *rabi* 19-20.

Screening for lentil rust (*Uromyces viciae-fabae*) at PAU, Gurdaspur: A total of 250 lentil germplasm along with a susceptible check were evaluated consecutively for rust resistance under natural incidence for two years at PAU, Gurdaspur. Experiments identified five genotypes, EC 223235, EC 225452, IC 212688, IC 231785 and IC 241249, as best performing (Score 1) and durable for rust resistance in this study. Identified accessions are being evaluated at HPKV, Dhaulakuan for validation in *rabi* 2019-20.

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

4.1.3.1 Evaluation of wheat germplasm for abiotic stress tolerance: Under NICRA project, a set of diverse wheat panel of 343 accessions were grown for second year evaluation against drought stress at farm of ICAR-NBPGR, Issapur 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: IC443722, EC463434, IC539155, IC443704, EC463382, IC539137 (>606 g); thousand grain weight: EC425336, IC290225, IC547561, IC252960, (>50g); Mean NDVI: IC619427, IC619431, IC621221, IC621224, IC619453, IC335761, IC532897 (>0.66).

In addition, a set of 100 wheat accessions selected from previous years' experiments was evaluated at NBPGR Experimental farm Issapur in 10 X 10 double lattice design using six checks HD-2967, Raj-3765, C-306, WR-544, HI-1531, HD-2932. These accessions were grown under normal sown, rainfed and terminal heat stress conditions and data were recorded for 16 morpho-physiological traits. Accessions IC252745, IC75246, IC619435, IC543428, IC416409, IC531257, IC393880, IC445366, performed better than the best check under drought conditions based on grain yield and Normalized Difference Vegetation Index whereas under late sown condition accessions namely,IC615005, IC615008, EC609571, EC575545, IC536113, IC619435, IC415672, IC531257, IC531498, IC75221 were found to be superior.

4.1.3.2 Evaluation of barley germplasm for drought tolerance: A set of 220 diverse barley germplasm of Indian (134) and exotic (86) origin was evaluated under rain-fed conditions in field as well as for polyethylene-glycol simulated drought stress at seedling stage. Based on stress susceptibility index, a panel of 10 barley genotypes (six most tolerant IC582699, EC578279, EC578711, IC113045, EC578521, EC492318 and four most susceptible EC578829, EC578822, IC079456, IC542206) was prepared for candidate gene association (*HVA1*) and study of allelic variation. Multiple sequence alignment of *HVA1* sequence from selected accessions has shown that there was 14 bp insertion in two tolerant accessions IC582699 and IC113045 in the promoter region of *HVA1*. Further, in the coding region of the *HVA1*, there was 33 bp deletion in another two tolerant accessions, EC578521 and EC492318 resulting deletion of 11 amino acids in *HVA1* protein sequence (Fig. 4.14). Other than the Indels, there were five SNPs in the coding region of *HVA1* of which two were of non-synonymous nature substituting amino acid Alanine (A) to Threonine (T) in protein sequence of the tolerant genotypes EC578521 and EC492318. These findings unravel novel genic markers in the form of InDels and SNPs in *HVA*1, however, association of these InDels and SNPs with drought would need variant information from more number of accessions in barley so that the statistical significance of these InDels and SNPs could be drawn.

4.1.3.3 Screenng of lentil germplasm for PEG mediated drought stress: A set of 150 lentil lines was evaluated for drought simulated conditions by using 15 % polyethylene glycol 6000. Germination percentage (GP), total biomass was recorded after harvesting. Roots were separated and scanned using Winrhizho root imaging system to record different

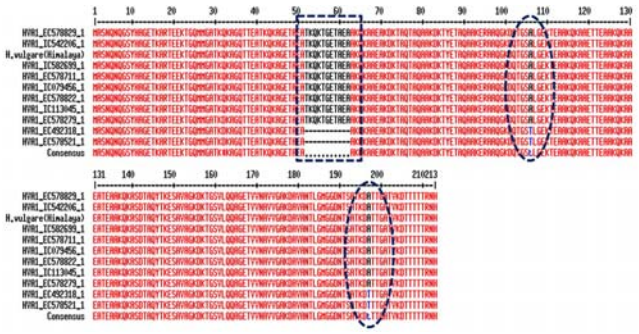


Fig. 4.16. Multiple alignment of amino acid sequence of *HVA1* from drought tolerant and susceptible genotypes of barley with query name *H. vulgare* Himalaya (X78205.1). Unfilled box indicate 33bp deletion at nucleotide level and oval indicate SNP, resulting in replacement of Alanine by Threonine

traits. Total root length (TRL), root volume (RV), total surface area (TSA), root diameter (RD), fragile root percentage (FRP), fragile root length (FRL) were measured in all the samples. Correlation between different traits was studied under control and drought conditions.

Significant reduction in germination percentage was observed under PEG mediated stress conditions. A total of 23 accessions showed 100 % germination and rest of accessions showed 20-90 % germination. Average total biomass reduced by 40 % in lentil lines in response to stress. All the recorded root traits (TRL, TSA, RV, RD, FRL and FRP) reduced in response to drought. Correlation analysis showed highly positive correlation between GP and FRL under both control (0.51) and drought (0.96) conditions. Other root traits, which showed positive correlation to GP are TSA, RD and FRP and the values were 0.68, 0.67 and 0.65 respectively at $p < 0.001$. No other root trait except FRL was positively associated with GP under control conditions. Coefficient of variation was the highest for FRL under drought and control conditions. Based on different parameters, 23 accessions showed drought tolerance, which include EC78414, IC268239, IC268243, IC321219, IC560051, IC560337, EC78424, IC346092, IC361296, IC385822 and IC559757.The accessions are being validated further in the field conditions.

Fig. 4.17. Root growth under control and drought conditions

4.1.3.4 Screening of Mungbean germplasm for heat stress: During summer 2019, a total of 80 accessions of mungbean were screened for summer heat stress at New Area Farm. Some of the promising accessions identified for heat responsive traits are given Table 4.2.

4.1.3.5 Genetic variation for tolerance to post-emergence herbicide, imazethapyr in lentil (*Lens culinaris* Medik.) germplasm conserved in genebank: Weeds pose a severe constraint to lentil production. Identification of post-emergence herbicide tolerance in germplasm can help breeders for developing varieties. Imazethapyr, a post-emergence herbicide was tested on 2,314 lentil germplasm in *rabi* 2018-19 and 2019-20 at NBPGR, New Delhi. Significant variation among the germplasm was observed for tolerance to imazethapyr. On a 1–5 scale, two genotypes were found highly tolerant, 28 tolerant, 265 moderately

Table 4.2: List of promising mung bean germplasm for heat stress responsive traits

Trait	Promising accessions
Canopy Temperature Depression (CTD)	IC616212 (15.19), IC616224 (15.16), IC616225 (15.02), IC76475 (14.81) & best check SML668 (14.17)
Membrane Stability Index (MSI)	PLM959 (88.33), IC616221 (88.07), IC548275 (87.98), EC15252 (87.71), PLM502 (87.28), PLM118 (87.08) best check Pusa Vishal (75.06)
Flower drop (%)	IC616149 (17.57), PLM38 (24.50), PLM118 (29.83), IC73532 (30.06), IC285532 (30.90), IC623914 (32.14), IC76388 (32.15), IC10487 (33.27), IC507415 (33.80), IC507463 (34.29), IC9137-1 (34.62) and best check IPM 99-125 (35.76)
Chlorophyll Content (CCM reading)	IC623914 (689.3), PLM959 (683.8), PLM116 (680.2), IC507481 (679.8), IC325788 (677.8), IC616149 (673.8), IC507517 (669), IC616224 (663.8), IC314595 (650.1) and best check IPM205-7 (619.7)
High Plant Biomass (g)	IC488843 (124.67), LGG460 (116.67), IC76585 (115.33), IC616208 (111.67), IC10487 (100), IC548275 (98.67), IC507463 (95.67), IC148531 (85.67), PLM502 (83.33) and best check IPM 99-125 (71.67)
Absence of seed shriveling	IC507481, IC121190, IC76344, PLM959

tolerant, 607 sensitive and 1412 highly sensitive after spray of Imazethapyr. Based on the first year's result, 30 genotypes, representing tolerant, moderately tolerant, sensitive and highly sensitive reactions, were being evaluated at two locations, NBPGR New Delhi and AU, Kota to determine the effect of herbicide on morpho-physiological and yield traits.

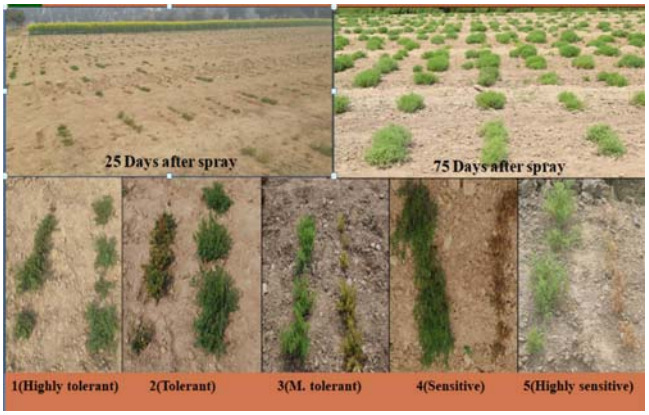


Fig. 4.18. Screening for post emergence herbicide tolerance in lentil at Issapur farm

4.1.4 Biochemical evaluation: Biochemical evaluation for quality traits in cereal crops (wheat, maize and barley); millets; oilseeds; underutilized crops; phytochemical traits in medicinal and aromatic plants; non-destructive (NIRS based) prediction model in rice were performed.

Fatty acid profile of maize accessions: A total of 43 maize accessions were analysed for fatty acid profile. Palmitic, stearic, oleic and linoleic acids ranged from 12.40-16.82, 2.09-7.40, 23.73-41.61 and 38.72-58.81 per cent, respectively. Accession IC624157 (41.61%) had higher oleic acid in comparison to check DHM 117 (33.49%). Value rich accessions for linoleic acid included IC624167 (58.81%), IC624168 (57.30%), IC624179 (53.94%), IC624161 (53.70%), IC624148 (52.90%), IC624156 (52.45%) IC624178 (52.29%), IC624159 (52.29%), IC624155 (52.27%) and IC624166 (52.18%) in comparison to check HQPM5 (43.67%).

Resistant starch content: Resistant starch content was determined in 45 maize accessions including two checks. Resistant starch content ranged from 0.17 to 3.61 g/100g. Value rich accessions included IC624152 (3.61 g/100g), IC624181 (2.62 g/100g), IC624153 (2.13 g/100g) and IC624151 (2.09 g/100g) in comparison to checks Bio9544 (1.35 g/100g). In addition, 40 accessions of potential crops including amaranth (20 accessions), *Chenopodium quinoa* (10 accessions) and *Chenopodium alba* (10 accessions) were also analysed for resistant starch content. In general, resistant starch content was less than 1g/100g among all the accessions.

Quality evaluation in wheat: 100 accessions of wheat were analysed for protein content. Superior accessions having >16% protein content were EC11360, EC217835, EC313710, EC11071, IC533610, IC28636, EC576187, IC252440 in comparison to check WH1021 (12.8%) and WR544 (12.69%) whereas low protein accessions were IC252906 (8.22%), EC556505 (8.54%), EC577448 (8.54%) and EC187159 (9.02%).

Biochemical evaluation of barley germplasm collection: About 7000 accessions of barley comprising hull less barley and hulled barley belonging to two row and six row types were scanned on NIR spectroscope. Based on spectral data analysis biochemically diverse set of 139 accessions in hull less barley and 147 accessions in hulled barley was identified. These samples were evaluated for total protein, beta glucan, total sugar, total starch and total phenols as these traits affect the baking, malting and brewing quality. High diversity was obtained for all the traits. Results are presented in (Tables 4.3 & 4.4).

Biochemical evaluation of finger millet germplasm: About 900 accessions of fingermillet were scanned on NIRS and based on spectral data analysis, 144 biochemically diverse accessions were identified and evaluated for different biochemical traits. Good amount of variability was observed in all traits analysed (Table 4.5).

Oil analysis of linseed germplasm: 218 linseed accessions including three checks Shekhar, Kartika and T-397 were analysed for oil content. The superior accessions identified in comparison to best checks Kartika (41.29%) and T-397 (40.19%) are listed in Table 4.6.

Table 4.3: Hulless barley germplasm nutrient profile

Trait	Range	Average ± std. dev	Superior germplasm
Total protein (%)	9.74 - 19.7	14.3 ± 1.99	IC82590, IC113048, IC361174, IC279146, IC255629 >18%
Beta glucan (%)	1.25 - 7.82	4.98 ± 1.05	IC82793<2%EC481703, IC144825, IC533209> 7.0%
Total sugar (%)	0.80 - 8.00	3.44 ± 1.04	EC481705, IC262366, IC279146>6.5%
Total starch (%)	51.1 - 80.3	70.5 ± 5.45	IC113051, IC0363969, IC278959, IC10758, EC578758>79% EC362230, IC279146, EC0105943, IC144825<60%
Total phenols (%)	0.076 – 0.486	0.219 ± 0.063	IC82716, IC113056, IC138923, IC361174> 0.3%

Table 4.4: Hulled barley germplasm (two row and six row type) nutrient profile

Trait	Range	Average ± std. dev	Superior germplasm
Total protein (%)	7.55-17.5	12.3±2.02	EC0578881, IC0446085, IC0533042 >17 IC0013206, IC0138220, EC0578342, EC955485 <9
Beta glucan (%)	0.522-7.31	3.59±1.03	IC0551315, IC0551309, EC0578728 >6.0 IC0082799, EC955606, EC955641 <1.5
Total sugar (%)	2.49-5.55	3.92 ± 0.58	EC0578357, EC0578531, IC0082799, EC0329008, IC0041577 >5.0
Total starch (%)	30.9-62.3	50.2±5.2	EC0578342, EC955451, EC955656, EC955471 >58
Total phenols (%)	0.247-0.671	0.359±0.067	IC0082799, IC0247764, EC0578342, EC0955642 <0.28 IC0446085, IC0446113, EC0578728, IV0445858 > 0.5

Table 4.5: Nutrient profile of finger millet germplasm

Trait	Range	Mean ±Stdev	Superior Acc
Protein %	5.02 - 13.2	9.10±1.53	IC473275, IC479042, IC473243, IC479161, IC479045, IC479184, IC479027 **> 12**
Phenol %	0.05 - 0.30	0.115±0.04	IC473165, IC473240 **> 0.20**
Sugar %	0.51-2.30	1.09±0.27	IC473466, IC587918, IC473385 **> 2**
Cu (µg/g)	1.93-11.15	4.61±1.99	IC 47903, IC 47907, IC 47916 **>10**
Fe (µg/g)	16.8-88.2	42.1±19	IC473164, IC473254, IC473351, IC479085, IC479095, IC479095, IC479075 **>80**
Zn (µg/g)	14.0-38.3	24.2±5.3	IC473219, IC474540, IC473347, IC473164, IC479085 **>30**

Table 4.6: Oil profile of linseed germplasm

Samples analysed	Range (%)	Mean Value (%)	Superior Acc. (%)
Linseed (218 accs.)	31.73-44.80	40.81	IC0002349 (44.80), IC0096746 (44.72), Binwa – IC420772 (44.61), IC0526058 (44.53), IC0096488 (44.37), IC0523807 (44.21), EC0041735 (44.14), IC0526069 (44.11), IC0526158 (44.02), IC0096494 (43.85), IC0096539 (43.81), IC0526118 (43.81), IC0096514 (43.66), IC0525953 (43.57), EC0000525 (43.50), IC0613907 (43.44), IC0061278 (43.39), IC0525967 (43.38), IC0525917 (43.33), EC0041700 (43.28), IC0096511 (43.24), IC0375899 (43.17), EC0000538 (43.12), IC0525910 (43.07), EC0041528 (43.05), IC0268344 (43.02)

Table 4.7: Validation statistics of Rice flour prediction model

Trait	N	% Range	Math treatment	RSQ	Slope	SD	SEP ©	RPD
Protein	59	6.06-13.4	2,8,8,2	0.912	1.097	0.996	0.353	2.82
TDF	40	4.43-5.84	3,16,8,2	0.945	1.164	0.208	0.068	3.06
Phenols	54	0.08-1.74	3,6,6,1	0.903	0.971	0.262	0.084	3.12
Starch	40	71.0-81.0	2,8,4,2	0.785	0.899	1.682	0.809	2.08
Oil	64	3.05-7.00	4,8,8,1	0.835	0.903	0.747	0.306	2.44
Amylose	33	5.23-30.8	3,6,6,1	0.831	1.035	5.149	2.409	2.14

Method Development

Validation of NIRS prediction model for rice flour samples: NIRS based prediction model was developed and validated for multiple traits estimation in rice flour, based on diverse sample set representing landraces and germplasm collected from plains and tarai belt of north India, Uttarakhand, Assam, Chattisgarh and southern India. More than 180 samples were evaluated over the period and biochemical evaluation data was regressed with the NIRS spectral data using WINISI software. We could successfully validate the developed model for six traits viz. Protein, total dietary fibre, phenols, starch, oil and amylose.

Improved apparent amylose estimation method and Inter laboratory validation: Apparent amylase estimation method was improved to increase sample throughput and reduce the consumption of distilled water and reagents. This method was validated on different food matrices viz. pearl millet, finger millet, maize, green gram, horse gram, moth bean, very low amylose rice, very high amylose rice, certified reference material of low, medium and high amylose rice at four different laboratories and compared with concavalin A based amylopectin precipitation method as per megazyme amylose/amylopectin kit. Results of inter laboratory validation for old and improved method and of megazyme amylose/amylopectin kit methods were in close agreement.

Quality analysis of potential crops: Vicine-convicine content is anti-nutritional factor in faba bean. It has been reported in literature that white flower colour is associated with low vicine-convicine content. Accordingly, selections were made in the nurseries received from ICARDA based on white flower colour and the seeds were analysed for vicine-convicine content. Seven single plant selections had vicine-convicine content of 0.53-0.62% as against checks HFB-1 (0.82%) and Vikrant (0.84%). The selected plant progenies will be raised in the next crop season for confirmation of the results.

Physio-chemical analysis of fruit tree germplasm: Physio-chemical analysis of fruit tree germplasm namely, ber fruit (12 acc.), aonla (4 acc.), bael (10 acc.), mulberry (3 acc.), pomegranate (5 acc.) and karonda (03 acc.) germplasm was undertaken and promising accessions are given in Table 4.8.

Table 4.8: Physio-chemical analysis of fruit germplasm

Crop	Traits	Accessions
Ber	Oblong fruit shape with pulp to stone ratio (21.15 %) and least stone length (2.66 cm) and width (0.6 cm)	IC0625596
Mulberry	High TSS content (19.5 °B)	IC628224

Phytochemical evaluation of medicinal and aromatic plants

Quality evaluation of 189 accessions of medicinal and aromatic plants (*Ocimum* species, *Hedychium* species, *Mucuna pruriens, Costus speciosus*)and potential crops (*Moringa oleifera*, *Fagopyrum* species germplasm was performed.

Analysis of aroma constituents in *Ocimum* germplasm

36 accessions of *Ocimum* germplasm comprising species of *O. americanum* (6); *O. kilmandscharicum* (3); *O. gratissimum* (10); *O. tenuiflorum* (6); *O. basilicum* (7) and *O. citridorum* (4) were analyzed for essential oil composition by GC/FID and GC/MS.

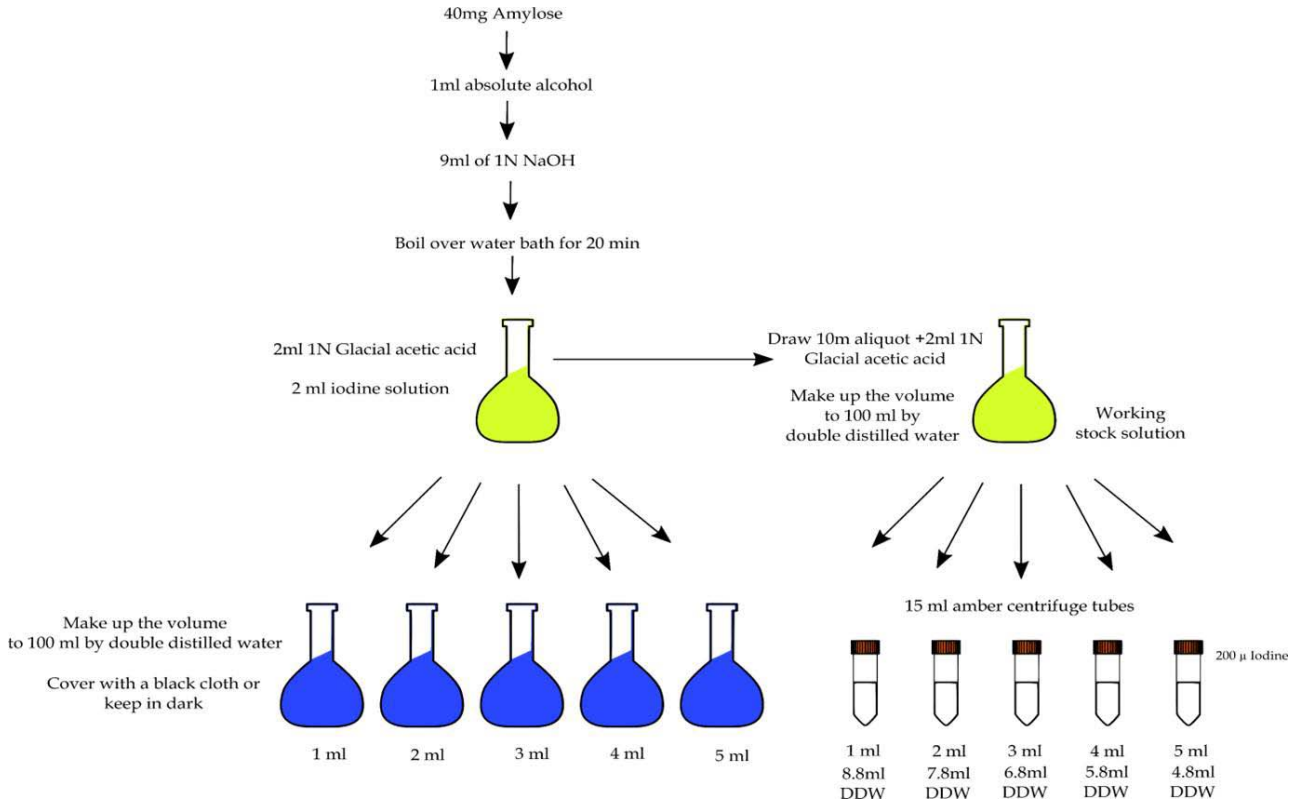


Fig. 4.19.

Promising accessions identified after two years of chemical evaluation for aroma compounds were: Camphor rich (IC599288), Methyl cinnamate rich (IC599363, IC589222, IC599351), Geranial rich (IC624514) and Eugenol rich (IC599317, IC599368, IC599316).

Evaluation of *Fagopyrum* germplasm for rutin content in seeds: Buckwheat seeds contain flavonoid rutin which is responsible for its medicinal properties. 131 accessions of *Fagopyrum* germplasm comprising three species of *F. tataricum*(94), *F. esculentum* (36) and *F. cymosum* (1) was evaluated for rutin content in seeds by HPTLC. Maximum rutin content was found in germplasm of *F. tataricum* (0.90 - 2.88 %), followed by *F. cymosum* (1.45 %) and *F. esculentum* (0.01-0.62 %) in mature seeds on dry weight basis. Promising accessions identified among *F. tataricum* germplasm with high rutin content (> 2 %) were EC104036, EC278738, EC18740, EC18173, IC14889, EC18629 and IC42423.

Quality analysis of *Moringa oleifera* germplasm: *Moringa oleifera* germplasm (19 accessions) analyses showed oil content in seeds ranged between 27.65 % - 38.63 % on dry weight basis with highest oil content present in IC613364. Fatty acid profiling of oil by GC/MS showed presence of highest content foroleic acid (> 50 %). Other fatty acids present were palmitic acid; palmitoleic acid; stearic acid; elaidic acid; linoleic acid; *cis*-11-Eicosenoic acid; arachidic acid; behenic acid and lignoceric acid.

4.2 Evaluation under CRP on agro-biodiversity

Under CRP on Agro-biodiversity, a total of 2,701 accessions comprising rice (1,022), wheat (917), chickpea (300) and okra (411) were evaluated at AICRP centres/hotspots for biotic and abiotic stresses. Biochemical analysis of grain samples (345 acc.) from NBPGR, Delhi were carried out at IIWBR, Karnal for protein content, sedimentation value and hectolitre weight. EC299060 and EC540810 were found promising for higher protein content (>14%

grain protein). EC575981, IC59610, IC449061, IC402042, IC28636, IC138852, IC533717, IC533903, IC536168 and IC539292 had high sedimentation value equal to 73.8. Promising accessions identified for various traits are given in the Table 4.9 and Fig. 4.20 & 4.21.

Table 4.9: 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**: IC277253, IC264727, IC277304, IC298564, IC346218,IC346228, IC264725, IC277234, IC283064, IC277234, IC346230, IC283127 Confirmed source :IC343395, IC346218 **Sheath Blight** : IC328519 **Bacterial Blight**: IC613810, IC449740, IC464668, IC203248, IC595241, IC55829, IC337615, IC86039, IC591471, IC242863 **Confirmed source:** IC283048, IC280500, IC337615 **Brown Plant Hopper**: IC426149, IC426126, IC426092, IC256780, IC283249, IC334193, IC256849, IC256842, IC273558, IC256545, IC346899, IC346892, IC273558, IC426148
Wheat	PAU, Ludhiana; IARI RS, Wellington; VPKAS, Almora; CSSRI, Karnal; IIWBR, Karnal; BHU, Varanasi; CSKHPKV, Palampur	**Karnal bunt:** EC463396, IC128150EC299335, IC539317, EC577050,IC449061, EC575981, IC402041, IC128151, EC10970, IC406688, IC542076, EC339611, IC335683, IC28584, EC178071-331, IC252419, EC273814, EC576578, EC574914 IC113734, IC290234, EC313755 IC443633, IC28621, IC574037 EC21058, EC574047, IC116276 IC309875, EC267020, EC578185 IC539313, EC0635727 (based on three years evaluation, 2016-17, 2017-18 and 2018-19) **Powdery mildew:** EC0105998, EC0529888, EC0530037, EC0530041, EC0582277, EC0582301, EC0582320, EC0582327, EC0582333, EC0582364, EC0595173, EC0595183, EC0597859, EC0598264, EC0598334, EC0598378, EC0610942, EC0612482, EC0612495, EC0612515, EC0612517, EC0635843, EC0638314, EC0675842, EC0790826, IC0598289, IC145343, IC443636, IC539137, IC542645, IC252928 **Confirmed source**- EC577448, IC 582706, IC543428, IC0104538 **Loose smut:** IC547640, IC531432, IC 531443, IC 296439, IC240802, EC582254, EC 576298, EC464032, IC542898, EC 190963, IC531542, IC531579, IC542820, etc. **Spot blotch**: EC578152, IC574387, EC187159, IC335998, IC822335A, EC578142, EC574047, EC21058, EC217803, EC577693 **DD Score at 3 stages <13** **Salinity tolerance:** IC35163, IC535330, IC443633, IC 252771, IC402041, IC75221, EC 11071, EC313719 **Protein content** (>14%): EC299060 and EC540810 Sedimentation value (=73.8): EC575981, IC59610, IC449061, IC402042, IC28636, IC138852, IC533717, IC533903, IC536168 and IC539292
Chickpea	JNKV, Jabalpur;;IIPR, Kanpur; PAU, Ludhiana; IARI, New Delhi	**Ascochyta blight:** IC275447, IC117744, EC220109, EC267186, EC267301, EC267309, IC248147 (disease severity score<3) **Confirmed source**: IC117744, IC275447, EC267301,IC248147, EC220109 **Collar Rot:** IC208318, ICC4582, IC468642, IC489924, IC350845, IC116352 <5% mortality **Fusarium wilt:** EC555400, IC116298, IC117657, IC271922, IC272089, IC272340, IC299241, IC327654, IC327655, IC347909, IC372348, IC468741, IC486024, ICC9087 (disease severity score<15) **Confirmed source** : IC116298, IC116406, IC271922,IC27237, IC328299, IC512061, IC83898 **BGM:**IC270739, EC547384, IC372344, IC269753, IC408288, IC269813, EC442698, EC548041, ICC3905, IC327373, IC275855, IC244171, IC299163, IC487001 (disease severity score<5)

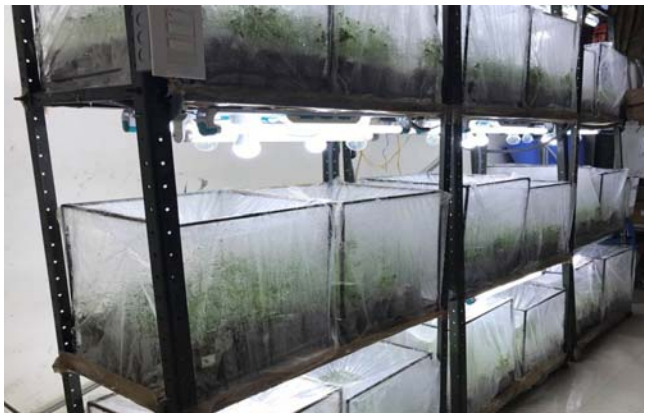


Fig. 4.20. Chickpea germplasm screening against BGM under controlled conditions at PAU, Ludhiana (*Rabi*, 2018-19)

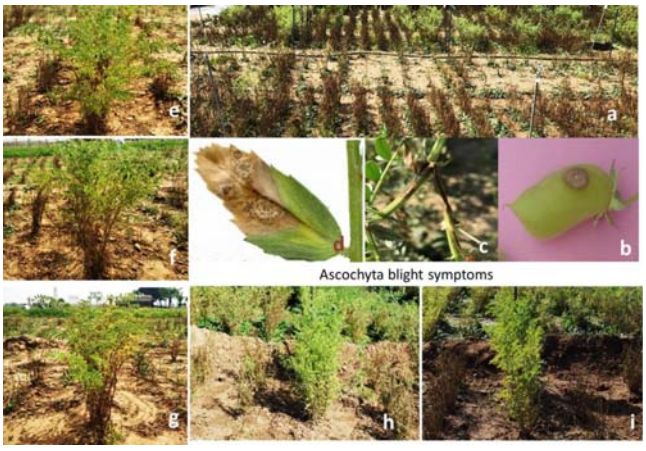


Fig. 4.21. Partial view of experimental plot depicting the disease severity and uniform spread of the pathogen (*A. rabiei*) at PAU, Ludhiana, during winter, 2018-19 (a). Typical Ascochyta blight disease identification symptoms which appear on leaf (b), stem (c) and pod (d) are highlighted in the photographs. The field photographs of some of the promising accessions viz. IC275447 (e), EC267301 (f), IC220109 (g), IC248147 (h) and IC117744 (i)

4.3 Pre-breeding and genetic enhancement

During the period, wild Capsicum (199), wild lentil accessions (50) and *Vigna* spp. (32 acc.) were grown for seed multiplication, characterization, evaluation and utilization in interspecific hybridization (Fig. 4.14). Inter-specific crosses between *Capsicum annuum*, *C. frutescens* and *C. chinense*, and *C. tovari* were attempted to study their cross compatibility and to introgress resistance genes for different traits. Different accessions of *Capsicum* species were used in crossing programme. Successful interspecific crosses were obtained between *C. chinense* (EC787141) x *C. annuum* (EC771555), *C. frutescens* (EC787119) x *C. annuum* (EC771555), *C. chinense* (EC787141) x *C. tovari* (EC790588), *C.tovari* (EC790588) x *C. annuum* (Kashi Anmol), respectively.

A total of seven accessions of *V. vexillata* was characterized for tuber morphology and quality parameters. Significant variability was observed for qualitative and quantitative traits. While evaluating the germplasm, variability was observed for traits *viz.* plant height, growth habit, pod length, seed size, seed colour and associated tuber traits (Fig 4.22). Tuber weight ranged from 0.69 g to 111.33 g (IC259503) while tuber length ranged from 2.5cm to 27.65 cm (IC259503). IC259504 also showed the highest pod length (15cm). The preliminary study revealed three distinct forms among the studied accessions of *V. vexillata*. Protein content was ranged from 7.64% to 9.93. Two accessions *viz*. IC277055 and IC259504 were found with more than 9.5 % protein content in tuber.

Fig. 4.22. Morphological characterization of tuber of *Vigna vexillata* accessions

Two types of interspecific crosses i.e. *Vigna glabrascens* × *V. radiata* and *V. mungo* × *V. stipulacea* were attempted to transfer MYMV as well as agronomic traits. F_1 seeds of two type of interspecific crosses i.e. *V. radiata* × *V. umbellata* and *V. mungo* × *V. stipulacea* were grown for generation advancement (Fig. 4.23). However, despite huge flowering there was no pod setting. To understand the genetic barrier, pollen and cytogenetic study is being done. F_1^s for *V. radiata* × *V. umbellata* are being maintained in tissue culture which were obtained via embryo rescue.

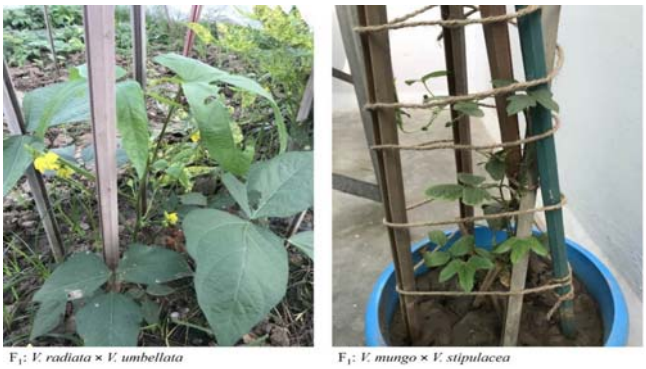


Fig. 4.23. Interspecific crossing in Vigna

In Okra, the pollen of 27 accessions of *Abelmoschus moschatus* were conserved in liquid nitrogen and later used in crossing with OYVMD susceptible Pusa Sawani. Fruit and seed development was observed in the crosses namely Pusa Sawani x EC360900, Pusa Sawani x EC360900-A, Pusa Sawani x EC360245, Pusa Sawani x EC360586 and seeds were harvested (Fig 4.24).

Eighteen accessions of wild brinjal germplasm comprising one accession each of (*S. aculeatissimum, S. campylacanthum, S. indicum, S. insanum*) and 13 accessions of *S. incanum* alongwith 6 accessions of *S. melongena* were evaluated for brinjal fruit & shoot borer (FSB). Out of the brinjal wild species, 10 accessions namely IC256240-A, IC421593, IC241674, IC531754-A, IC421594, IC620612, IC256181, IC253963-A, IC253957, IC203607-A were found field resistant (<10% infestation) for brinjal fruit and shoot borer. Based on last three years data the promising accessions resistant to fruit and shoot borer are given below.

S. no.	Accs	Species	Percent Infestation in fruit by FSB (2016-17)	(2017-18)	(2018-19)
1	IC253957	*S. incanum*	6.49	0.00	8.46
2	IC253963-A	*S. incanum*	0.00	0.00	7.95
3	IC421594	*S. incanum*	0.00	10.48	6.66
4	IC531754-A	*S. incanum*	7.32	7.14	6.51

Four crosses were made between female parent (Pusa Shyamla and Pusa Purple Long) and male parent (IC253952, IC539855) of *S. incanum* resistant to FSB (Fig 4.25).

Pusa Sawani x EC360245 **Pusa Sawani x EC360586** **Pusa Sawani x EC360900** **Pusa Sawani x EC360900-A**

Fig. 4.24. Fruit development in various crosses of okra

Pusa Shyamla x IC253952 **Pusa Shyamla x IC539855** **PPL x IC253952** **PPL x IC539855**

Fig. 4.25. Fruit setting of inter-specific derivatives of brinjal

4.4 Trait specific germplasm registered with PGRC of ICAR

Based on detailed evaluation, 20 trait specific accessions identified in different crops and notified as unique germplasm by PGRC of ICAR.

Group	Crop	Acc ID	Trait
Cereals	Rice	IC199562	Blast resistance
	Rice	IC121685	Blast resistance
	Wheat	IC529684,	Spot blotch resistance
	Wheat	IC529962	Spot blotch resistance
	Barley	IC113045	Extra dwarf plant stature coupled with early maturity
	Barley	EC492301	Awnless spikes
	Barley	EC667420	Early maturing hooded barley
	Barley	IC113052	Long spikes coupled with more grains per spike
	Barley	IC542197	Early maturity
Pulses	Lentil	IC317520	Unique seed morphotype with extended funiculus
	Lentil	IC208329	High protein content
	Lentil	IC208326	High protein content
	Lentil	IC559673	Root-knot nematode resistance
	Lentil	IC559890	Root-knot nematode resistance
	Cowpea	EC725122	Root-knot nematode resistance
	Cowpea	EC724523	Root-knot nematode resistance
	Cowpea	EC723686	Root-knot nematode resistance
Oilseeds	Linseed	IC268345	High oil content
M&APs	Ocimum	EC174527	High Linalool content
	Mucuna	IC599290	High L-Dopa content

4.5 Germplasm supply

During the period, a total of 4,863 accessions of various crops, *viz.,* cereals (2313), pulses (1761), oilseeds (396), vegetable crops (361) and medicinal and aromatic plants (32) were supplied to 85 indenters belonging to ICAR Institutes, SAUs and other research organizations engaged in crop improvement programmes.

4.6 Active germplasm holding

A total of 41,011 accessions of various crops comprising wheat (8,273), barley (7,331), maize (2,500), 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 (2,750) linseed (3,000), 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.

Table 4.10: Perennial species maintained in field gene bank at Issapur farm (2018-19)

S.No.	Fruit crops	Species	No. of acc.
1.	Karonda	*Carissa carandas, C. grandiflora, C. spinarum*	05
2.	Ber	*Ziziphus mauritiana, Z. nummularia*	15
3.	Mulberry	*Morus alba*	05
4.	Lasoda	*Cordia myxa*	02
5.	Aonla	*Emblica officinalis*	06
6.	Bael	*Aegle marmelos*	06
7.	Phalsa	*Grewia asiatica*	02
8.	Citrus	*Citrus medica*	01
9.	Guava	*Psidium guajava*	01
10.	Pomegranate	*Punica granatum*	07
11.	Khirni	*Manilkara hexandra*	02
12.	Ker	*Capparis decidua*	01
13.	Jamun	*Syzygium cumini*	04
14.	Imli	*Tamarindus indica*	01
15.	Datepalm	*Phoenix dactylifera*	01
16.	Monkey pod	*Pithecellobium dulce*	02
17.	Wood Apple	*Feronia limonia*	01
18.	Arjun	*Terminalia arjuna*	01
19.	Drumstick	*Moringa oleifera*	01
20.	Amaltas	*Cassia fistula*	01

S.No.	Fruit crops	Species	No. of acc.
21.	Gulmohar	*Delonix regia*	01
22.	Kachnar	*Bauhinea varigata*	
23.	Kadambh	*Neolamarckia cadamba*	01
24.	Dhaak	*Butea monosperma*	01
25.	Shisham	*Dalbergia sisoo*	01
26.	Neem	*Azadirachta indica*	01
27.	Phalsa	*Grewia asiatica*	04
28.	Mahua	*Madhuca longifolia*	02
29.	Chironji	*Buchanania lanzan*	01
30.	Jackfruit	*Artocarpus heterophyllus*	01
31.	Giloy	*Tinospora cordifolia*	01
32.	Arjun	*Terminalia arjuna*	01
33.	Cactus	*Sansevieria trifasciata*	02
34.	Pipal	*Ficus religiosa*	02
35.	Ornamental species		10
36.	Other species		15
Total		**Total species (50)**	**110**

Collection of perennial species germplasm from CHES, Godhra: During July 2019, germplasm of six species (*Buchanania lanzan, Madhuca indica, S. cuminii, Grewia subinaequalis, Carissa congesta, Aegle marmelos*) were collected from CHES, Godhra and presently, is being maintained at FGB Issapur Farm.

Establishment of mulberry cutting: 15 diverse mulberry cutting collected from Srinagar and adjoining area have been planted in B block field gene bank of Issapur.

Research Programme (Code: Title, Programme Leader)

PGR/GEV-BUR-DEL-01.00 Characterization, evaluation and documentation of genetic resources of agri-horticultural crops (Programme Leader: **Ashok Kumar**)

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

PGR/GEV-BUR-DEL-01.01 Characterization, evaluation and documentation of wheat, barley and triticale germplasm (**Jyoti Kumari**, Sandeep Kumar, Sundeep Kumar, Vikender Kaur, Ruchi Bansal, SK Kaushik and *Y S Rathi*)

PGR/GEV-BUR-DEL-01.02 Characterization, evaluation and documentation of maize germplasm (**Ashok Kumar**, Jyoti Kumari, Ishwar Singh, Vinay Mahajan and *RK Sharma*)

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

PGR/GEV-BUR-DEL-01.04 Characterization, evaluation, and documentation of oilseeds germplasm **(Rashmi Yadav**, Sandeep Kumar, Vijay Singh Meena, Vikender Kaur, Mamta Singh, Jameel Akhtar, Sapna and *BL Meena*)

PGR/GEV-BUR-DEL-01.05 Characterization, evaluation and documentation of vegetable and ornamental crop germplasm (**KK Gangopadhyay,** Rakesh Srivastava, Vijay Singh Meena, SK Yadav, Vinod Kumar, Pragya, Pooja Kumari, Bharat H. Gawade, Rajkiran, T Boopathi and *Nand Lal Meena*)

PGR/GEV-BUR-DEL-01.06 Biochemical evaluation of field and vegetable crops germplasm **(Rakesh Bhardwaj**, Sandeep Kumar, Manjusha Verma, Vijay Singh Meena, Sapna, Nand Lal Meena and *Poonam Suneja*)

PGR/GEV-BUR-DEL-01.07 Characterization and evaluation of medicinal and aromatic plantsgermplasm **(Archana P Raina**, Ashok Kumar, Ishwar Singh, Rakesh Singh and *BS Panwar*)

PGR/GEV-BUR-DEL-01.09 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)

PGR/GEV-BUR-DEL-01.10 Characterization of wild species and pre-breeding in selected crops **(Vinod Kumar**, KK Gangopadhyay, Gayacharan, Kuldeep Tripathi, Mohar Singh, MK Rana, M Latha and R Gowthami)

PGR/GEV-BUR-DEL-01.11 Characterization, evaluation and documentation of underutilized crops germplasm **(SK Kaushik**, SK Yadav, Hanuman Lal, Vinay Mahajan, KK Gangopadhyay, Ishwar Singh Archana P. Raina and Rakesh Srivastava)

PGR/GEV-BUR-DEL-01.12 Application of statistical techniques in management of information on plant genetic resources (**Hanuman Lal**)

DIVISION OF GENOMIC RESOURCES 5

Summary: Total of 92 samples comprising sixteen agri-horticultural crops, namely, chilli, cotton, cowpea, finger millet, foxtail millet, maize, mung bean, paddy, pearl millet, pigeon pea, sesame, soybean, sponge gourd, urdbean, walnut and wheat were DNA profiled during the period under report, from various public and private sector organizations. Thirty-seven (37) landraces of maize from Chhattisgarh were received from ICAR-NBPGR's Regional Station, Ranchi were DNA profiled using Simple Sequence Repeat (SSR) markers. Genome wide SSRs were mined from the assembled whole genome sequence of the Indian landrace 'Thottumuriyan' of blackpepper (*Piper nigrum*) and used for diversity analysis studies, and development of a SSR database. For grain Amaranth, development of SSR markers was initiated using public databases and a total 2, 80,997 SSR loci were identified and a total 66,243 SSR markers were identified. Total 66,243 SSR primer pairs were designed, out of which 53, 067 primer pairs were unique. A draft genome of *Luffa acutangula* was assembled using hybrid assembly from NGS data. Rice accessions from East coast (2,243 accessions) were genotyped with 36plex SNP assay and used for core development. The C_4-specific gene copies for *aat*, *gpt*, and *ppdk* gene were significantly differentially expressed in grains than in leaves, across all studied genotypes of rice. A comprehensive study was designed for exploration of genetic factor(s) associated with robust root growth under saline conditions in Indian mustard germplasm. A total of 397 Genomic accessions from 6 species (Cotton 25; Sunflower 96; Rice 151; Linseed 20; Mustard 25; Wheat 80) were conserved both at - 70^{0}C as well as -196^{0}C. In wheat a total of 51 MTAs/QTLs in nineteen different genomic regions were found to be linked with resistance to four different pathotypes at the seedling stage i.e., 18 MTAs (*T* pathotype), 14 SNPs (*46S119*), 7 SNPs (*110S119*) and 12 SNPs (*238S119*), through GWAS. A total of 67 samples of 27 consignments of five crops including brinjal, cotton, papaya, rice, and wheat were tested for checking the GM status or for event confirmation.

5.1 DNA fingerprinting

Ninety-two samples of 16 agri-horticultural crops, namely, chilli, cotton, cowpea, finger millet, foxtail millet, maize, mung bean, paddy, pearl millet, pigeon pea, sesame, soybean, sponge gourd, urdbean, walnut and wheat were DNA profiled during the period under report for various public and private sector organizations. The DNA profiling was mostly done using mapped Simple Sequence Repeats (SSRs) markers. The crop-wise details for the number of samples are provided in the Table 5.1. By rendering DNA fingerprinting services, resources to the tune of ₹ 2,14,840-00 was also generated.

Table 5.1: Details of samples DNA finger printed during 2019

S. No.	Crop	Scientific name	Number of samples
1	Chilli	*Capsicum annuum*	2
2	Cotton	*Gossypium sp.*	20
3	Cowpea	*Vigna unguiculata*	2
4	Finger millet	*Eleusine coracana*	1
5	Foxtail millet	*Setaria italica*	1
6	Maize	*Zea mays*	7
7	Mungbean	*Vigna radiata*	4
8	Paddy	*Oryza sativa*	21
9	Pearl millet	*Pennisetum glaucum*	4
10	Pigeon pea	*Cajanus cajan*	4
11	Sesame	*Sesamum indicum*	6
12	Soybean	*Glycine max*	4
13	Sponge gourd	*Luffa cylindrica*	3
14	Urdbean	*Vigna mungo*	1
15	Walnut	*Juglans regia*	7
16	Wheat	*Triticum aestivum*	5
	Total		**92**

5.2 DNA profiling of maize landraces

Thirty-seven (37) landraces of maize from Chhattisgarh which were received from ICAR-NBPGR's Regional Station, Ranchi were DNA profiled using Simple Sequence Repeat (SSR) markers (Table 5.2). A total of 34 SSR markers were used which generated 100 bands. A representative profile of using one of the SSR loci is depicted in Fig. 5.1. All the maize landraces could be discriminated from one another using this set of 34 markers (Fig. 5.2). UPGMA-based clustering showed that all the 37 landraces were quite distinct from the other maize accessions (11) included in the study for comparison purpose. Landraces from the Koriya district of Chhattisgarh were found to be clustered in a separate group as evident from the dendrogram.

Table 5.2: List of maize landraces used for SSR marker-based characterization

S. No.	Name	IC Number	Village/Block/District
1	SKB/PM-5	IC624140	Dipatoli/Jaspur/Jaspur
2	SKB/PM-6	IC624141	Dipatoli/Jaspur/Jaspur
3	SKB/PM-7	IC624142	Dipatoli/Jaspur/Jaspur
4	SKB/PM-8	IC624143	Dipatoli/Jaspur/Jaspur
5	SKB/PM-9A	IC624144	Khatanga/Mahakultoli/ Jaspur
6	SKB/PM-10	IC624145	Khatanga/Mahakultoli/ Jaspur
7	SKB/PM-11	IC624146	Khatanga/Mahakultoli/ Jaspur
8	SKB/PM-12	IC624147	Khatanga/Mahakultoli/ Jaspur
9	SKB/PM-14	IC624148	Bilaspur/Kunkuri/Jaspur
10	SKB/PM-15	IC624149	Matashi/Kunkuri/Jaspur
11	SKB/PM-16	IC624150	Matashi/Kunkuri/Jaspur
12	SKB/PM-17	IC624151	Deoratoli/Jaspur/Kunkuri
13	SKB/PM-19	IC624152	Rauni/Bagicha/Jaspur
14	SKB/PM-21	IC624153	Rauni/Bagicha/Jaspur
15	SKB/PM-22	IC624154	Budhadand/Gajupura/ Jaspur
16	SKB/PM-28	IC624157	Chikani pani/Pathalgaon/ Jaspur
17	SKB/PM-31	IC624158	Sakdukala/Korba/Korba
18	SKB/PM-35	IC624159	Madanpur/Pali/Korba
19	SKB/PM-36	IC624160	Madanpur/Pali/Korba
20	SKB/PM-30	IC624161	Madanpur/Pali/Korba
21	SKB/PM-46	IC624164	Dubar muddha/Pali/Korba
22	SKB/PM-47	IC624165	Ranwa/Pondi/Korba
23	SKB/PM-48	IC624166	Beran/Pondi/Korba
24	SKB/PM-54	IC624168	Amjhar/Pondipurpara/ Korba
25	SKB/PM-56	IC624169	Devadant/Khadgaon/ Koriya
26	SKB/PM-58	IC624170	Pahadpara/Sonhat/Koriya
27	SKB/PM-61	IC624171	Turi Pauni/Sonhat/Koriya
28	SKB/PM-63	IC624172	Turi Pauni/Sonhat/Koriya
29	SKB/PM-66	IC624173	Senghor/Sonhat/Koriya
30	SKB/PM-71	IC624174	Chainpur/Manendergarh/ Koriya
31	SKB/PM-73	IC624175	Mauari/Manendergarh/ Koriya
32	SKB/PM-75	IC624176	Gutra/Manendergarh/ Koriya
33	SKB/PM-76	IC624177	Siroli/Manendergarh/ Koriya
34	SKB/PM-77	IC624178	Siroli/Manendergarh/ Jaspur
35	SKB/PM-78	IC624179	Rauni/Bagicha/Jaspur
36	SKB/PM-79	IC624180	Rauni/Bagicha/Jaspur
37	SKB/PM-83	IC624181	Songada/Manora/Jaspur

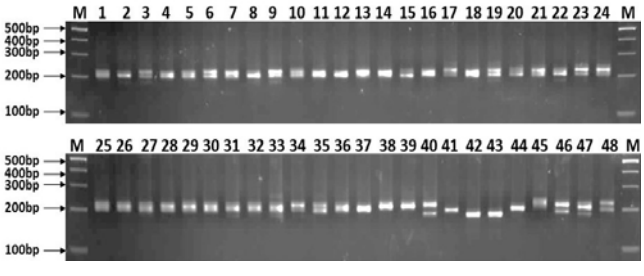


Fig. 5.1. Profile of maize landraces from Chhattisgarh generated using SSR locus BNLG 615. Lanes numbered 1-37 are the landraces as depicted in the Table 1. Lanes 38-48 are the samples included for comparison

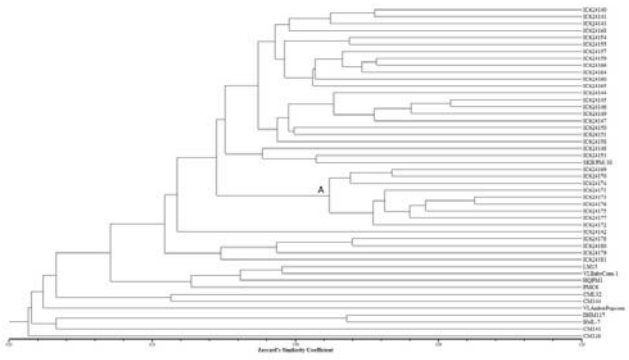


Fig. 5.2. Dendrogram generated based on UPGMA cluster analysis of maize landraces using SSR markers. A in the figure indicates group of landraces from Koriya district of Chhattisgarh

5.3 Novel SSR markers in black pepper

The sequence information from the recently sequenced black pepper (*Piper nigrum*) genome of the Indian landrace 'Thottumuriyan' has been used for identification and characterisation of Simple Sequence Repeats (SSRs). Totally, 69,126 SSRs were identified from assembled genomic sequence of *P. nigrum*. Among the different types of microsatellite repeat motifs, dinucleotides were the most abundant (48.6%), followed by trinucleotide (23.7%) and compound repeats (20.62%). A set of 85 SSRs were used for validation, of which 74 produced amplification products of expected size. Genetic diversity of 30 black pepper accessions using 50 SSRs revealed four distinct clusters. Further, the cross species transferability of the SSRs was checked in nine other *Piper* species (Fig. 5.3). Out of 50 SSRs used, 19 and 31 SSRs were amplified in nine and seven species, respectively. Thus the identified SSRs may have application in other species of the genus *Piper,* where genome sequence is not available yet.

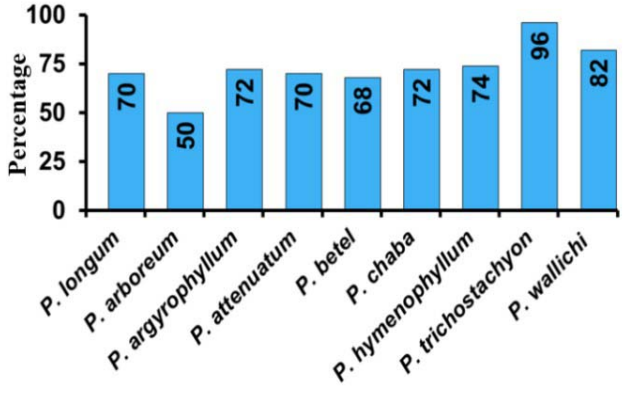


Fig. 5.3. Cross species transferability of SSR markers from *Piper nigrum* to nine species of *Piper*

5.4 Development of SSR and SNP markers for molecular characterization of Amaranth

Development of SSR markers was initiated using public databases and a total of 2,80,997 SSR loci were identified. For 2,14,754 SSR loci, primers pairs could not be generated, hence total 66,243 SSR markers were identified. Total 66,243 SSR primer pairs were designed, out of which 53, 067 primer pairs were unique. For validation of newly developed SSR markers in the wet laboratory; 110 primer pairs were synthesized and amplified on three accessions of Amaranth. All the primers showed good amplifications (Fig. 5.4). For SNP discovery all 16 chromosomes has been taken into consideration. Approximately 8.50 lakh SNP has been identified which will be tested for development of low density chip for characterization of total collection of Amaranth.

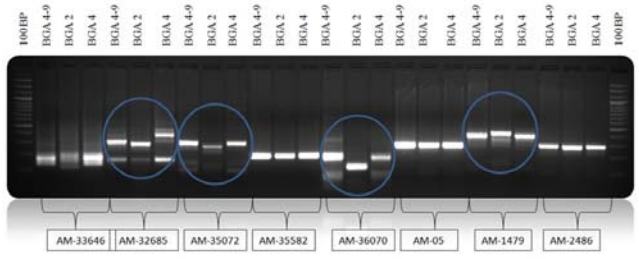


Fig. 5.4. DNA profile for three genotypes of amaranth (BGA 4-9, BGA-2 and BGA-4), 100 BP = 100 bp molecular weight size standard

5.5 Sesame fingerprinting

The samples (eight) received for generating fingerprinting profiles for sesame cultivars were done using a set of 43 SSR primer pairs representing across the linkage groups. A sample profile for the SSR primer Si-6 is provided in the fig. 5.5.

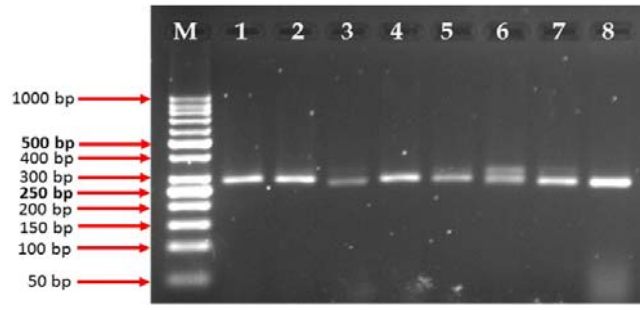


Fig. 5.5. Sample SSR profile for eight sesame cultivars (1: VRI1, 2: VRI2, 3: VRI3, 4: TMV7, 5: GT10, 6: RT372, 7: TKG22, and 8: Swetha; M: 50bp marker) subjected to fingerprinting using the primer pair Si-6

5.6 Piperine estimation in different developmental stages of black pepper

Piperine content in developing fruits of black pepper (DS1-anthesis to DS9-maturity) in four genotypes *viz*., Karimunda, Thottumuriyan, Panniyur-8, and Panniyur-1, were estimated using HPLC technique. The piperine content at maturity is around 80 mg g-1 of dry fruit. Of the four genotypes studied, Thottumuriyan genotype exhibited the highest piperine content during fruit development, especially the stages DS4 and DS5. Seeds with removed pericarp exhibited higher values indicating that the piperine biosynthesis is mostly in the seeds and not in pericarp.

5.7 Development of a SSR database in Black pepper

Based on genome sequencing and genome wide identification of microsatellite repeats in black pepper (*Piper nigrum* L), a freely available public database PinigSSRdb has been developed, which allows one to search *in silico* predicted genomic microsatellites in black pepper, according to various parameters *viz.,* SSR complexity, motif and genic/intergenic region. PinigSSRdb constitutes a valuable resource for a whole fleet of applications in genetics and plant breeding studies in various *Piper* species. The database is hosted on the NBPGR website (Fig. 5.6).

Fig. 5.6. Screenshot of Piper nigrum microsatellite database developed

5.8 Development of core set for Rice East Coast Collection

Rice accessions from East coast (2,243 accessions) were genotyped with 36plex SNP assay and used for core development. The east coast accessions (2,243) showed genetic diversity of 0.30 which is good level of diversity based on SNP markers. The heterozygosity was 0.07 and major allele frequency was 0.78. Based on genetic indices mentioned above, a core set of 248 rice accessions was developed for east coast which showed that 99% of alleles present in the total collection (2,243 accessions) is getting represented in the core set of 248 rice accessions (Fig. 5.7). The genetic diversity analysis of core (248 accessions) showed two clear clusters in the Neighbour joining tree (NJ tree) whereas, population structure study showed that core is getting distributed into four populations (Fig. 5.8).

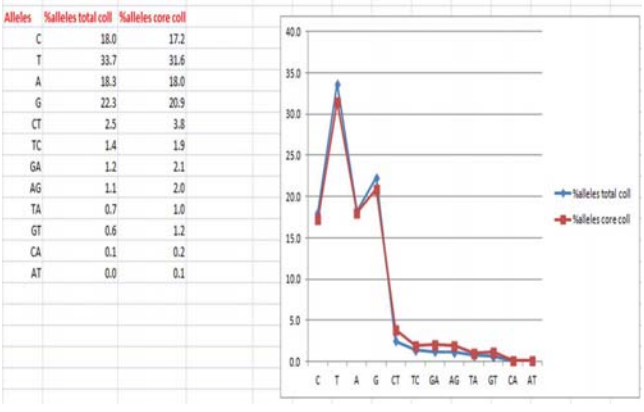


Fig. 5.7. Allele frequency- Total collection Vs Core collection

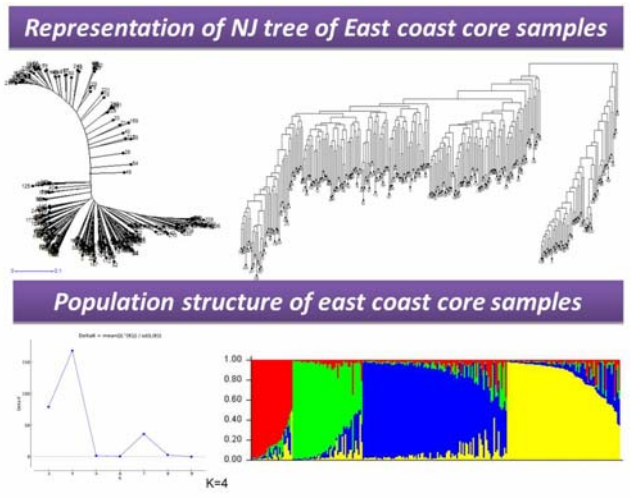


Fig. 5.8.

5.9 Draft Genome Sequencing of *Luffa acutangula*

Luffa acutangula (L.) Roem. is an economically important vegetable crop in Asia. In the dearth of genomic resources for the crop, a survey of *L. acutangula* genome was carried out using NGS technology. In total, 36.6 Gb sequence data of *L. acutangula* were obtained using Illumina and Nanopore sequencing, in which the guanine plus cytosine (GC) content was calculated to be 38%. In total, 248978 contigs (>500 bp) with 2070bp N50 length and 168509 scaffolds (>500 bp) with 274.5 Mb total length were obtained. Further analyses is in progress.

Table 5.3: Assembly Statistics for *L. acutangula* using Illumina and Nanopore data

N50	Number of scaffolds	Total Length	Min Contig Length	Largest Contig Length
2070	168509	274461611	500	26072565

5.10 Molecular taxonomy in *Cucumis melo*

The neighbor joining tree constructed using multiple alignment of rbc L sequence data revealed that the described species deviate from other varieties of *C. melo* supporting the morphological and ecological distinctness of the variety and categorizing into new taxa. *C. sativus* was used as outgroup (Fig. 5.9). The other *C. melo* varities used in the study were var. *flexuosus*, var. *cantapaulensis*, var. *momordica* and var. *conoman*. Out of these studied varieties var. *flexusous* is closely related to var. *alwarensis* and found to be intermediate between *flexuosus* and *cantapaulensis* which is the case in the case of morphological description also where all three have elongated fruit. Chromosome count on root cell revealed that 2n = 24 which support that it belongs to the *Cucumis melo* group. The cultivars from *C. melo* are cyto morphologically constant and they do not show any morphological changes in the chromosome. The newly described cultivar also showed similar number with average chromosome length below 1.2 um which differentiate from the outgroup *C. sativus* (2n=14) and larger chromosomes.

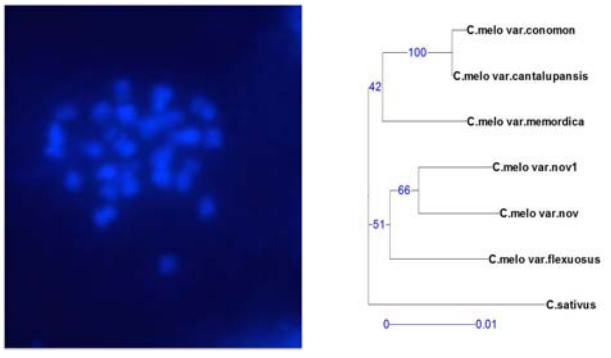


Fig. 5.9.

5.11 Missing links that could potentially accomplish C4 photosynthesis in rice grain pericarp were identified

Genes accomplishing C4 photosynthesis (and their paralogs) in wheat grains were used to identify the corresponding orthologs in indica rice reference genome (ASM465v1), available from the public domain. Transcriptome analysis was performed using different tissues (leaf, peduncle and grain) of three rice genotypes, viz., APO (EC734333), BAM4234 (EC497171), and CROSSA (IC575838), and their expression pattern (in RPKM values) for the selected 16 gene orthologs in rice (based on wheat) were studied (Fig. 5.10). Results indicate that the C4-specific gene copies for *aat*, *gpt*, and *ppdk* gene were significantly differentially expressed in grains than in leaves, across all three genotypes. Hence,

genetic or genomic interventions in C4-specific gene copies of *ppc*, *mdh* and *me2* gene might potentially help accomplishing C4 photosynthesis in grains of rice, that might be extended for their potential expression in leaves too.

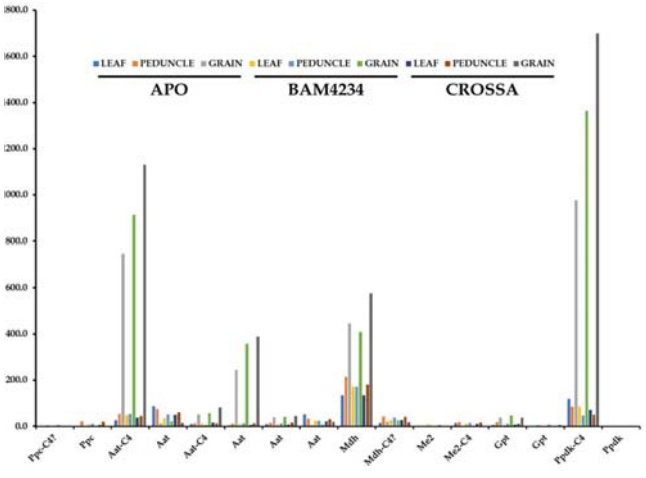


Fig. 5.10. Expression profiles (in RPKM values, X-axis) for 16 genes (six C4 photosynthetic genes with their paralogs, Y-axis) between three tissues (leaf, peduncle, and grain) in three rice genotypes estimated using indica rice reference genome (ASM465v1)

5.12 Characterization of *Cucurbita moschata* germplasm

Cucurbita moschata germplasm (219) procured from the National Genebank was sown in microtrays and transplanted in the field. Plant morphological data were recorded and single plant tissue was collected for molecular characterization.

5.13 Exploration of robust root phenotype in Indian mustard germplasm

Soil salinity is one of the important abiotic factor resulting in significant reduction in crop yield. In Indian mustard varieties, the increase in soil salinity level causes major loss in net output. In plants, root remains in direct contact with soil and information related to root phenotype in saline conditions in Indian mustard is limited. Root architecture that includes tap root and lateral roots, is the result of coordinated interaction between the genetic and environmental factors, which is essential for optimizing water and nutrient extraction from soil.

A comprehensive study was designed for exploration of genetic factor(s) associated with robust root growth under saline conditions in Indian mustard germplasm. To accomplish this, a customized high-throughput platform for germination and subsequent seedling growth have been developed. Screening were conducted in growth chamber (Humidity: ~75%; Photoperiod: 16 H light and 8 H dark; Temperature: ~25^{o}C); seeds were allowed to grow in saline condition (EC ~9 ds m-1) along with requisite control. Digitally captured images of seedling were analyzed by Image J software. Screening of three thousand twenty germplasm/accessions have shown ~20-60% reduction in root growth as compared to control (Water). Comparison of root length of one hundred and forty lines (~20% reduction in growth) have yielded 42 lines having root length relatively similar to saline tolerant control line. However, in secondary screening, conducted on same 42 lines at three different saline conditions (higher than EC ~9 ds m-1), four lines demonstrated ~15-20% enhanced root length growth even at higher salinity compared to saline tolerant control line.

5.14 Genome wide association mapping for stripe rust resistance in bread wheat using Breeders' 35K Axiom® array

Stripe rust caused by (*Puccinia striiformis* f. sp. *tritici*), is an important disease of wheat worldwide. It causes significant yield losses that can be up to 100% in severe condition. Information about seedling resistance genes need to be generated for developing resistant wheat cultivars with adequate resistance against new virulent pathotypes of stripe rust. With the aim to identify seedling resistance genes, a diverse set of 391 spring bread wheat germplasm lines were evaluated against four different pathotypes of stripe rust at seedling stage i.e., *T, 46S119, 110S119* and *238S119* in green house at IIWBR, Regional Station, Flowerdale, Shimla in 2017 & 2018 winter seasons. Genotyping of association mapping panel was done using 35K

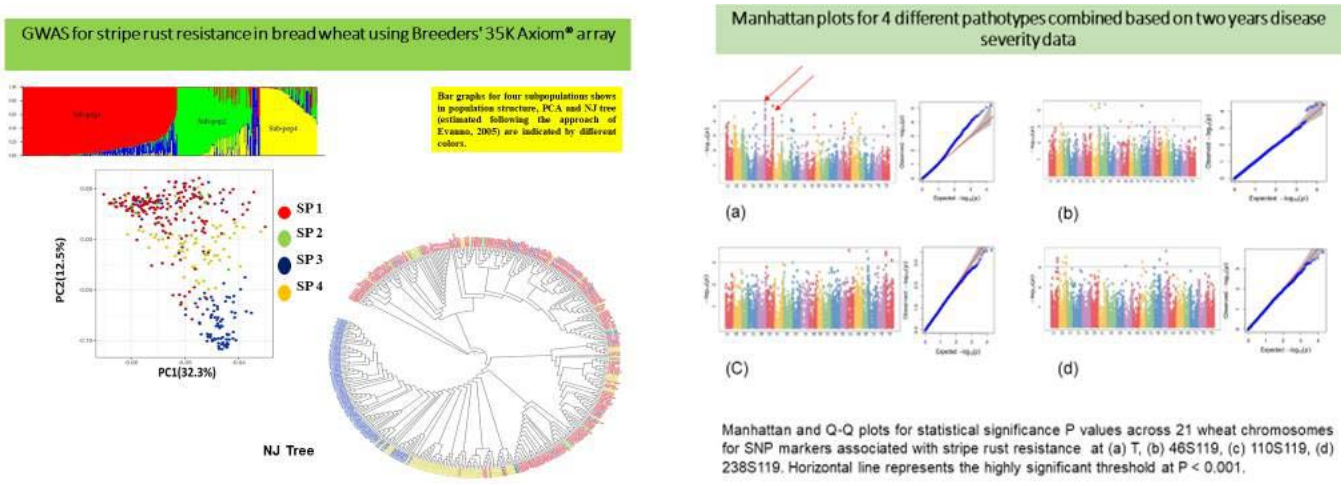


Fig. 5.11. Analysis of stripe rust resistance trait in wheat

Axiom® array. A genome-wide association study (GWAS) was conducted to determine marker-trait associations (MTAs)/quantitative trait loci (QTLs) conferring resistance to stripe rust in bread wheat germplasm. A total of 51 MTAs/QTLs in nineteen different genomic regions were found to be linked with resistance to four different pathotypes at the seedling stage i.e., 18 MTAs (*T* pathotype), 14 SNPs (*46S119*), 7 SNPs (*110S119*) and 12 SNPs (*238S119*). A total of 58 gene candidates for *T, 46S119, 110S119* and *238S119* were identified by further downstream analysis of identified markers (Fig. 5.11). Two of these genes, *TraesCS6D 02G384800* and *TraesCS7A02G021700*, are annotated as leucine-rich repeat receptor-like containing N-terminal, plant type, which have a role in pathogen recognition and disease resistance. The novel effective MTA/QTL for seedling resistance to stripe rust will improve understanding of the genetic mechanisms that control the spread of stripe rust, and will aid in the molecular marker-assisted selection-based breeding of wheat for stripe rust resistance.

5.15 SNP haplotype of floral homeotic gene APETALA 2 (AP2) in early and late flowering-maturing germplasm accessions of linseed

By evaluating a set of 220 linseed germplasm accessions over two years (2017-18 and 2018-19) at ICAR-NBPGR New Delhi and in NBPGR RS Akola during 2018-19, a panel of early and late flowering germplasm have been identified. To check allelic variation in flowering related gene in early and late accessions, a floral homeotic gene APETALA 2 (AP2) was PCR amplified, isolated and sequenced from two early and late linseed germplasm accessions. Sequence analysis and alignment revealed a total of 11 SNPs and one indel. Five SNPs were from the coding region of the gene, two of which are non-synonymous nature resulting in change of amino acid

Table 5.4: SNP haplotype of floral homeotic gene APETALA 2 (AP2) in early and late flowering/maturing germplasm accessions of linseed. Nucleotides in green and red font color are from exonic and intronic regions, respectively

Haplotype		Floral homeotic gene APETALA 2 (AP2)											
Nucleotide Position		21	106	217	691	958	960	981	1003	1707	1970	1986	2105
Ref. CDS Bethune		T	T	T	G	C	A	T	G	C	G	C	-
Late	EC0115148	T	T	T	G	C	A	A	G	C	T	C	-
	EC0718827	T	T	T	G	C	A	T	G	C	G	C	-
Early	IC0523807	C	A	A	A	T	T	T	C	T	T	C	A
	IC0525939	C	A	A	A	T	T	T	C	T	T	A	A

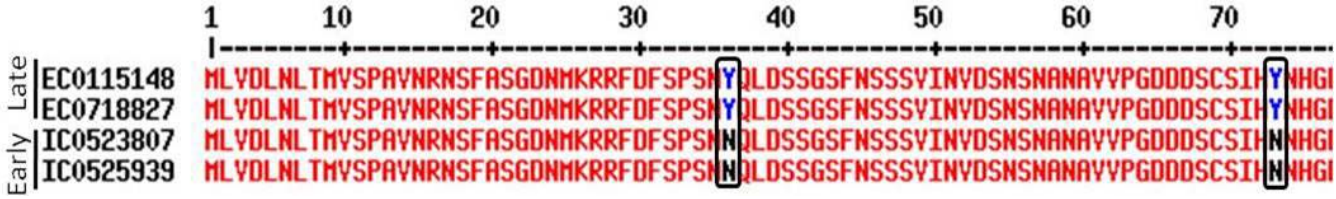


Fig. 5.12. Amino acid sequence alignment of the floral homeotic gene APETALA 2 (AP2) from early and late flowering-maturing accessions of linseed

Tyrosine (Y) at position 36 and 73 in late accessions to amino acid Asparagine (N) in early accessions (Table 5.4, Fig. 5.12). Further, evaluation of 220 accessions at NBPGR research farm, New Delhi during *Rabi* 2018-19 helped identification of four linseed germplasm accessions EC0041700, IC0096489, EC0041469 and IC0525910 for large seed area (>14 mm^2). Four germplasm accessions EC0041700, EC0041469, EC0001475 and EC0001419 were identified for high seed weight (>10 g for thousand seed weight).

5.16 Identification of SNPs in linseed by genotyping by sequencing approach

In order to have an insight into the genetic diversity in the linseed germplasm accessions as well as for genotyping purpose, 131 germplasm accessions were used for generating genome wide SNPs using Genotyping by Sequencing approach (GBS). For 131 accessions, a total of 68925 high quality SNPs were obtained after standard filtrations from the total 2513832 raw SNP. From the selected SNPs, 52% were transitions and 48 percent were transversions (Fig. 5.13). These high quality 68925 SNPs were used for genetic diversity and genetic population structure analysis, which classified the 131 linseed germplasm accessions into four distinct populations, POP-I (73 accessions), POP-II (21 accessions), POP-III (30 accessions) and POP-IV (7 accessions) (Fig. 5.14). POP-I to POP-III showed some degree of admixture among these populations. These SNPs will be used for genome wide association mapping for flowering, maturity and key agromorphological traits in selected set of linseed germplasm accessions.

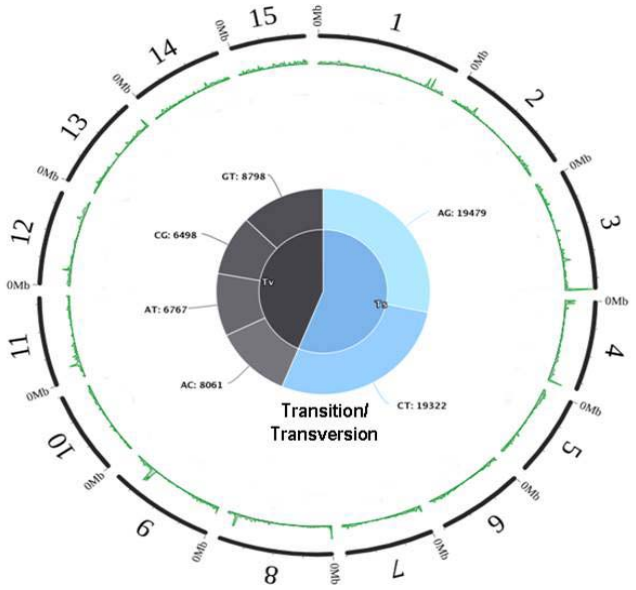


Fig. 5.13. Distribution of SNPs in all 15 chromosomes of *Linum usitatissimum*. Inner pie chart shows transitions and transversions

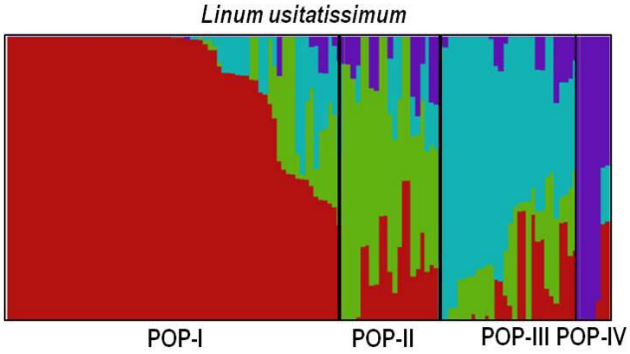


Fig. 5.14. Population genetic structure for 131 linseed germplasm accessions using 68925 SNPs. 131 accessions are placed into four populations (K = 4)

5.17 Sesame characterization and purification of approximately 3000 accessions

In order to undertake the genomic studies in sesame germplasm; preliminarily, 3000 accessions were sown during Feb 2019, at RRS-TNAU,

Fig. 5.15. Selfing of sesame germplasm accessions (three plants per accession) for genomics work. A: clay mixture; B and C: applying procedure (clay mixture) on the flowers prior to opening; D: clay mixture on the flower prevents it from opening and the seeds formed are selfed ones.

Vridachalam. Three plants per accession were selected and the flowers were selfed before anthesis using clay technique (Fig. 5.15). Hence tagged plants were harvested before capsule dehiscence, mature dehisce capsules were plucked and collected in individual cloth bags. They were then dried till the capsule opens, and the seeds were collected, cleaned and packed with labels (Fig. 5.16). The sesame germplasm grown for purification (Fig. 5.17A) was also used simultaneously for preliminary characterization as per the standard sesame descriptor. One accession (EC346151) exhibited pre-harvest sprouting in sesame (Fig. 5.17B), indicating its prevalence in sesame too. A promising accession (EC346441) for number of capsules per plant was identified and found to contain 408 capsules (Fig. 5.17C).

Fig. 5.16. Sesame germplasm purification. Also, signifies the importance of women in agriculture. A-D: labelling and plucking of capsules from harvested plants before dehiscence; E: collected capsules were kept on threshing yard for drying and dehiscence; F: Selfed seeds from dried and dehisced capsules of each of the three plants per accession were cleaned and packed

Fig. 5.17. Field view of the sesame crop grown at TNAU-RRS, Vridachalam; B: Pre-harvest sprouting spotted in sesame accession EC346151; C: Promising accession for the trait – number of capsules per plant (EC346441, 408 capsules) – identified

5.18 Validation of SSR markers in kodo millet

Out of 10,947 primer pairs designed from kodo millet leaf transcriptome, a set of 352 primer pairs was selected and synthesized. These primer pairs were having di-, tri- and hexa-repeats with amplicon size ranging from 100 to 363 bp. The primers pairs were selected based on their annotated functions like transcription factors (GATA, GRAS, bZIP, bHLH, MYB, WRKY, AP2-EREBP, NAM, LOB, GNAT), lipoxygenase, pyruvate kinase, peroxidase,

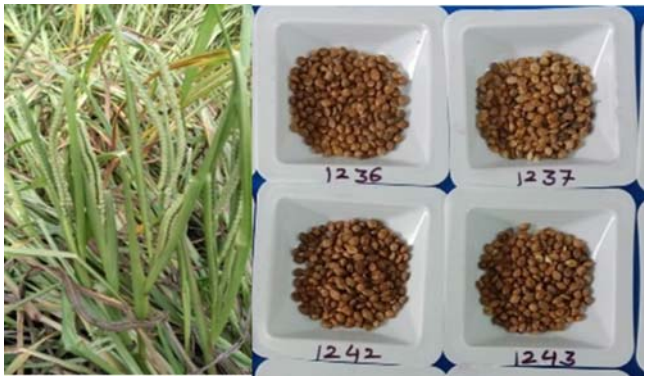


Fig. 5.18. Kodo millet germplasm

endoglucanase, calcineurin B-like protein, glutathione peroxidase, potassium and ammonium transporters, putative disease resistance protein *etc*. These 352 primer pairs were tested in four germplasm lines of kodo millet (Fig. 5.18) and 216 showed amplification and thus could be validated (Fig. 5.19). These will be tested in diverse set of kodo millet accessions for polymorphism study.

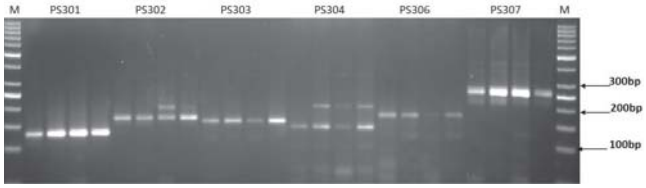


Fig. 5.19. DNA profile of the SSR markers validated in kodo millet along with the plant and seed picture of the germplasm accessions used

5.19 Agro-morphological variability in little millet germplasm

Data entry was completed for days to 50% flowering, tiller number, plant height, flag leaf blade length and width, panicle length and compactness and thousand grain weight (TGW). Of the 1,635 little millet accessions majority of them showed open type panicle compactness followed by intermediate and compact type. Maximum accessions were of late flowering type (>50 days) followed by medium (40-50 days) and early (<40 days) flowering. Most of the accessions have medium tiller number (10 to 20) followed by low (<10) and high (>20) tillers (Fig. 5.20). The little millet accessions showing TGW (Thousand Grain weight) greater than 3.0 g are: IC0483072, IC0483302, IC0482980, IC0482852, IC0345046, IC0483133, IC0483042, IC0404919 and IC0483040.

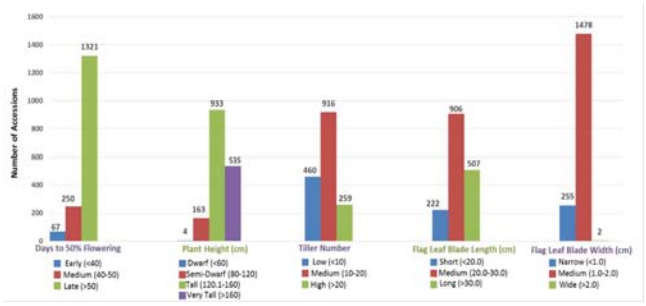


Fig. 5.20. Representation of variability among 1,635 little millet accessions for days to 50% flowering, plant height, tiller number, flag leaf blade length and flag leaf blade width

5.20 Genetic stocks registered

- IC536365 (INGR19007): displayed resistance reaction to all the three rusts pathotypes namely stem rust pathotypes: 40A (62G29) & 40-1(62G29-1); leaf rust pathotypes: 17(61R24), 77A (109R31), 77-5(121R63-1), 77-7(121R127) & 77-8(253R31); stripe rust pathotypes: 46S119, 78S84 & I. Hence, germplasm could be vital source for imparting durable rust resistance in wheat.
- EC574482 (INGR19008): resistant to stem rust pathotypes: 40A (62G29) & 40-1(62G29-1); leaf rust pathotypes: 17(61R24), 77A (109R31), 77-5(121R63-1), 77-7(121R127) & 77-8(253R31); stripe rust pathotypes: 46S119, 78S84 & I. It carries combination of three minor/adult plant rust resistance genes (APR) for leaf rust Lr46/Sr58/Yr29/Pm39/Ltn2, Lr67/Sr55/Yr46/Pm46 Ltn3 and Lr68) and one for stripe rust (Yr48) and two major genes for stripe rust (Yr5 & Yr15) and one for leaf rust (Lr50) hence, could be vital source for imparting durable rust resistance in wheat.
- IC290150 (INGR19046): Resistant to stem rust, leaf rust and stripe rust pathotypes prevalent in Indian condition Based on linked marker analysis, this germplasm has combination of different leaf rust, stem rust, stripe rust and spot blotch resistance genes Lr46+, Lr67+, Yr5, Yr15, Yr36, Yr48, Sr13, Sr24/Lr24, QSb.bhu-2B hence, could be vital source for imparting durable rust resistance in wheat.
- Spot blotch resistant wheat germplasm: IC0529684 (INGR19045): Highly resistant to spot blotch, hence, can be used as source for spot blotch resistance in wheat improvement programme.
- IC0529962 (INGR19044): Highly resistant to spot blotch and stability in yield performance. Hence, could be vital source for imparting spot blotch resistance and high yield in wheat.

5.21 Bioinformatics and NGRR (National Genomic Resource Repository)

A total of 397 Genomic accessions from six species (Cotton 25; Sunflower 96: Rice 151; Linseed 20; *Brassica juncea* 25; Wheat 80) were conserved both at - 70°C as well as -180°C. The current status (as on Dec. 31, 2019) of total collection in National Genomic Resource Repository (NGRC) is 6,177 from 45 species (Fig. 5.21). National genomic resource repository on line database is regularly updated and available for users providing relevant available genomic resource information on ICAR.NBPGR web page (http://www.nbpgr.ernet.in:8080/NPGRR/Home.aspx).

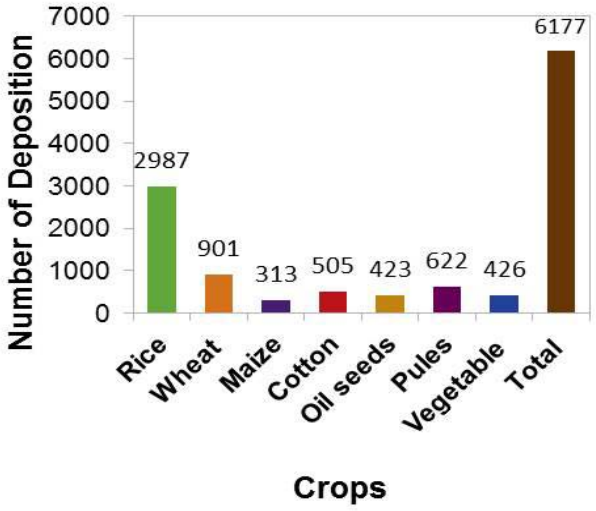


Fig. 5.21. National Genomic resource repository (NGRR), 397 from 6 crops during 2019 (total submissions. 6177 from 45 crops), b). Crop wise depositions as on 31.12.2019

5.22 High performance computational facility (HPC)

High performance computational facility established under NAIP project has been made functional 24 x 7 x 365 days with secured power backup. HPC server has been re-configured with help from CDAC, Pune, to achieve high efficiency in data computation. The facility/services are being extended to researchers from DGR, ICAR-NBPGR & NARS for genomics/bioinformatics related data analysis. Researchers were being trained in genome analysis skills.

Improvement in Pigeonpea genome coverage has been achieved from existing 72.0 % in draft assemblies to 82.4 % in finished genome by adopting new in-house developed assembly frame work pipeline and mate pair techniques (Fig. 5.22 and Table 5.5).

A new bioinformatics computational pipeline has been designed and utilized for improving the coverage of *Cajanus cajan* and Karnal bunt pathogen *Tilletia indica* genome draft assembly sequences. Fifty-four candidate genes involved in *Fusarium* wilt disease resistance in host pigeonpea were predicted from improved pigeonpea genome. Single copy NBS-LRR genes, implicated in *Fusarium* wilt resistant were predicted from improved genome assembly of *Cajanus cajan*, cv. Asha. Isolated resistant genes were used for screening *C. cajan* cultivars for identification of *Fusarium* resistant cultivars during *Kharif* 2011and 2012 seasons at NBPGR, Ranchi farm. Isolated resistant gene sequences were submited to NCBI (KF130786.1 to KF130783.1). Multiple sequence analysis of FAD2 genes from Indian mustard varieties were accomplished.

Table 5.5: Pigeonpea assembly characteristics and Predicted Genes

Parameter	Draft Assembly, A1GCA_000340665.1: 2011	Draft Assembly, A2GCA_000230855.2: 2012	Improved Assembly, NBPGR, A3
Genome coverage	75.6 % (199 x)	72.7 % (160x)	82.4 % (174x)
Scafold length, Mb	599,920,000	592,870,700	548,600,000
Scafold, N50	6041	555,764	574,622
Genes Predicted	56,888	48,680	51,737
F. wilt resistant genes	—	—	54

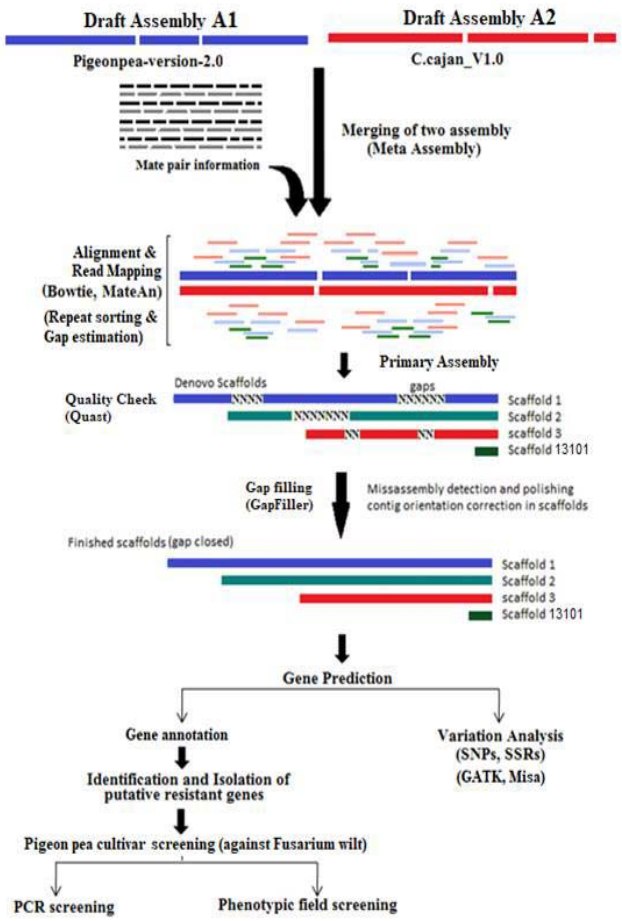


Fig. 5.22. Reassembly of Pigeonpea Genome Experimental Frame work

5.23 GM Detection

5.23.1 Monitoring adventitious presence of transgenes in brinjal collections from North Eastern states and in genebank accessions: Bt Brinjal event EE1 for fruit and shoot borer (FSB) resistance was under field trials in the country. The same event was approved in the neighbouring country Bangladesh in 2013, which shares porous borders with North Eastern states of India. The unintentional introgression and transboundary movement of genetically modified (GM) brinjal needs to be monitored in a systematic way. As an initiative to address these issues, 211 brinjal samples including leaves, fruit peel and seeds were collected from 32 locations of five North Eastern states (Assam, Meghalaya, Mizoram, Tripura and West Bengal) from farmers' fields, vegetable markets and local seed shops. Adventitious presence of transgenes was monitored in these samples employing PCR/ real-time PCR assays targeting cry1Ac gene, CaMV35S promoter, nptII and aadA marker genes. Based on the tests conducted, adventitious presence of transgenes was not detected in any of the collected samples.

Similar study was also conducted in 96 brinjal accessions (collected during 2007-2016 from areas adjacent to Bangladesh), conserved in the National Genebank. Adventitious presence of transgenes was not detected in any of these accessions. This preliminary study showed that brinjal accessions (cultivated and wild) collected from adjoining areas of Bangladesh, post field trials and release, did not contain the event EE1.

5.23.2 Monitoring adventitious presence of transgenes in Indian mustard (*Brassica juncea*) accessions being conserved in the National Genebank: Adventitious presence of transgenes was checked in 160 accessions of Indian mustard from National Genebank (collected from Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand) employing PCR assays targeting CaMV35S promoter and ocs (octopine synthase) terminator. The collection sites represented states/ nearby states where field trials of GM mustard event DMH-11 were conducted in 2010. Based on the screening tests conducted, adventitious presence of transgenes was not detected in the tested samples.

5.23.3 Construct-specific loop-mediated isothermal amplification technology for detection of insect resistant and herbicide tolerant GM events: Screening methods are being widely employed for preliminary testing to check the GM status of samples, which may target control elements, transgenes, and marker genes or construct regions. Among these, construct-specific methods are more specific, which targets the junction between two transgenic elements of the inserted foreign gene cassette.

Visual and real-time loop-mediated isothermal amplification (LAMP) assays (Fig. 5.23) were developed targeting following construct regions:

(i) cry2Ab2-tnos (between cry2Ab2 gene and nos terminator) – for insect resistance

(ii) cp4epsps-tnos (between cp4-epsps gene and nos terminator) – for herbicide tolerance

The developed assays showed acceptable specificity and sensitivity to test for presence of insect resistant and herbicide tolerant GM events. Specificity of each assay was confirmed using a set of 21 test samples including targets and non-targets for respective construct region. Limit of detection of visual LAMP was found up to 0.005% detecting 2 copies of specific GM target. The developed real-time LAMP assays were found effective to detect as low as 4 copies of the target within 40 minutes, making them suitable for on-site GM testing. These assays could be employed by GM testing laboratories to effectively address some of the biosafety and post-release monitoring issues, as well as to check for approved and unapproved GM events in a country.

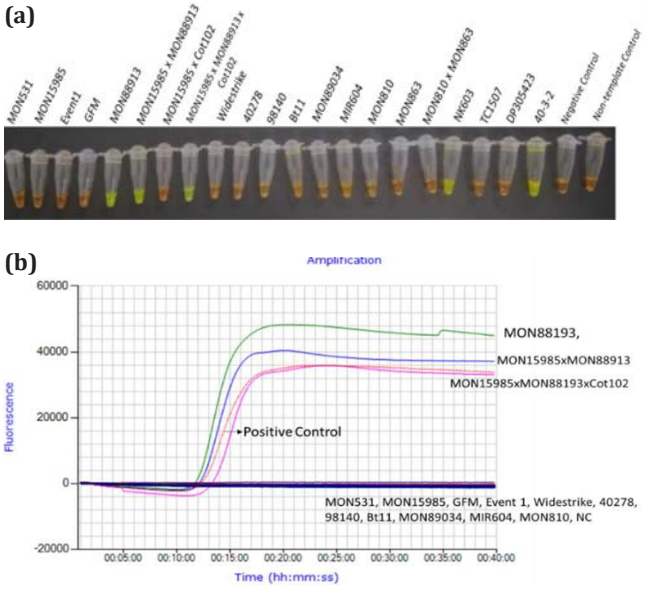


Fig. 5.23. Specificity of (a) visual and (b) real-time LAMP assays targeting *cp4epsps-tnos* construct region. In visual LAMP, change in colour from orange to green indicates positive amplification. In real-time LAMP, positive amplification is detected as amplification curves

5.23.4 Molecular testing of imported transgenic planting material: Four consignments of imported transgenic lines including 4 transgenic lines of three consignments of *Zea mays*, and 19 transgenic lines of one consignment of *Oryza sativa* were received and tested for ensuring absence of embryogenesis deactivator gene (terminator gene technology) employing primers specific for cre recombinase gene. None of these lines showed the presence of terminator gene technology (Fig. 5.24a). These imported lines were also tested for presence of specific transgenic element(s) (Fig. 5.24b).

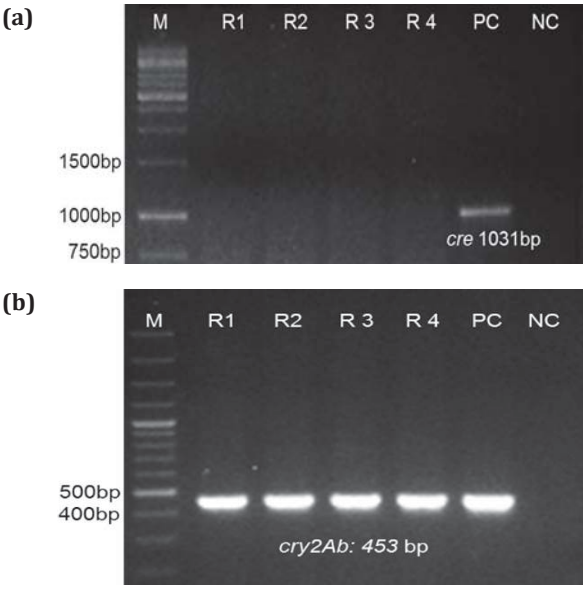


Fig. 5.24. Molecular testing of imported transgenic consignment of *Zea mays* IQ379/2019 (R1-R4, four replicates) (a) to ensure absence of embryogenesis deactivator gene (PC: Positive control giving an amplicon of 1031 bp, NC: Negative control, M: 1 kb DNA ladder); (b) PCR amplification profile for detection of *cry2Ab* gene (PC: Positive control, M: 100 bp ladder)

5.23.5 For quality assurance and global harmonization, participation in the international proficiency testing on GM detection: ICAR-NBPGR participated in the proficiency testing organized by the United States Department of Agriculture, Agricultural Marketing Service, Federal Grain Inspection Service (USDA-AMS-FGIS Proficiency Program – April 2019) to check unknown GM content in maize. Qualitative testing was done for 11 GM maize events, viz., T25, GA21, MON810, NK603, TC1507 (Herculex),

MON863, 59122 (HerculexRW), MIR604, Event 3272, MON89034 and MIR162 in two maize test samples. Qualitative screening for P-35S, P-FMV T-nos was also satisfactorily done. Quantitative analysis for 7 GM maize events (GA21, NK603, MON863, 59122, MIR604, 3272, MON89034) was conducted with satisfactory Z-score (from -2 to +2).

5.23.6 GMO testing of samples: A total of 67 samples of 27 consignments of five crops including brinjal, cotton, papaya, rice, and wheat were tested for checking the GM status or for event confirmation (details are enclosed in Table 5.6), with the revenue generation of Rs 2, 51, 680.

Table 5.6: Details of consignments received for GMO testing during 2019

Crop	No. of Samples	Source	Test
Cotton	02	Surya Seeds Ltd., Guntur	Event confirmation
	02	Surya Seeds Ltd., Guntur	
	02	Surya Seeds Ltd., Guntur	
	04	Surya Seeds Ltd., Guntur	
	04	Accurate Biotech Seed India Pvt. Ltd. Guntur	
	04	Shatavahan Biosciences Pvt. Ltd., Hyderabad	
	04	Sun Seeds and Biosciences, Hyderabad	
	03	Surya Seeds Ltd., Guntur	
Papaya	02	DPPQ&S, Regional Plant Quarantine Station (PQS), Rangpuri, New Delhi*	GM status
	04	East West Seeds India Pvt. Ltd., Aurangabad (Through PQS, Mumbai)	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	01	DPPQ&S, Regional Plant Quarantine Station, Rangpuri, New Delhi*	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	03	East West Seeds India Pvt. Ltd., Aurangabad (Through PQS, Mumbai)	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	01	DPPQ&S, Regional PQS, Rangpuri, New Delhi*	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	02	DPPQ&S, Regional PQS, Rangpuri, New Delhi*	
	01	DPPQ&S, PQS, Bengaluru*	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	01	Known-You Seed (India) Pvt. Ltd., Pune (Through PQS, Mumbai)	
	01	DPPQ&S, PQS, Bengaluru*	
Wheat	12	Food Corporation of India (FCI), Regional Office, Bhopal*	GM status
	04	FCI, Regional Office, Bhopal*	
Brinjal	02	District Horticultural Office, Fatehabad*	GM status
Rice	02	Nature Bio-Foods Limited, Sonepat	GM status

**Received from public sector*

5.23.7 New Initiative: GM detection in processed food derivatives: As per the proceedings of the Review meeting of activities of ICAR Bureaus held on 28 Aug 2019, the work on employing GM diagnostics for food derivatives has been initiated. Based on the GM events of crops such as canola, corn (maize), potato, soybean approved in different countries, matrix for different food derivatives was identified. DNA extraction protocols have been standardized using modified CTAB method or commercial kit and PCR amplifiability with endogenous gene specific assays has been confirmed (Fig. 5.25) for different food matrices – Canola Oil, Cornflakes, Corn Soup, Puff Corn, Packed Cornflour, Packed Corn, Corn Biscuits, Soy Milk, Soy Chunks, Potato Chips, Baby food (Infant cereal, Milk Powder),

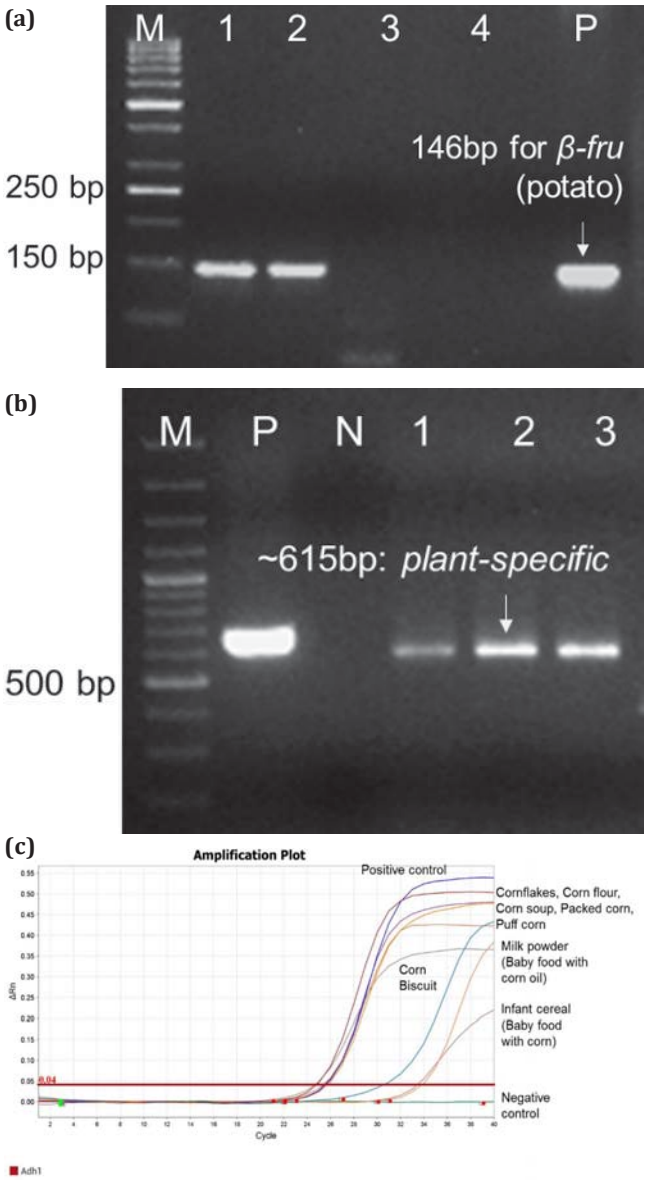


Fig. 5.25. PCR/Real-time PCR profiles to confirm the amplifiability of DNA samples of food derivatives using endogenous gene specific PCR assay (a) for Canola Oil (M: 100 bp ladder, 1-3; Canola Oil, P: Positive control, N; Negative control); (b) for potato and tomato products (M: 50 bp ladder, 1-2: Potato chips, 3-4: Negative controls, P: Positive control), (c) for maize/corn products (Real-time PCR amplification profile)

I. Success Story: Commercialization of duplex TaqMan® real-time PCR technology

The technology was transferred to DSS Imagetech Private Limited in 2015, which was launched as GMO Screening and Quantification Kit by the company for screening of GM events in major crops including cotton, maize, rice, soybean, wheat, canola, mustard (Fig. 4). The kit provides an efficient GMO screening tool to check the GM status of a sample in a rapid/cost-efficient way. The kits are in use by over 15 Food Testing and Food Processing Laboratories in the country.

Fig. 5.26. GMO screening and quantification kit by DSS Imagetech Pvt. Ltd.

As an outcome, DSS Imagetech Private Limited has invited ICAR-NBPGR for collaboration for the BIRAC (BIPP Scheme) Funded Project on GM detection entitled "Validation Trial, Field Trial, Scale-up and Commercialisation of two products, a. Real Time PCR Assay and b. LAMP based assay for the identification of GM crops by detecting specific molecular markers as well as common genetic elements", which has been implemented w.e.f. October 2019, in collaboration.

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

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

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

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

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

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

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

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

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

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

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

DIVISION OF GERMPLASM CONSERVATION 6

Summary: Thirty one thousand four hundred fifty five (31,455) accessions of germplasm, including regenerated germplasm, varieties to be notified, released varieties 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 12,255 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 4,43,921. Of the conserved accessions, 4,203 were new and 8,052 accessions were received after regeneration. Monitoring of germination and seed quantity in stored germplasm (9,573 accessions) and distribution (56,481) for characterization/evaluation/regeneration/research were the other priority activities. The germplasm supplied includes those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). Studies on the seed storage behaviour of *Euryale ferox* (Makhana) revealed its orthodox nature. Procedure for its seed moisture testing (high temperature oven method) and quick viability testing using TTZ was also standardized. Study on contribution of indigenous landraces in the Indian rice varietal development revealed that 517 Indian landraces are involved in the pedigree of rice varieties released in India. Upgradation / Modernization of National Genebank was undertaken and 11 LTS and 3 MTS new modules have been commissioned.

In the National Genebank, conservation of seeds of various agri-horticultural crops under long term (LTS, at -18^{0}C) and medium-term storage (MTS, at +8^{0}C^{-hr}) 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 has been the other important activity, to facilitate their use in crop improvement programmes.

6.1 Germplasm augmentation

A total of 31,455 germplasm accessions of various agri-horticultural crops were received for long-term conservation in the National Genebank, these include 24,100 germplasm accessions regenerated under the CRP-AB project; 12,255 accessions qualified for conservation as per the genebank standards were conserved at –18±2^{0}C as base collections. Of the conserved accessions, 4,203 were new and 8,052 accessions were received after regeneration (Table

Table 6.1: Status of germplasm holdings in the National Genebank (as on December 31, 2019)

Crop/Crop Group	No. of Acc. conserved during (01/01/2019 to 31/12/2019)				Present Status
	Regenerated Acc.	New Acc.	New Species Added	Total Species	
Cereals	2,451	623	11	134	1,64,842
Millets	2,843	300		26	59,413
Forages	28	183	4	198	7,249
Pseudocereals	50	223	1	55	7,753
Grain legumes	112	597	8	108	66,819
Oilseeds	1,378	1,511	6	85	60,345
Fibre	0	53		77	15,746
Vegetables	939	478	6	213	26,786
Fruits & Nuts	0	5	2	67	280
Medicinal & Aromatic plants	11	99	4	677	8,126

Crop/Crop Group	No. of Acc. conserved during (01/01/2019 to 31/12/2019)				Present Status
	Regenerated Acc.	New Acc.	New Species Added	Total Species	
Ornamentals	0	9	1	121	666
Spices, condiments and flavour	240	115		28	3,237
Agroforestry	0	7	1	191	1,653
Duplicate safety samples	0	0		-	10,235
Trial material (wheat, barley)	0	0		-	10,771
Total	8,052	4,203*	44	1,980	4,43,921*

* The figure includes germplasm of varieties proposed for released/notification and genetic stocks

6.1). 386 accessions were rejected during quarantine examination. Accessions which did not qualify the genebank standards in terms of seed quantity were stored in MTS and will be multiplied subsequently for further long-term conservation.

Among the new accessions added to the genebank, oilseeds (1,511),cereals (623) and legumes (597) comprised a major portion of germplasm followed by vegetables (478), millets (300), pseudo-cereals (223), forages (183), spices & condiments (115), medicinal aromatic plants (99) and fibres (53). The total germlasm holdings in the National Genebank has increased to 4,43,921; representing 1,980 species (including 10,771 trial material and 10,235 accessions of lentil and pigeonpea as safety duplicates). Accessions received after regeneration (8,052) belonged to cereals (2,451), millets (2,843), pulses (112), oilseeds (1,378), vegetables (939), medicinal and aromatic plants (11), spices and condiments (240), forages (28) and pseudo- cereals (50) crop groups.

In addition, 4,739 vouchers samples of exotic germplasm of agri-horticultural crops received from different parts of the world were stored in medium term storage by the respective crop curators for further multiplication and maintenance. The received accession comprised of cereals (1,665), vegetables (1,818), grain legumes (63), spices (98), oilseeds (1,081) and others (14).

6.2 Monitoring of germplasm

Germplasm conserved in the long-term storage condition for >10 years (9,573 accessions) were monitored for seed viability and seed quantity, to ensure the status of the conserved germplasm as per the genebank standards (Table 6.2). The accessions showing less than 85% of the initial germination will be regenerated to replace low viability seeds in genebank.

6.3 Distribution of germplasm for characterization, regeneration and utilization

A total of 56,481 accessions were supplied for utilization by different stakeholders. Most of the accessions were distributed for research, regeneration, characterization (under CRP on Agrobiodiversity) and evaluation. The details are given in Table 6.3.

6.4 Upgradation / modernization of national genebank, documentation and database management

The existing LTS and MTS facility at NGB was installed and commissioned in 1995-1996 and had 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

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

Crop	Numbers of accession tested for viability	Initial viability range(%)	Present viability range(%)	No. of accessions identified for regeneration
Paddy	1,172	80-100	40-100	112
Maize	763	85-100	80-100	3
Barley	360	90-100	90-100	0
Sesame	100	90-100	85-100	-
Mustard	200	92-100	90-100	-
Groundnut	220	85-100	72-100	8
Niger	100	95-100	90-100	-
Soybean	150	85-100	70-100	12
Ridge Gourd	73	70-90	70-90	-
Pumpkin	177	70-90	40-50	5
Ash gourd	189	70-90	40-50	10
Cucumber	359	70-90	40-50	15
Sponge gourd	222	70-90	40-50	7
Amaranth	3,241	90-100	86-100	
Lentil	350	90-100	85-100	-
Tagetes,	53	70-96	40-96	16
Atriplex	42	70-96	88-96	11
Cotton	1,670	65-100	20-100	1,035
Jute	6	85-100	80-100	6
Sunhemp	2	85-100	75-100	2
Forages	124	20-100	10-100	8
Total	**9,573**			**1,250**

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

Crops (No. of accessions)	Purpose	No. of accessions
Paddy (7337), finger millet (2000), foxtail millet (339), sorghum (2050), pigeonpea (1200), maize (1846)*, *Brassica* (1195), niger (1807)	CRP (AB)	17,774
Paddy (5000), linseed (138), groundnut (59), sesame (867), okra (748), oat (132)	Regeneration and/ or evaluation	6,944
Paddy (400), *Atriplex* (11), tobacco (41), jute and allied fibers (269), guar (50), cotton (224)	Multiplication / characterization	995
Paddy (677), pea (5030), horsegram (3444), cowpea(5319), mungbean (5243), lentil (194), lathyrus (11), sem (177), *Vigna vexillata* (89) chickpea (5), pigeonpea (904), urdbean(13), cucumber (321), *Cucumis* species (267), brinjal (250), bitter gourd (175), tomato (40), cauliflower (150), muskmelon (10), maize (30), wheat (4535), amaranth (3273), *Andrographis* (28), *Mimosa pudica* (24), *Ocimum* (87), *Physalis alkekengi* (1), *Decalepis hamiltonii* (5), *Avena* (454), *Teosinte* (8), *Pennisetum* (4)	Research	30,768
	TOTAL	**56,481***

*Figure includes those characterized under CRP-AB.

Genebank facilities with updated technology of refrigeration and operation, including spare parts, accessories, and equipment are being concluded by M/s Controlled Environment Ltd (CONVIRON) Canada. So far 11 LTS and 3 MTS have been commissioned (Fig. 6.4).

Management of MTS and LTS facilities

Operation of 12 Long Term Storage (LTS) and 5 Medium Term Storage (MTS) modules, seed dryers and other facilities have been maintained without any AMC. Repairing works of condensing unit of refrigeration system, 32KVA, 48KVA stabilizers, recharging of R-22 gas, Recharging of compressor oil, walk-in drying facility, seed drying cabinets etc. have been done in National Genebank.

Technical support for NAGS, Agriculture Universities and Research Institutes

- Technical know-how of low cost conservation (MTS) and detail layout drawing, specifications of MTS were provided to for Directorate of Research, Sher-E-Kashmir University of Agricultural Science and Technology of Jammu, ICAR-IIHR, Bangalore University. Agricultural University, Jodhpur, Basmati Export Development Foundation, SVBPUA&T Campus, Meerut.
- Assistance in preparing technical specifications for dehumidifier and spares was provided to ICAR-NBPGR Regional station, Hyderabad. Bhowali, Akola , and Thrissur.

6.5 Supportive research

6.5.1 Determination of seed storage behaviour of *Euryale ferox* (Makhana)

Euryale ferox (Nymphaeceae), commonly known as Makhana, is an aquatic medicinal plant grown for its edible starchy seeds, which are beneficial to person suffering from high blood pressure, heart diseases and obesity due to their high magnesium and low sodium content. Though there is abundant diversity for this species, no efforts have been made for it's *ex situ* conservation due to lack of information pertaining to its seed storage behaviour. Hence, a detailed study was conducted to determine whether the seeds have orthodox seed storage behaviour and also to standardize the basic seed processing protocols. The experiment revealed that *Euryale* seeds do not lose their viability below 7% seed moisture content and hence it qualifies as an orthodox seed. In order to chart out a protocol for processing of *Euryale* for long term conservation, the procedure for seed moisture testing (high temperature oven method) and quick viability testing using TTZ was also standardized, since they are not available in the ISTA protocol (Fig. 6.5 & 6.6).

Fig. 6.4. Work in progress for upgradation /modernization of National Genebank

Fig. 6.5. Germinated seed of *Euryale ferox*

Fig. 6.6. TTZ stained viable embryo of *Euryale* seed having moisture content below 7%

6.5.2 Study of contribution of indigenous landraces in the Indian rice varietal development

A study was conducted to know the germplasm flow in the Indian rice varietal development and ascertain the contribution of indigenous landraces utilized by compilation of the pedigree data of 1681 Indian released varieties (RV) till the terminal ancestors. Of these, 1,031 are also notified varieties and 445 are released prior to 1960s. 63 RVs lacked pedigree information. A pedigree compilation and sanctity check was made using custom excel sheet (VBA code) (Fig. 6.7). A total of 5,130 lines/crosses and 4,862 germplasm lines were involved in the development of RVs. The analysis based on Pedigree database model revealed that 517 Indian landraces are involved in the pedigree of rice varieties released in India. The frequency of landraces varied from 0-15 in a pedigree of RVs. The majority of direct selections from landraces are in the varieties released prior to 1960s and immediately after the Seeds Act, 1966, since the major breeding strategy was pure line selection from the existing landraces in cultivation. Further, 834 varieties are derived from existing released varieties through selection or hybridization. This study shows the extent and pattern of Indian landrace germplasm utilization and emphasizes the importance of their collection, conservation, characterization, evaluation and utilization in the rice improvement programme in India.

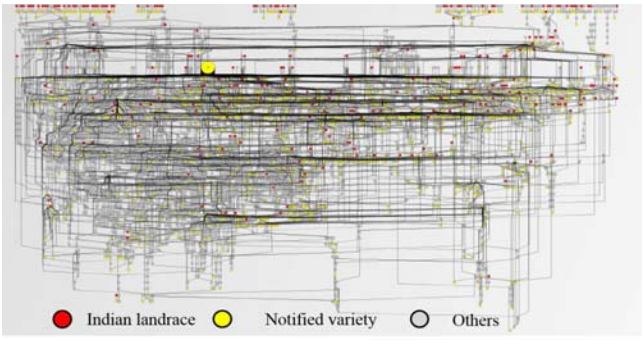


Fig. 6.7. Pedigree database analysis of 1647 Indian rice varieties

6.6 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. During the

Table 6.4: Status of registered genetic stocks in the National Genebank (as on December 31, 2019)

Crop-group wise germplasm registered		
Crop group	**Current status**	**Registered during January 01, 2019-December 31, 2019**
Cereals and pseudocereals	543	41
Millets	82	-
Fibre and forages	119	5
Grain legumes	151	13
Vegetables	84	3
Commercial crops	100	-
M & AP and spices	91	9
Ornamentals	62	6
Oilseeds	203	21
Fruits and nuts	44	2
Tubers	39	2
Agro-forestry	8	1
Grand total	**1,526**	**103**

Fig. 6.8. (IC113045; INGR19055), an extra dwarf plant of six-rowed and hulled Barley (*Hordeum vulgare*) with early maturity

Fig. 6.9. (IC0629501; INGR19031), a Flame of Forest (*Butea monosperma*) with trifoilate leaflet with larger dull orange flower and early biological maturity

Fig. 6.10. (IC0627616; INGR19014), a semi erect Chickpea (*Cicer arietinum*) germplasm resistant to wilt

period under report two PGRC meetings (XXXIX and XXXXth) were held at ICAR-NBPGR, New Delhi on January 28, 2019 and October 21, 2019, respectively, under the Chairmanship of Dr AK Singh, DDG (CS) ICAR, New Delhi. Out of the 158 proposals submitted, 131 were considered for registration. Finally, 103 proposals belonging to 40 species were approved for registration (Table 6.4). Some notable registered germplasm were: rice tolerant to alkalinity stresses up to pH 9.9 and salinity stresses up to EC 10.0 dS/m with long slender grain; wheat soft grain genotype (very low grain hardness index), suitable for biscuit making; Barley with high grain zinc content; Buffel grass rich in sugar (more than 7%), suitable for ensiling; multi -poded pea genotype; pistillate line in castor with papaya leaf type and non-spiny capsules; Safed musli with high root weight, high saponin; *Butea monosperma* with trifoilate leaflet Larger dull orange flower and early biological maturity (Fig. 6.8-6.10).

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

PGR/GCN-BUR-DEL-01.00: *Ex situ* conservation of plant genetic resources of agricultural and horticultural crops using conventional methods **(Veena Gupta**)

Research projects (PI; Co PI; *Associate/s***)**

PGR/GCN-BUR-DEL-01.01: Management of Information and National Germplasm Conservation Network and associated research **Anjali Kak Koul,** Sunil Archak, J. Aravind, *Rajvir Singh, Smita Jain, Rajiv Gambhir, S.P Sharma* and *Nirmala Dabral*)

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

PGR/GCN-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods and associated research (**S Vimala Devi,** J Aravind, Sherry Rachel Jacob and *AD Sharma*)

PGR/GCN-BUR-DEL-01-04: Conservation of oilseed germplasm using conventional seed storage methods and associated research. (**J Radhamani**, Neeta Singh, Sherry Rachel Jacob and J Aravind)

PGR/GCN-BUR-DEL-01-05: Conservation of cereal germplasm excluding paddy, using conventional seed storage methods and associated research. (**Sherry Rachel Jacob**, J Radhamani and Padmavati G. Gore)

PGR/GCN-BUR-DEL-01-06: Conservation of pseudo-cereals, medicinal and aromatic plant, narcotic and spices germplasm using conventional seed storage methods and associated research (**Veena Gupta**, Anjali Kak and Padmavati G. Gore)

PGR/GCN-BUR-DEL-01-07: Conservation of millets germplasm using conventional seed storage methods and associated research (**Sushil Pandey**, Chithra Devi Pandey and S Vimala Devi)

PGR/GCN-BUR-DEL-01-08: Conservation of forage and fibre germplasm using conventional seed storage methods and associated research (**Anjali Kak** and Veena Gupta)

PGR/GCN-BUR-DEL-01-09: Conservation of vegetable germplasm using conventional seed storage methods and associated research (**Chithra Devi Pandey**, Neeta Singh and Sushil Pandey)

TISSUE CULTURE AND CRYOPRESERVATION UNIT 7

Summary: Cultures of 1,886 accessions of 145 plant species of different horticultural crops were conserved in the *In Vitro* Active Genebank at ambient and/or at low temperature, with subculture duration ranging from 2-24 months. A total of 13,896 accessions of agri-horticultural species were conserved as seeds, embryonic axes, pollen and genomic resources in the cryogenebank. New accessions (27) added *in vitro* were of *Actinidia chinensis* (5), *Acorus calamus* (1), *Allium chinense* (2), *Dioscorea deltoidea* (2), *Ensete glauccum* (1), *Hedychium coronarium* (1), *Malus domestica* (4), *Musa* spp. (5) and *Prunus* spp. (6). A total of 533 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. *In vitro* multiplication and conservation protocols were refined in *Elettaria cardamomum, Hedychium* spp. and *Vanilla planifolia*. Varying degrees of success was achieved in cryopresevation experiments using vitrification, encapsulation-dehydration, encapsulation-vitrification, droplet vitrification and V- and D-cryoplate techniques, in *Allium chinense*, *A. fasciculatum*, *A. fistulosum*, *A. lineare*, *Bacopa monnieri*, *Colocasia esculenta*, *Dahlia*, *Dioscorea deltoidea*, *D. floribunda*, *D. rotundata*, *Ensete glaucum*, *Fragaria*, *Gentiana kurroo*, *Humulus lupulus* and *Stevia rebaudiana*. *In vitro* cryobanking was done in *Allium* spp. (10), *Bacopa monnieri* (5), *Dioscorea deltoidea* (6), *Ensete glaucum* (1), *Gentiana kurroo* (3), *Malus* sp. (21) and *Musa* spp. (10). Cryopreserved accessions revealed high level of genetic similarity in profiles of cryopreserved and regenerated plantlets and their respective controls in *Allium* spp. (using 30 SSR markers) and *Gentiana kurroo* (using 30 SSR and 39 ISSR markers). A total of 533 accessions were cryostored as seeds, embryonic axes, pollen, dormant buds and genomic resources at temperatures between -160°C to -180°C. Periodic testing for viability of 62 accessions of orthodox and non-orthodox seeds revealed retention of original viability in most of the accessions after 22-31 years of cryostorage.

7.1 Conservation of vegetatively propagated/ horticultural crops

7.1.1 Germplasm maintenance

A total of 1,886 accessions of different horticultural crops were conserved in the form of 37,300 *in vitro* cultures and/or *in vitro* cryopreserved meristems/shoot tips in the *In Vitro* Active Genebank (IVAG) or *In Vitro* Base Genebank (IVBG), respectively (Table 7.1). Cultures of mandated crops in IVAG are normally conserved at 25±2°C under 16 h photoperiod, and in some species, at low temperature (8-10°C, in dark). The average subculture period under these conditions varied from 2-24 months, depending on the species/genotype and the conservation strategy employed.

7.1.2 Germplasm augmentation and addition

During the period under report, germplasm augmented for its conservation in IVAG/IVBG comprised 153 accessions including *Malus domestica* (21) and *Prunus* spp. (6) from CITH, Srinagar; *Malus domestica* (27) from RS, Shimla; *Dioscorea deltoidea* (10) from Kashmir; *Podophyllum hexandrum* (1) from Sikkim; *Allium sativum* (25 accessions representing the core collection from ICAR-DOGR, Pune) and *A. schoenoprasum* (6) from RS, Bhowali. In addition to this, exotic *Actinidia* sp. (27 accessions) were received from Germplasm Exchange Unit. Under two focused projects on *Musa*, 15 accessions of crop wild relatives (CWR) *viz. Musa acuminata, M. balbisiana* var. *andamanica, M. indandamanensis, M. kattuvazha* and *M. sikkimensis* were procured in the form of seeds/male flower buds from Great Nicobar, Andamans and North-eastern region (NER). Fifteen accessions of cultivated banana were also received from Pithoragarh and NER for conservation.

Based on collections received, a total of 27 new accessions of seven genera viz., *Actinidia chinensis* (5), *Acorus calamus* (1), *Allium chinense* (2), *Dioscorea deltoidea* (2), *Ensete glaucum* (1), *Hedychium coronarium* (1), *Malus domestica* (4), *Musa acuminata* (1), *M. balbisiana* (2), *M. kattuvazha*

Table 7.1: Status of *in vitro* conserved germplasm in IVAG/IVBG (as on Dec. 31, 2019)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	No. of Accessions (% of total)	Major collections (no. of accessions)
Tropical fruits (banana)	2	18	10,000	**435 (23%)**	*Musa* spp. (**435**)
Temperate and minor fruits (apple, apricot, blackberry, blueberry, pear, strawberry)	10	42	8,500	**360 (19%)**	*Actinidia* spp. (11), *Aegle marmelos* (2), *Artocarpus lakoocha* (1), *Fragaria* x *ananasa* (81), *Malus domestica* (33), *Morus* spp. (61), *Prunus* spp. (15), *Pyrus communis* (73), *Rubus* spp. (62), *Vaccinium* spp. (21)
Tuber crops (sweet potato, taro, yam)	5	14	6,500	**518 (28%)**	*Alocasia indica* (4), *Colocasia esculenta* (90), *Dioscorea* spp. (153), *Ipomoea batatas* (261), *Xanthosoma sagittifolium* (10)
Bulbous and other crops (garlic, gladiolus)	4	13	4,000	**171 (9%)**	*Allium* spp. (157), *Dahlia* sp. (6), *Gladiolus* sp. (7), *Cicer microphyllum* (1)
Medicinal and aromatic plants	25	34	4,000	**175 (9%)**	*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 (12%)**	*Curcuma* spp. (110), *Elettaria cardamomum* (5), *Humulus lupulus* (8) *Piper* spp. (7), *Simmondsia chinensis* (12), *Stevia rebaudiana* (1), *Vanila planifolia* (4), *Zingiber* spp. (80)
TOTAL	**54**	**145**	**37,300**	**1,886**	

(1), *M. sikkimensis* (1) and *Prunus* spp. (6) were added into IVAG.

7.1.3 *In vitro* cryobanking

Cryobanking from *in vitro* derived shoot-tips was initiated in one new species, *Allium lineare* (EC328492) and three new accessions of *A. chinense* (IC627868, IC630346, IC623461) whereas it was continued in six accessions including *A. albidum* (EC328484), *A. chinense* (IC613375, IC623455), *A. hookeri* (IC623454), *A. scorodoprasum* (EC328500) and *A. tuberosum* (IC353524) based on the protocols developed earlier. Among the medicinal plants, cryobanking was done in *Bacopa monnieri* (5), *Gentiana kurroo* (3) and *Dioscorea deltoidea* (6). In bananas, four cultivated varieties (IC250813, IC250566, IC250642, IC251153,) were cryobanked using shoot tips and seven CWRs (*M. balbisiana, M. cheesemanii, M. indandamanensis, M. itinerans, M. saddalensis* and *Ensete glaucum*) were cryobanked using excised zygotic embryos (Table 7.2). Thus a total of 35 accession were cryobanked, taking the total of IVBG to 217.

7.1.4 *In vitro* germplasm supply for utilization

Repatriation of *in vitro* conserved taro (*Colocasia esculenta* L.) germplasm to the farmer's field: Genetic erosion in taro is one of the highest in India due to changed cropping pattern to monoculture and replacement of landraces by improved varieties. However, few progressive farmers from Kerala requested NBPGR to repatriate lost landrace diversity in homestead farms. Accordingly, 40 traditional accessions of taro, which were collected and conserved in the IVGB from the last 20 years were multiplied, *in vitro* micro-corms with roots were induced, hardened and sent to ICAR-NBPGR, RS, Thrissur (Fig. 7.1). After preliminary establishment in polybags, ready-to-transplant plantlets were supplied to three selected volunteer

Table 7.2: Status of germplasm cryobanked in the IVBG (as on Dec. 31, 2019)

Crop/Species	Accessions added during 2019	Total no. of accessions in IVGB	Technique(s)*	Explant(s)#
Allium sativum	0	68	V, DV	ST
A. albidum	1	1	V, DV	ST
A. chinense	5	7	V, DV	ST
A. hookeri	1	2	V, DV	ST
A. lineare	1	1	DV	ST
A. ramosum	0	1	V, DV	ST
A. scorodoprasum	1	1	V, DV	ST
A. tuberosum	1	3	V, DV	ST
Bacopa monnieri	5	7	V, DV	ST
Dioscorea bulbifera	0	2	V	ST
D. deltoidea	6	12	V	ST
Ensete glaucam	2	2	AD	ZE
Gentiana kurroo	3	3	V	ST
Musa spp.	4	74	DV, V, AD	SM, ECS, ZE
M. acuminata	0	6	DV	SM, ZE
M. balbisiana	1	7	AD, DV	SM, ZE
M. cheesemanii	1	1	AD	ZE
M. indandamanensis	1	1	AD	ZE
M. itinerans	1	1	AD	ZE
M. ornata	0	1	AD	ZE
M. puspanjaliae	0	1	AD	ZE
M. saddalensis	1	1	AD	ZE
M. textilis	0	1	DV	SM
Rubus hybrid	0	6	ED	ST
Vaccinium ovatum	0	7	ED	ST
TOTAL	**35**	**217**		

*__AD__: Air dehydration; __DV:__ droplet vitrification; __ED:__ Encapsulation-dehydration; __EV:__ Encapsulation-vitrifcation; __V:__ Vitrification;
__ECS:__ Embryogenic cell suspension __DB:__ : Dormant bud; __SM:__ shoot meristem; __ST:__ shoot tip; __ZE:__ Zygotic embryo

farmers for their feedback and enhancement of genetic diversity of taro in homesteads. This helped the farmers to increase the genetic diversity of the taro collections with the aim to revive some of the old landraces of Kerala. Performance of the restored landraces is being monitored for two cropping seasons in terms of response to stresses, palatability and consumer/farmers preferences. Based on the on-farm results, the promising accessions will be further extended to tribal areas under various ICAR outreach programmes.

Table 7.3: Supply of *in vitro* cultures

Crop/Species	No. of Accessions/plants supplied	Beneficiary institute	Remarks
Artocarpus lakoocha	One accession	Dept. of Horticulture, (SVBPUA & T, Meerut)	For research purpose
Banana	Four accessions of *Musa* (Grand Naine, Elakkie Bale, Udhayam and Red Banana)	College of Agriculture, (SVPUA&T), Meerut	For research purpose
Plumbago zeylanica	13 accessions	Delhi Technical University	For research purpose
Temperate fruit crops	92 *in vitro* rooted plants of 51 accessions *viz.*, *Rubus* (44 accs.; 78 plants), *Pyrus* (3 accs.; 6 plants) and *Vaccinium* (4 accs.; 8 plants)	RS, Shimla	For hardening and field evaluation

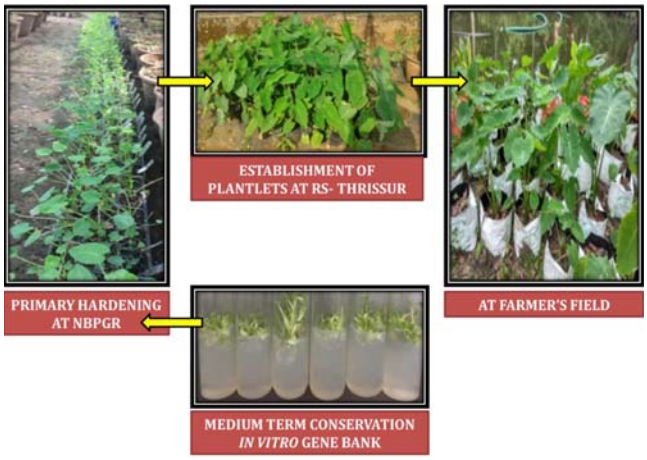


Fig. 7.1. Repatriation of taro germplasm in Kerala

7.2 Supportive Research

7.2.1 Micropropagation and slow growth protocols

7.2.1.1 Slow growth of *Allium chinense:* Shoot cultures of four accessions (IC623459, IC613375, IC623458 and IC623455) maintained on shoot multiplication medium (B5 + 0.1 mg/l naphthalene acetic acid (NAA) + 0.5 mg/l isopentenyladenine (2iP)] for 3 years at 8°C in dark, exhibited 32-48% regrowth upon subculture to fresh medium.

7.2.1.2 Micropropagation in *Hedychium* spp.: Experiments were conducted in *Hedychium coccineum* and *H. spicatum* for rapid multiplication using rhizome buds as explants. Of the 17 media tested, multiple shoot formation (4-5 shoots/explant) occurred on medium with Murashige and Skoog (MS) salts + 6-benzyl amino purine (BAP) (4.0 mg/l) + NAA (0.4 mg/l). Experiments are continued for optimization of rooting and hardening.

7.2.1.3 Micropropagation protocol in *Elettaria cardamomum*: Shoot primordia in one accession (IC349370) were cultured on 45 media combinations for multiple shoot induction, and optimum proliferation (5.83 shoots/explant) was observed on MS medium + 4.4 µM BAP + 2.32 µM Kinetin (Kn), and largest shoots (6 cm) on MS medium + 0.44 µM BAP and 2.32 µM Kn, 12 weeks after culture (Fig.7.2 a, b). Eight media combinations were tested for induction of root and highest number of well-developed roots (3.5 roots/explant) were observed on MS basal medium, with an average root length of 4.3 cm (Fig.7.2c). Thereafter, 60 rooted plantlets were hardened in soilrite and 80% survival was recorded three weeks after transfer. The developed protocol was successfully applied to four other cardamom accessions, viz., IC349371, IC349372, IC349373 and IC349374.

7.2.1.4 Direct protocorm-like bodies (PLBs) induction and proliferation in *Vanilla planifolia*: For rapid multiplication, protocol for induction of PLBs directly from nodal explants was developed in *Vanilla planifolia* (IC573993). A total of 16 combinations of plant growth regulators, namely, benzyl adenine (BA), zeatin and NAA, were evaluated

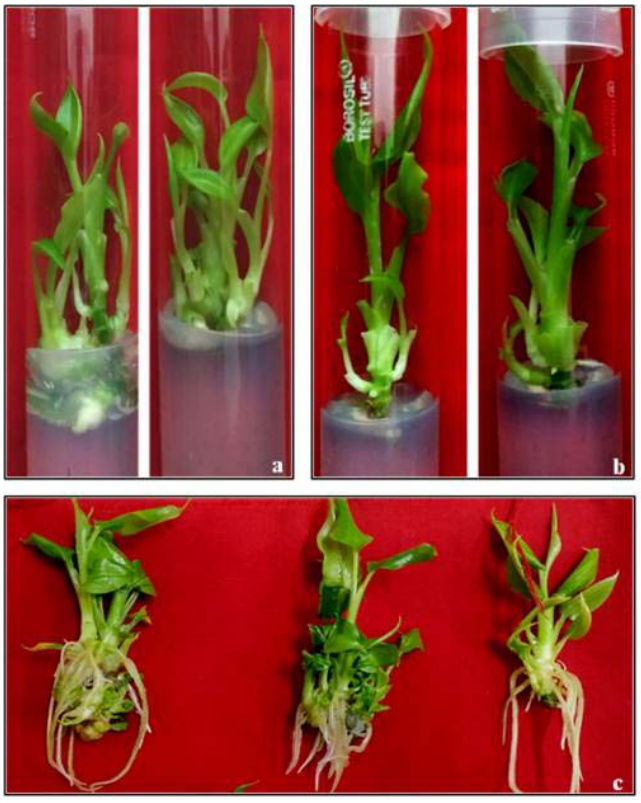


Fig. 7.2. *In vitro* multiplication of *Elettaria cardamomum*: (a) multiple shoot induction (b) shoot elongation and (c) rooting of shoots

for the induction of PLBs directly on vanilla nodes. MS medium + 6.66 ìM BA + 10.75 ìM NAA was the most effective in inducing an average of 4.83 PLBs/ explant in 93% of the explants, within 15 days of culture. PLB proliferation was tested in four media combinations containing BAP, NAA and peptone, both in semi-solid and liquid state. Shiny white, elongated protocorms proliferated on all the tested media, with the highest rate of PLB proliferation on peptone-supplemented semi-solid PLB induction medium.

7.2.1.5 *In vitro* establishment of *Amorphophallus paeoniifolius* (elephant foot yam): Seeds of this underutilized tropical tuber crop were highly recalcitrant. Hence, efforts were made for *in vitro* culture establishment. Seeds were surface-sterilized and cultured on MS basal medium and MS supplemented with various growth regulators including auxins (IAA, NAA) or cytokinins (BAP, Kinetin) alone or in combinations. Plantlets have been established *in vitro* on MS medium supplemented with a combination of NAA and BAP (Fig. 7.3).

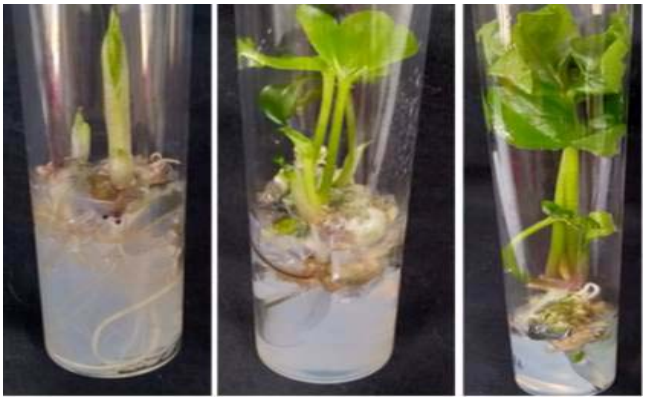


Fig. 7.3. *In vitro* established plantlets of *Amorphophallus paeoniifolius*

7.2.1.6 Rooting in *Pyrus communis*: Rooting in shoot cultures of four accessions was attempted on half and full strength MS medium supplemented with auxins (IAA, IBA and NAA @ 0, 1, 2, 3 mg/l). Seventy percent cultures exhibited rooting (avg 1-2 cm length) on ½ strength MS basal medium. In other media, rooting was only 0-20%. Rooted plants were sent to RS Shimla for hardening.

7.2.2 Cryopreservation protocols for long-term storage of germplasm

7.2.2.1 Dahlia: With application of droplet-vitrification (DV) protocol developed earlier to *in vitro* shoot tips of one accession of *Dahlia cv.* (IC318973), there was 40% post-thaw regrowth

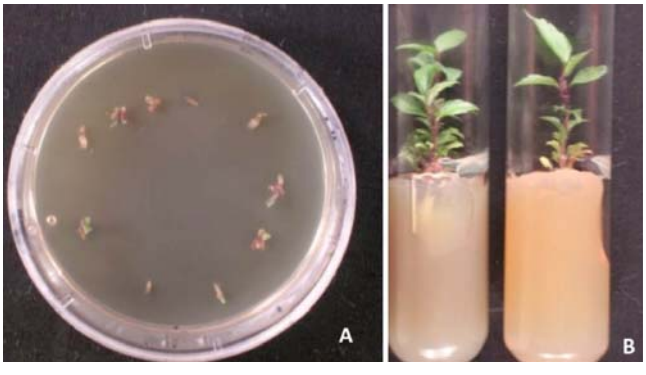


Fig. 7.4. Post thaw regrowth (A) and plantlet regeneration (B) in *Dahlia*

following incubation with loading solution (MS + 2 M glycerol + 0.4 M sucrose) (LS) for 80 min prior to plant vitrification solution 2 (PVS2) dehydration (30 min). In accession, IC318978, cryopreservation experiments repeated after 6 years led to almost same post-thaw regrowth (44%; 80 min LS and 30 min PVS2) indicating little effect of culture passage on cryopreservation response (Fig. 7.4).

7.2.2.2 Diverse *Allium* spp. and retesting of cryostored germplasm: Cryopreservation experiments carried out in *A. fistulosum* (IC353541) using vitrification (V) technique revealed 13% post-thaw regrowth of shoot tip explants (pregrown on 10% sucrose at 5°C) following PVS2 dehydration for 30 min With the replacement of PVS3 (60 min) in place of PVS2 (30 min), there was 20% post-thaw regrowth. Following use of DV in place of V technique, there was 44% regrowth of cryopreserved shoot tips, post-LN freezing (Fig. 7.5).

Fig. 7.5. Post-thaw regrowth (A) and plantlet regeneration (B) in *Allium fistulosum*

In *A. lineare* (EC328492), with the use of DV in place of V technique, though post-thaw regrowth remained at 20% yet shoots were healthier. Following exposure of shoot tips to LS (20 min) for 1 h prior to PVS2 dehydration (40 min), there was improved post-thaw regrowth (34%) of shoots. Cryopreservation experiments continued in *A. fasciculatum* (IC623460), using DV technique. There was improved post-thaw regrowth (20% compared with 10% earlier) following incubation of shoot tips with LS and PVS2 dehydration for 80 min. The DV protocol, developed thus far in *A. chinense*, was applied to another accession (IC623461) employing PVS3 (150 min) in place of PVS2 (60 min) and there was 60% post-thaw regeneration.

The cryostored germplasm of *A. scrorodoprasum* (1) and *A. sativum* (7) were tested for regeneration after 5 years of cryosotorage. The shoot tips of *A. scorodoprasum* exhibited 30% regrowth and *A. sativum* showed 0-50% regrowth, which is nearly the same as in the year of cryostorage (Table 7.4).

Table 7.4: Response of cryopreserved accessions of *Allium sativum* and *A. scorodoprasum* after five years of cryostorage

Accession	Survival (%)		Regrowth (%)	
	A	B	A	B
A. sativum				
IC375025	100	80	50	50
IC372918	75	60	8	30
IC373001	66	40	16	0
IC372905	100	90	20	20
IC281876	60	60	10	10
IC141153	83	38	16	15
IC375097	90	100	10	30
Allium scorodoprasum				
EC328500	66	50	30	25

A=response at the time of experiment; B= response after 5 years of cryostorage

7.2.2.3 Taro (*Colocasia esculenta*): The protocol of DV in taro accession (IC317585) was standardized. Shoot-tip (1 mm) explants derived from *in vitro* plantlets were subjected to 20 min LS followed by 20 min PVS2 treatment at 0°C followed by rapid immersion into liquid nitrogen (LN). Thawing was done at room temperature (25°C) and shoot-tips were incubated in recovery solution for 15 min followed by transfer to MS with 0.3 M sucrose for 24 h in dark. Explants were then transferred to MS + 2.22 µM BAP in petridishes. The DV protocol improved the mean post-thaw regeneration rates to 86–90% from 20% obtained with the previously attempted V protocol.

7.2.2.4 *Dioscorea rotundata*: Cryopreservation experiments were initiated in *D. rotundata* accession (IC582611), using vitrification technique. Shoot tip and nodal explants excised from mother cultures were tested. Maximum post-thaw regeneration

(37%) was obtained following treatment with PVS2 for 90 min Nodal explants subjected to similar treatment in another accession (IC582618) exhibited 23% regeneration.

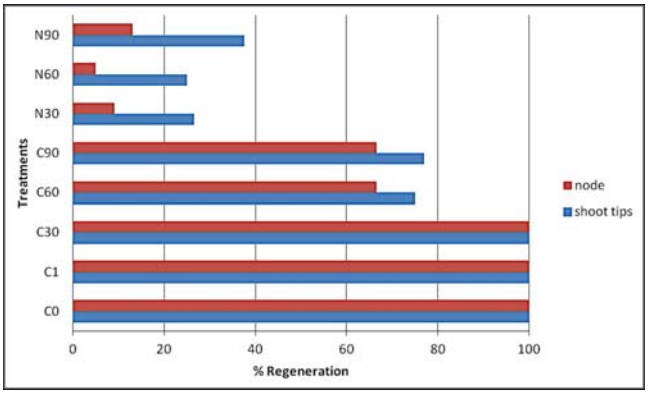


Fig. 7.6. Regeneration response of nodal explants/ shoot tips of *Dioscorea rotundata* (IC582611) after cryopreservation using vitrification technique. CO- untreated, C1- pretreated with 0.3 M sucrose, C30, C60, C90- PVS2 treated for 30, 60, 90 min, respectively, N30, N60, N90- LN treated after PVS2 duration of 30, 60, 90 min (n = 10, replication = 3)

7.2.2.5 *Fragaria* sp.: Experiments were carried out to cryopreserve *in vitro*-grown shoot tips. using four techniques, *viz*., Encapsulation-dehydration (ED), Vitrification, V-cryoplate and D-cryoplate. Excised shoot tips were precutured on 0.3 M sucrose medium. For control (-LN), 15 shoot tips and for cryo-preservation (+LN), 60 shoot tips were taken in three replicates. The D-cryoplate method appeared best as there was 40 ± 1.2% post-thaw recovery compared to ED (0%), vitrification(6.2±1.5) and V-cryoplate (15 ± 1.0%) methods respectively (Fig. 7.7).

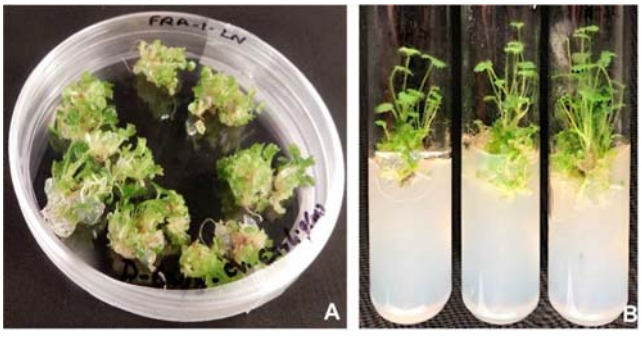


Fig. 7.7. Cryopreserved *Fragaria* plants. (A) Growth of LN-treated explants after 8 weeks of recovery. (B) Four-weeks old cultures exhibiting healthy shoots

7.2.2.6 *Malus* spp.: Dormant buds of *Malus* spp. (21 accs.) procured from field genebank of Central Institute of Temperate Horticulture (CITH), Srinagar (in Jan., 2019) were cryopreserved. The sections of budwood were subjected to -20°C for 24 h prior to LN treatment. Cryopreserved dormant buds accessions were sent to CITH, Srinagar (5) and NBPGR RS, Shimla (2) for assessment of viability of cryopreserved buds through patch budding on the rootstocks.

7.2.2.7 Medicinal plants: In *Bacopa monnieri*, cryopreservation protocol was refined and improved post-thaw regrowth (60%) was obtained in two accessions (IC353204 and IC375976) using DV compared with 40% in earlier experiments.

Cryopreserved shoot-tips of *Dioscorea deltoidea* exhibited 60% post-thaw recovery with DV technique whereas those of *Dioscorea floribunda* showed only 20% post-thaw regrowth with V technique. Cryobanking was carried out in *B. monnieri* (5) and *Gentiana kurroo* (3) with post-thaw 60% recovery using DV technique and in *D. deltoidea*

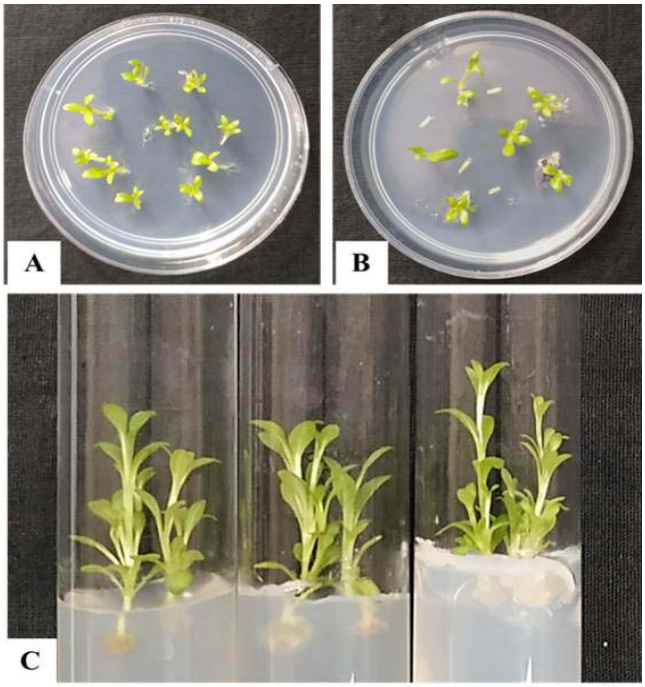


Fig. 7.8. Cryopreservation of *Gentiana kurroo* using DV technique. A) Control, B) Post-thaw regrowth of cryopreserved shoot tips, C) Regenerated plantlets from cryopreserved shoot-tips

(6) with 20-30% post-thaw recovery using V technique.

Shoot tips of three accessions (IC266697, IC554589 and IC612563) of *Gentiana kurroo* (a critically endangered medicinal plant of India) exhibited 60% post-thaw recovery, using DV technique. The regenerated plants from non-frozen controls and cryopreserved shoot tips exhibited morphological similarity to respective parental material (Fig. 7.8).

7.2.2.8 *Humulus lupulus:* Feasibility studies were carried out for cryopreservation of hops (*Humulus lupulus,* EC452691) using two techniques viz., encapsulation-vitrification (EV) and V. Isolated shoot tips were precultured for 20h on medium containing 0.3 M sucrose followed by osmoprotection with LS (2 M glycerol and 0.4 M sucrose) for 30 min, dehydration with PVS2 solution for 0, 30 and 45 min at room temperature, and subsequent plunging in LN. After 1 h, shoot-tips were re-warmed rapidly, followed by unloading in MS medium with 1.2 M sucrose for 30 min. Using V technique, 10% survival and regeneration was observed post-cryopreservation, while using EV, the survival was 20% (Fig. 7.9).

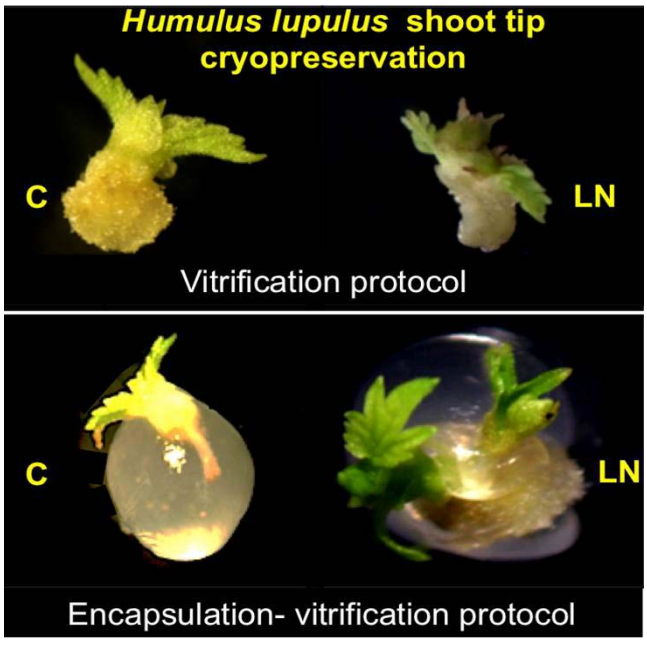


Fig. 7.9. Regeneration response of cryopreserved shoot tips of hops

7.2.2.9 *Stevia rebaudiana*: Experiments were initiated in the *in vitro* cultures of stevia (IC624506), leaves of which are used for preparation of a sweetener and as a sugar substitute. Apical and lateral shoot tips were used as explants and subjected to cryopreservation using DV technique. Stock cultures were pre-grown on MS medium supplemented with 0.4 M sucrose for 15 days. Explants were osmotically dehydrated in LS for 20 min at room temperature and cryoprotected in PVS2 solution for 30, 60, 90 and 120 min at 0°C. After freezing in LN, explants were thawed rapidly. Data obtained for post-thaw survival, shoot regeneration and whole plantlet formation is depicted in Fig 7.10, which indicated that 60 min duration is optimal, based on whole plant formation (61.6%) after cryopreservation. The protocol needs further testing on other genotypes to assess applicability for cryobanking of stevia germplasm.

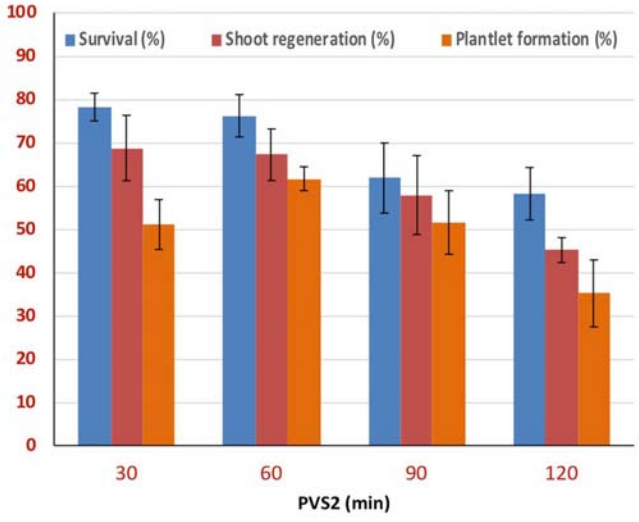


Fig. 7.10. Post-thaw survival, shoot regeneration and shoot formation in explants of stevia cryopreserved by DV and subjected to various durations of PVS2 cryoprotection

7.2.2.10 *Ensete glaucum*: Mature fruits of two seeded accessions (MZU-DBT-T15 and HSB-8) from two geographically distinct North-eastern regions of India were studied for desiccation and freezing tolerance. Fresh seed (31% MC) viability, measured through *in vitro* germination of excised embryos, was not significantly different in both accessions (87-89%). Seeds could tolerate desiccation up to 5-10% MC without significant loss in germination potential (83-84%). Air dehydrated seeds (10 ± 2% MC) and

embryos (12 ± 2% MC) were cryopreserved (in liquid and vapour phase of LN). High post-thaw recovery was achieved in both tissues i.e. seeds (80.2 ± 2.2%) and embryos (83.1 ± 2.6) by *in vitro* culture of excised embryos on MS medium + 2 µM gibberellic acid + 1 µM BAP + 1 µM ascorbic acid. The seedlings converted into multiple shoots (15-20 shoots/explant) within 2 months of culture on medium with MS salts + 10 µM BAP + 1 µM IAA + 1 µM ascorbic acid. Using the method devised, seeds and zygotic embryos of two accessions of *E. glaucum* are safely conserved in the Cryogenebank, while *in vitro* plantlets are maintained in the IVGB of ICAR-NBPGR, New Delhi, India (Fig. 7.11).

Fig. 7.11. *In vitro* proliferating cultures of *Ensete glaucum*

7.2.3 Health testing of *in vitro* germplasm

Ten accessions of *in vitro* cultures of *Rubus* spp. were multiplied for screening of *in vitro* germplasm against associated viruses of economic importance by DAS enzyme-linked immunosorbent assay (ELISA) at the Division of Plant Quarantine, ICAR-NBPGR. Contamination-free cultures of four accessions of *A. shoenoprasum* were established (using shoot bases as explants) on MS + 0.1 mg/l NAA + 0.02 mg/l 2iP, with only one shoot per explant. Due to high incidence of bacterial contamination, heavy antibiotic treatment reduced the number of cultures to one or two, per accession.

7.2.4 Genetic stability of *in vitro* and cryopreserved germplasm

7.2.4.1 Analysis of cryopreserved *Gentiana* germplasm: A total of 30 SSR primers developed *in silico* from *Gentiana* EST sequences and 39 ISSR primers were used for genetic stability analysis of plants of three accessions of *Gentiana kurroo* (IC266697, IC554589 and IC612563), regenerated post-cryopreservation by two different techniques. Banding profiles of *in vitro* multiplied material (tissue culture controls); plants used as cryopreservation controls; plants conserved by V and DV techniques were compared. High levels of genetic similarity were observed between the plants of the same accession, indicating no loss of genetic stability of the tested plants post-cryopreservation (Fig. 7.12 and 7.13).

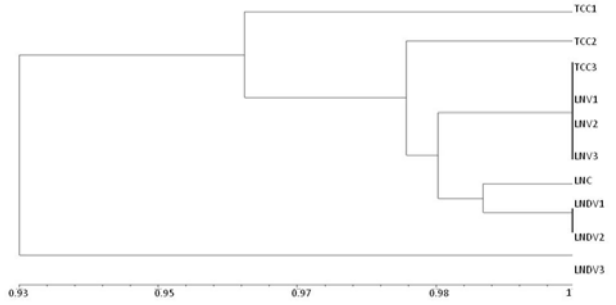


Fig. 7.12. Clustering of plants regenerated from cryopreserved shoot tips of *Gentiana* accession IC554589 based on genetic similarity analysis using ISSR primers

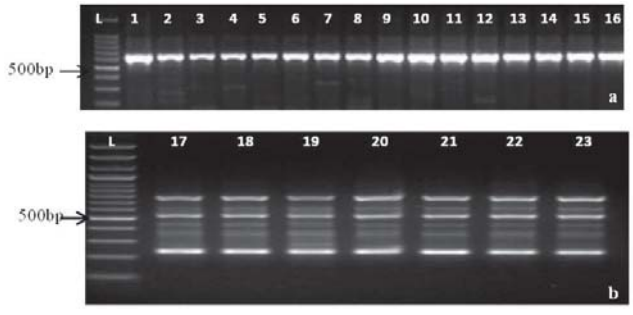


Fig 7.13. Representative Gel Image of amplification of (a) IC266697 and IC554589 with SSR primer G16; (b) IC0612563 with ISSR primer UBC835; Lane L: 100bp DNA marker; 1-8 GK-1 (1-tissue culture control; 2-cryopreservation control; 3-5 LN-vitrification; 6-8–LN - droplet-vitrification); 9-16 GK2 (9 -tissue culture control; 10- cryopreservation control; 11-13- LN-vitrification; 14-16–LN - droplet-vitrification); 17-24 GK3 (17,18- tissue culture control; 19- cryopreservation control; 20,21- LN-vitrification; 22-23–LN-droplet-vitrification)

7.2.4.2 Analysis of cryopreserved *Allium* spp.: Genetic stability analysis of one accession of *Allium fasciculatum* (IC623460) regenerated post-cryopreservation was carried out using 30 ISSR primers. On similarity analysis, 88–94% similarity was observed between the mother plant, LN controls and cryopreserved plants (Fig. 7.14).

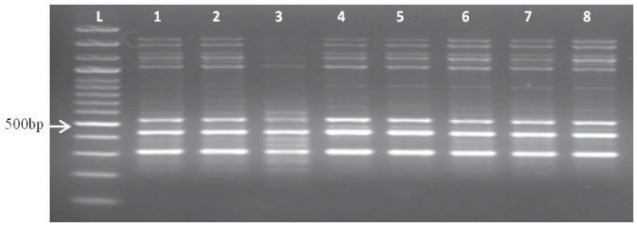


Fig. 7.14. Representative gel image showing amplification of *A. fasciculatum* (IC623458) with ISSR Primer IS8; L – Molecular weight marker, 1 – Mother Plant; 2,3,4- LN control, 5,6,7,8 – cryopreserved samples

Stability of the mother plants; tissue cultured plants, LN controls and cryopreserved plants of three accessions of *A. tuberosum* (IC353524, IC623464, IC554562) was assessed with respect to morphology using descriptor and pollen viability using *in vitro* germination test. Pollen viability ranged from 60 to 65% in mother plants; tissue cultured plants, LN controls and cryopreserved plants. No significant difference in pollen viability was observed in *ex vitro* established mother plants, tissue cultured plants, LN controls and cryopreserved plants and they also exhibited morphological similarity.

7.2.4.3 Screening and testing of markers for genetic diversity and integrity analysis of *in vitro* conserved sweet potato germplasm: To analyze the genetic diversity and eliminate genotype redundancy among the sweet potato (*Ipomoea batatas*) germplasm accessions conserved in the IVGB, a set of SSR markers were developed by mining 18,299 non-redundant EST sequences assembled from 37,698 EST sequences available at NCBI. A total of 1,856 perfect SSRs were identified in 1,569 sequences, with relative abundance of 158.63 loci/Mb and relative density of 2107.09 bp/Mb, occupying 0.21% of the total sequence. Mononucleotide repeats were most abundant (1,063), accounting for 57.27% of total SSRs, followed by dinucleotides (353) at 19.02% and trinucleotides (345) at 18.58%. A total of 899 primer pairs were designed from the identified EST-SSRs and are being used for diversity analysis and genetic stability analysis of the conserved germplasm (Fig. 7.15).

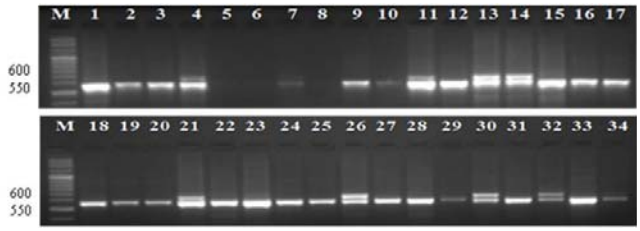


Fig. 7.15. SSR amplification profile with primer pairs SP3; L – Molecular weight marker, 1-34 – Sweet potato accessions

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

7.3.1 Germplasm augmentation and cryostorage

A total of 13,896 accessions comprising non-orthodox (intermediate and recalcitrant) and orthodox seed species are being conserved in the cryogenebank (Table 7.5). During the period, a total of 568 accessions of diverse germplasm comprising fruits and nuts, industrial crops, medicinal, vegetables including wild species and wild relatives of crop plants were received out of which 533 accessions were cryostored as seeds, embryonic axes, pollen and genomic resources and dormant buds at temperatures between -160°C to -180°C.

Most of the germplasm were received from ICAR-NBPGR Headquarter and ICAR-IIOPR, Andhra Pradesh. ICAR-NBPGR has effective collaboration for cryobanking of diverse germplasm with institutes like ICAR-IIOPR, Andhra Pradesh, ICAR-CPCRI, Kerala, CHES, Ranchi, NRC for Orchids, Sikkim and IBSD, Manipur and sizeable variability has been cryoconserved in the form of pollen, embryos and seeds. Following the protocol standardized earlier for almond bud cryopreservation, two accessions of almond (*Prunus dulcis*) were cryobanked using the step-wise freezing technique from 9 cm long bud stick.

Table 7.5: Status of cryopreserved germplasm (as on December 31, 2019)

Categories	No. of accessions added in 2019	Total Accessions (no.)
Recalcitrant & Intermediate Seeds		
Fruits & Nuts	64	3,583
Spices & Condiments	12	164
Plantation Crops	58	121
Agroforestry & Forestry	0	1,645
Industrial crops	0	1,341
Medicinal & Aromatic Plants (incl. Orchid)	3	37
Sub-Total	**137**	**6,891**
Orthodox Seeds		
Cereals	0	289
Millets and Forages	0	293
Pseudo-cereals	0	76
Grain Legumes	0	813
Oilseeds	0	668
Fibers	0	68
Vegetables	6	587
Medicinal & Aromatic Plants	3	1,004
Narcotics & Dyes	0	35
Miscellaneous	0	78
Sub-Total	**9**	**3,911**
Dormant Buds	**2**	389
Pollen Grains	**35**	591
Genomic Resources	**350**	2,114
Total	**533**	**13,896**

7.3.2 Studies on desiccation and freezing sensitivity of germplasm

New species studied for their desiccation and freezing sensitivity were *Etlingera fenzili, Bursera serrata, Cornus capitata*, *Prunus nepaulensis*, *Pyrus pashia, Sauropus androgynus*, *Sorbus microphylla, S. cuspidata, Spondias axillaris* and *Zanthoxylum armatum*. Seeds of *Etlingera fenzili* (11% MC) and *Cornus capitata* (6% MC), *Pyrus pashia* (9% MC), *Sauropus androgynus* (7% MC), *Sorbus microphylla (6% MC), S. cuspidata (6% MC)* and *Zanthoxylum armatum* (12% MC), showed intermediate seed storage behavior and were stored at between 6-12% MC, with good post-thaw viability. Seeds of *Prunus nepaulensis* were found to be recalcitrant showing high sensitivity to desiccation. Seeds of *Bursera serrata* and *Spondias axillaris* showed unique seed structures posing problem of long-term conservation through cryobanking.

7.3.2.1 Standardization of protocol for embryonic axis cryopreservation in *Prunus nepaulensis*: In *P. nepaulensis* (a crop wild relative of cherry), fresh seeds had very high moisture (46% MC) as compared to the other members of *Prunus* species. Seed is enclosed in hard shell and has a thick seed coat. On desiccation, the seed coat/cotyledons got split which was a unique observation among the *Prunus* species (Fig. 7.16). The seeds showed significant loss in viability (by 80%) with reduction in seed moisture to 30% indicative of recalcitrant seed storage behavior. However, the embryonic axes were tolerant to desiccation and at 11% MC, embryos showed high regeneration after LN exposure and thawing. The regenerated shoots, however failed to form roots *in vitro* probably due to freeze-induced damage to the radical tissues. Experiments are underway to induce *in vitro* rooting in the LN regenerated shoots. The embryonic axes are successfully cryobanked with high recovery rate (81%).

7.3.2.2 Seed morphological studies in difficult to conserve seeds: Seeds morphology in large and difficult-to-germinate seeds of *Bursera serrata* and *Spondias axillaris* was studied. Both the species had a very thick seed coat containing cotyledons sensitive to desiccation. The seeds of *Bursera serrata* showed unique ruminate cotyledonary structure beneath the thick seed coat which showed desiccation sensitivity in preliminary studies (Fig. 7.17).

7.3.3 Pollen germination studies and cryobanking

Pollen germination media was standardized for diverse *Allium* species viz. *A. auriculatum, A. chinense, A. schoenoprasum* and *A. tuberosum* for maximum pollen tube germination before and after LN storage. In *A. tuberosum* and *A. chinense,* maximum pollen germination was observed on media containing 8%

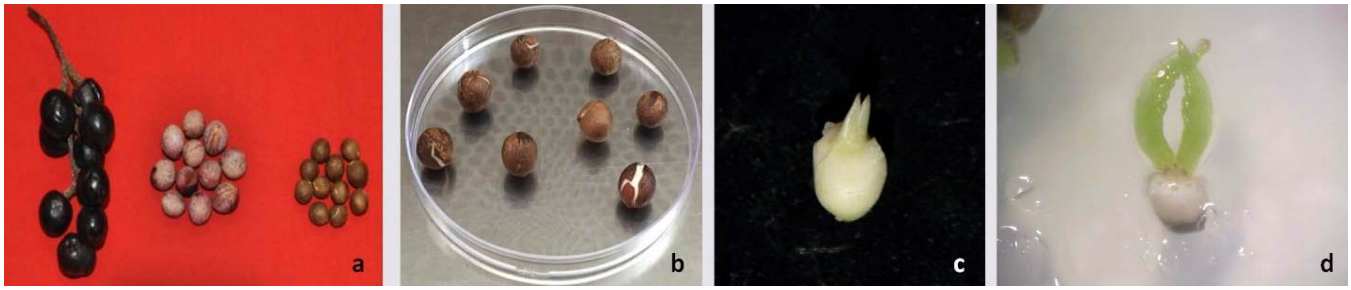


Fig. 7.16. *Prunus nepaulensis* a. Mature fruits, seeds with hard shell and without shell; b. Seeds with ruptured coat after desiccation; c. Isolated embryonic axis; d. *In vitro* regeneration of cryopreserved axes

Fig. 7.17. Seed and cotyledon of *Bursera serrata* a. Thick seed testa causing seed coat dormancy; b. Cotyledon after seed coat removal; c. Ruminate cotyledons posing difficulty in locating embryo

sucrose, 1% agar, 1% gelatin, 0.01% boric acid, after cryostorage. In *A. auriculatum* and *A. schoenoprasum,* maximum pollen tube germination was obtained on media containing 15% sucrose, 0.8% Agar and 0.01% boric acid. These species showed good pollen tube growth *in vitro* after cryostorage and are successfully cryobanked. The fresh pollen of *A. hookeri* showed 10% pollen tube germination *in vitro* but failed to germinate post-LN treatment. Under Inter-Institutional collaborative work, pollen samples of sixteen accessions of *Cocos nucifera* (received from CPCRI, Kasargod) and of two accessions of *Elaeis guineesis* (received from IIOPR, Pedavegi, Andhra Pradesh) were cryobanked after checking initial moisture and germination percentage.

7.3.4 Testing health status and regeneration of cryostored germplasm

Health status of 133 accessions of diverse crops, both fresh and cryostored, were checked and only one was infected with fungi. Periodic viability testing done for more than 62 accessions of orthodox and

Fig. 7.18. Response of cryopreserved germplasm of *Sesbania grandiflora* (A), *Aegle marmelos* (B) and *Buchnania lanzan* (C)

non-orthodox seeds revealed retention of original viability after 22-31 years of cryostorage (Fig. 7.18).

7.3.5 Transfer and establishment of cryostored germplasm in field genebank

Twenty-five plantlets (post-cryostorage) of different species namely *Carissa carandas*, *Phoenix dactylifera*, *Pithecellobium dulce* and *Tamarindus indica* were initially established in the net house at ICAR-NBPGR, New Delhi till they reached a height of 25 cm before transfer to Issapur farm field genebank. Plants of *Pithecellobium dulce* (manila tamarind) and

of *Tamarindus indica* (tamarind) raised from cryopreserved seeds were successfully established at Issapur farm field genebank of ICAR-NBPGR (Fig. 7.19). In addition, nine seed accessions of *Vigna vexillata* and *V. trilobata* were provided to Division of Germplam Evaluation for their ongoing studies and 80-100% germination was observed in the field.

7.3.6 Cryodatabase

More than 500 new entries comprising more than 10 attributes of cryobanked germplasm have been updated in the existing Cryodatabase. Curation of data for more than 125 EC accessions and 300 IC accessions had been done.

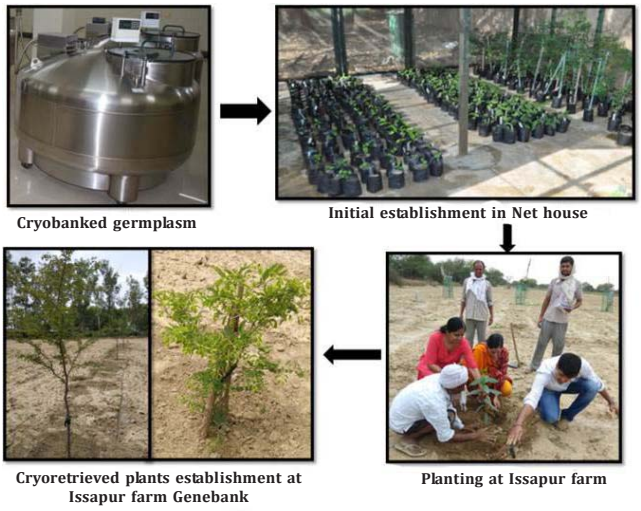


Fig. 7.19. Transfer and establishment of cryostored germplasm at Issapur farm field genebank

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**, Vartika Srivastava and *DK Nerwal*)

PGR/TCCU-BUR-01.02: *In vitro* conservation of spices, plantation and new industrial crops (**Era Vaidya Malhotra**, Anuradha Agrawal, *DPS Meena*)

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, *DPS Meena*)

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

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

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 and *AP Singh*)

PGR/TCCU-BUR-02.02: Investigating desiccation and freezing tolerance in non-orthodox seed species, dormant buds and pollen for cryopreservation. **(Vartika Srivastava** and Rekha Chaudhury**)**

AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT

8

Summary: Agricultural Knowledge Management Unit (AKMU) at ICAR-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. Aim of the unit is to facilitate easy access to PGR information to enhance PGR utilization. The PGR Portal, ICAR-NBPGR's principal web-based information portal, was accessed from many countries with an average number of >4200 views per month in 2019. An online application to access characterization data was developed replete with infographics. AKMU's endeavor to disseminate information on PGR activities via Twitter has attracted as many as 1.9 lakh impressions (146% increase compared to last year) popularizing the role of ICAR-NBPGR.

8.1 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. The application is running 24X7 for past seven years. Further improvements were incorporated for stability and a process of linking characterization data with accessions was initiated in consonance with the development of other databases (Fig. 8.1).

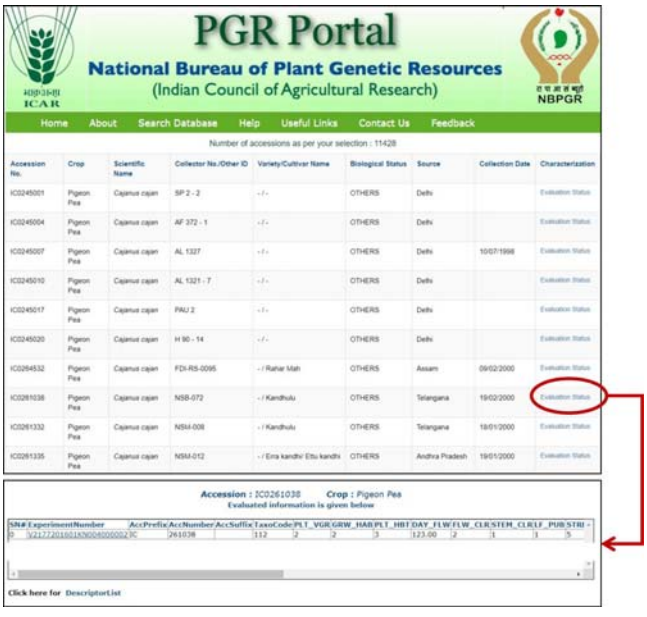


Fig. 8.1. PGR Portal has started linking characterization data with passport data

Fig. 8.2. PGR Portal accessed by researchers across the world

During 2019, PGR Portal had 51,505 page views, a 22% increase over previous year. Google Analytics data show that 2948 users, 93% of which were from India, clocked >140 page views per day across 5006 sessions (Fig. 8.2). Increasing popularity of PGR Portal among researchers was evident as 41% users reached PGR Portal directly without any search engines (32% increase). The PGR Portal was compatible across browsers and devices, and was accessed on mobile devices by 26% users (a 37% increase).

8.2 Characterization and evaluation database and web-based application

Characterization and Evaluation database was built and populated with characterization data of 1.6 lakh accessions of 90 crops to be reflected in the newly built application. The application CEdb has multiple features of searching and viewing data. The home page shows *Infographics* of current status of data. User has options

to use a *Free Search* based either on crop, researcher, location or experiment number to get a list of experiments. Each experiment will then lead to tabulated characterization data. Alternatively, researchers can opt for *Advanced Search* to choose a combination of traits and values therein to filter data across experiments. A quick view at the variation present in each trait can be had by using the option *Graphical View* (Fig. 8.3).

Fig. 8.3. User interface of the Characterization and Evaluation Database has a homepage with links to search data as well as infographics (A); Graphical view of phenotypic variation in a quantitative trait (B) and a qualitative trait (C) of a selected crop; Free search based on crop, researcher, location or experiment number returns a list (D) and data (E); Advanced search allows users to choose a combination of traits and values (F) to filter data across experiments (G)

8.3 PGR documentation activities

8.4 Maintenance activities

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

b) A new server was procured and installed in AKMU. PGR Portal and all web applications meant for 24x7 public access are transferred on it. The server works as an intermediary thereby restricting the public access to the main database server.

c) Regular maintenance back-up of databases, NBPGR website and applications was carried out as per standard practices. Scripts for scheduled database backup were updated and installed on new server.

d) Hosted a php based web application for *Piper nigrum* microsatellite database on the web server. http://www.nbpgr.ernet.in:9091/index.php

e) NBPGR website was regularly updated by addition of advertisement (26), annual reports (1); books/manuals/bulletins (6); circulars (27); corrigendum (12); events (2); e-publications (5); newsletter (6); purchase / rate contract (8); tender (111); training (3); news (46)

f) Conducted a detailed analysis of existing LAN system at NBPGR and prepared a proposal-cum-tender document for a comprehensive LAN upgradation at NBPGR new and old buildings and processed the same for implementation.

Table 8.1: PGR data status (number of accessions)

Information	Activity	Additions during 2019	Status as on Dec. 31, 2019
Indigenous collections	IC number allotment	4,742	6,28,578
Exotic collections	EC number allotment	89,458	1,06,1447
Genebank information	Data addition	5,556	4,45,273
Characterization data (CRP-AB)	Data porting	1,149	1,61,790
CryoBase	Data addition	200	7,582
Plant germplasm registration	Data addition	71	1,494

g) Aadhaar Enabled Biometric Attendance System (AEBAS) configured with UIDAI-RD Service at NBPGR headquarters is being maintained. Four new LAN-enabled AEBAS wall-mount devices got procured and installed successfully in the office.

h) RTI quarterly returns were uploaded.

8.5 NBPGR on social media

NBPGR maintains a strong presence on the social media via the official twitter account @INbpgr (Fig. 8.4). During 2019, NBPGR tweeted 152 information bits, which attracted as many as 1,91,700 (146% increase compared to last year) impressions with 2876 profile visits, 336 mentions and an addition of 251 new followers.

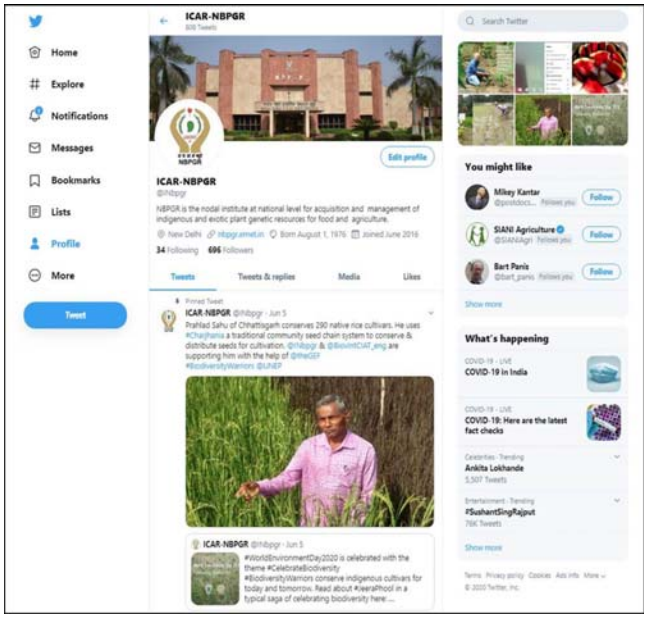


Fig. 8.4. ICAR-NBPGR on twitter

8.6 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	pgrinformatics.nbpgr.ernet.in/pgrclim
Registered Crop Germplasm	www.nbpgr.ernet.in/registration/
Multi-location Evaluation Database	www.nbpgr.ernet.in/tsgi/index.htm
Digital Library of Bruchids	14.139.224.57/bruchidlibrary
Network of GMO Testing Laboratories of India	gmolabs.nbpgr.ernet.in
National Genomic Resource Repository	www.nbpgr.ernet.in:8080/NGRR
Cryogene Bank	www.nbpgr.ernet.in:8080/cryobank
Piper nigrum microsatellite database	www.nbpgr.ernet.in:9091/index.php
Mobile Apps	Genebank, PGR Map, IP PGR

Research Programme (Programme Code, Title, **Leader)**
PGR/AKMU-BUR-DEL-01.00: Genetic Resources Information Programme (**S Archak**)
PGR/AKMU-BUR-DEL-01.01: PGR Informatics (**S Archak**, Radhamani J, Anuradha Agrawal, R Chaudhury, MC Singh, DP Semwal, Pragya, Kuldeep Tripathi, *Rajeev Gambhir, Nirmala Dabral, Anang Pal*)
Externally Funded Project
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 9

Summary: Three explorations were undertaken during the year 2019 and a total of 257 accessions of vegetables, legumes, drumstick, *bael* and wood apple crops were collected from selected districts of Maharashtra and Karnataka. A total of 2,336 accessions comprising 457 accessions during *Rabi* 2018-19 and 1,879 accessions during *Kharif* 2019 were characterized and evaluated. Crop-wise accessions characterized were linseed (221), chickpea (77), safflower (59) and grain amaranth (100) during *rabi* 2018-19, and moth bean (1545), little millet (234), barnyard millet (50) and winged bean (50) during *kharif* 2019. Supplied 1,169 accessions of various crops for research purposes to 39 user agencies within India. Multiplied and regenerated 1,081 germplasm accessions of different crops during the reporting period. A total of 20,838 accessions of various crops/species germplasm comprising oilseeds (10,452), pulses (4,687), vegetables (2,034), potential crops (1,399), millets (1,536) and wild relatives of crop plants (730) are being maintained under controlled conditions in the medium term storage of the Regional Station at Akola.

9.1 Exploration and collection of germplasm

First exploration programme for collection of vegetables, legumes and their wild relatives were carried out from Uttar Kannada, Sindhudurg and adjoining districts during December 29, 2018 - January 07, 2019. The surveyed area is located between 15.48 to 16.22 N latitude and 73.41 to 74.05 E longitudes. In total, 98 accessions were collected from two districts *i.e*. Uttar Kannada (48) and Sindhudurg (50) from 10 distinct collection sites. These accessions includes vegetable amaranth (06), *Basella alba* (01), *Momordica charantia* (01), *Vigna mungo* (04), brinjal including wild types (10), *Cajanus scaraboides* (01), *Cicer arietinum* (01), *Capsicum annuum* (12), *Cyamopsis tetragonaloba* (01), *Coccinia grandis* (01), *Vigna unguiculata* (09), cucumber including wild (05), *Lablab purpureus* (01), *Vigna radiata* (01), *Macrotyloma uniflorum* (07), *Lens culinaris* (01), *Vigna aconitifolia* (01), okra including wild (06), *Allium cepa* (02), *Cucurbita maxima* (01), *Oryza sativa* (04), *Luffa acutangula* (04), *Trichosanthes cucumerina* (02), *Luffa cylindrica* (01), *Crotalaria* spp. (04), *Canavalia* spp. (02), *Solanum lycopersicum* (01), *Phaseolus angularis* (01), *Vigna sylvestris* (01), *Diplocyclos palmatus* (01) and *Vigna unguiculata* subsp. *sesquipedalis* (05). Very high variability was collected in chilli, brinjal and *Vigna* spp. (Fig. 9.1-9.3).

Second exploration programme was undertaken for collection of *Feronia limonia*, Bael, *Moringa oleifera* and Khirni from Sangli, Kolhapur, Belgaum, Bijapur and adjoining districts during April 29 - May 07, 2019. The surveyed area is located between 15.42 to 17.48°N latitude and 74.07 to 75.36°E longitudes. In total, 77 accessions were collected from five districts *i.e.* Sangli (28), Kolhapur (18), Belgaum (22),

Fig. 9.1. Brinjal landrace collected from Sindhudurg district

Fig. 9.2. Okra landrace with long pods collected from Sindhudurg district

Fig. 9.3. *Kumta* onion landrace collected from Kumta block, Uttar Kannada District

Fig. 9.4. Drumstick variability for pod length, pod shape, seeds shape and seed colour

Fig. 9.5. Variability observed for *Bael* fruit size, shape and number of seeds

Fig. 9.6. Collection of Drumstick and Bael from Sangli Kolhapur and Belgaum districts

Bagalkot (01) and Solapur (08) from 47 distinct collection sites. These accessions includes *Moringa oleifera* (38), *Feronia limonia* (06), *Aegle marmelos* (28) and Tamarind (05). Very high variability was collected in *Aegle marmelos* and *Moringa oleifera*. In *Moringa oleifera* substantial variation was observed for pod length, thickness, seed number and seed size. In Bael (*Aegle marmelos*) broader variability were recorded for fruit size, fruit shape and pulp aroma. (Fig. 9.4-9.6).

Third exploration programme of the year was undertaken from tribal areas in Yavatmal, Wardha and Chandrapur districts of Maharashtra for collection of Cucurbits (cult. & wild), brinjal, chilli & *Abelmoschus* (wild) during 30th November – 08th December, 2019. A total of 82 accessions were collected from 56 collection sites which includes 52 villages from 25 tehsils of three districts i.e. Yavatmal (35 accessions), Wardha (28 accns) and Chandrapur (19 accns). In total, 82 accessions belonging to 09 genera were collected. These include, the targeted species of *Abelmoschus ficulneus* (12), *Abelmoschus tetraphyllus* (12), *Abelmoschus tuberculatus* (06), *Abelmoschus esculentus* (03), *Capsicum annuum* (08), *Cucurbita maxima* (03), *Cucumis melo* spp. *agrestis* (09), *Lagenaria siceraria* (05), *Luffa acutangula* (06), *Luffa cylindrica* (09), *Momordica charantia* var. *muricata* (04), *Solanum melongena* (01) and *Trichosanthes cucumerina* (04). During the exploration, out of the 82 accessions, unique accessions of wild okra were collected. Good variability was observed for fruit size in chilli. In *Lagenaria siceraria* and *Luffa* spp. good variability was observed for fruit size and shape. (Fig. 9.7-9.9).

Fig. 9.7. *Abelmoschus tuberculatus* collected from Wardha district

Fig. 9.8. Variability collected in chillies from Madhya Pradesh

Fig. 9.9. Variability collected in bottle gourd from Madhya Pradesh

9.2 Characterization and evaluation of germplasm

9.2.1 *Rabi* 2018-19

A total of 2,336 accessions comprising 457 accessions during *rabi* 2018-19 and 1,879 accessions during *kharif* 2019 were characterized and evaluated. Crop-wise accessions characterized were linseed (221), chickpea (77), safflower (59) and grain amaranth (100) during *rabi* 2018-19 and moth bean (1545), little millet (234), barnyard millet (50) and winged bean (50) in *kharif* 2019. The experiments were conducted in ABD/ RBD and the morpho-agronomical characters were recorded as per the Minimal Descriptors (For characterization and evaluation) of agri-horticultural crops (Part-I), NBPGR (2000).

Chickpea

Seventy seven chickpea accessions and four checks (PG-12, Vijay, SAKI 9516 and Warangal) were evaluated in Augmented Block Design (ABD). Promising accessions identified for days to 50% flowering were EC441900 (44 days), ICC2242 (45 days) and ICC13219 (45days); for primary branches per plant: EC441755 (18.4), EC441900 (18.0) and EC442048 (16.0); for plant height: ICC13461 (63.20cm), ICC13219 (56.8) and ICC2210 (55.8); for pods per plant: ICC6874 (183.6), ICC2969 (121.4), ICC1230 (117.0); for seed yield per plant: ICC6874 (28.17g) and ICC7819 (23.42g); and for 100 seed weight : EC442045 (29.33g), EC441971 (27.74g) and ICC1392 (23.82g). (Fig. 9.10).

Linseed

A total of 221 accessions of linseed were evaluated along with three checks (T-397, Kartika and Shekhar) in ABD. High variability was observed for days to flowering, plant types, plant height and other morpho-agronomical traits. The promising genotypes identified for days to 50% flowering were EC0000526 (46 days) and IC0096496 (52 days); for plant height: EC0718830 (79.30cm), EC0041765 (75.70cm) and EC0041644 (72.30cm); for number of balls per plant: IC0280927 (746), IC0384578 (489) and Shekhar (458); and for 1000 seed weight: IC0096488 (9.75g), EC0041700 (9.11g) and IC0526152 (8.88g). (Figs. 9.11, 9.12).

Safflower

A total of 59 accessions of safflower along with four checks (A-1, AKS-207, Bheema and JLA-152) were evaluated in Randomized Block Design (RBD) in two replications. For days to 50% flowering: IC0631963 (65 days), IC0631962 (83 days), IC0631943 (83 days) were promising. Superior genotypes identified for plant height were IC0631971 (105.40 cm), IC0631945 (100.40cm) and IC0631952 (99.10cm); for seed yield per plant: IC0631985 (21.80g), IC0631980 (17.92g) and IC0631946 (16.88g); and 100 seed weight: IC0631941 (7.26g), IC0631933 (5.92g) and IC0631931 (5.87g) (Fig. 9.13).

Fig. 9.10. Chickpea characterization-field view

Fig. 9.11. Linseed characterization and evaluation-field view

Fig. 9.12. Linseed accession (IC0280927) with high ball number per plant

9.2.2 *Kharif* 2019

Moth bean

A total of 1,545 moth bean accessions along with four checks (RMO 40, RMO 225, RMO 435 and CZM-2) were raised in ABD in twenty blocks. Good variation was recorded for days to 50% flowering, plant growth habit, plant vigour and plant morphology. All the checks and accession IC396881 recorded lowest days to 50% flowering (34 days). Superior plant height was recorded in IC10284 (193.8cm) followed by IC35950 (188.0cm). Number of primary branches per plant were high in IC121059 (9.6) followed by IC120979 (6.4). Higher number of pods per plant was recorded in accessions IC35978 (77) and IC35973 (59) (Figs. 9.14, 9.15).

Little millet

A set of 200 promising accessions and three checks (JK-8, BL6 and DHLM-36-6) of little millet were evaluated for yield and yield attributing traits in RBD with two replications. Promising genotypes identified for days to 50% flowering were IC326779 and IC326802 (51 days); for plant height IC482973 (121.4cm) and IC306459 (119.7cm); for panicle length IC482926 (31.5cm) and IC482799 (28.9cm); for number of tillers per plant IC483224 (13.5) and IC482786 (11.3). Another set of 34 little millet genotypes including three checks (JK-8, BL-6 and DHLM-36-6) were evaluated in RBD with two replications. Genotypes promising for plant height, number of tillers per plant and earliness were identified. For days to 50% flowering, GPMR6 (59 days) and IC0493076 (63 days) were early. Accession IPMR-1075 recorded superior plant height (123.70 cm). For panicle length: IC0483171 (33.70cm) and IC0483193 (32.70cm) were found promising.

Barnyard millet

Fifty entries including five checks (VL29, VL172, VL207, TNAU101 and KL-1) of barnyard millet were evaluated in RBD with three replications. Significant variation was observed for days to 50% flowering, plant height, number of productive tillers per plant, panicle length. Promising accessions identified for traits days to 50% flowering were IC331109, VL 172 (47 days) and IC 326752 (48days); for number of productive tillers per plant VL 29 (5.66) and IC597348 (5.33); for plant height TNAU 101 (121.3 cm) and IC97034 (114.3cm) and for panicle length IC77034 (23.26cm) and IC97031 (23.06cm) (Fig. 9.16).

9.3 Germplasm regeneration and multiplication

A total of 175 accessions comprising sesame (98) and chickpea (77) were regenerated during the *Rabi* 2018-19 and 906 accessions consisting of sesame (298), okra (190), winged bean (244) and horse gram (174) were regenerated during *Kharif* 2019.

Multiplication of West Indian Cherry plant

At Regional Station Akola only one plant of West Indian Cherry accession (EC13587) is present in field

Fig. 9.13: Safflower characterization and evaluation-field view

Fig. 9.14. Moth bean characterization and evaluation- field view

Fig. 9.15. Moth bean plant types

Fig. 9.16. Barnyard millet evaluation

gene bank. Efforts were made to conserve this single accession by multiplying it through vegetative propagation. Air layering (Gooty) propagation method was used to multiply the single accession. A total of 12 plants were successfully developed using the vegetative propagation method (Fig. 9.17).

9.4 Germplasm supply

A total of 1,169 accessions of germplasm of various crops/species were supplied to the indenters within India for their research purposes under Material Transfer Agreements. The crops/species (accessions) supplied were of different crops *i.e.* okra including wild (435), small millets (261), winged bean (265), horse gram (41), grain amaranth (106), linseed (20), sesame (04) and grasspea (37).

Fig. 9.17. Air layering in west Indian cherry plant (EC13587)

9.5 Germplasm receipt

Received 1,712 accessions/varieties of germplasm comprising 1,553 accessions of moth bean, 154 accessions of grain amaranth, horse gram (03) and small millets (02) from different agencies.

9.6 Medium term storage of germplasm

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

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

PGR/GEV-BUR-AKO-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources in the Central Indian Plains (**Dinesh Chand**).

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

PGR/GEV-BUR-AKO-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of cereals, pulses (pigeon pea and chickpea), vegetables (okra) and potential crops (winged bean and amaranth) (**Dinesh Chand** and Sunil S. Gomashe).

PGR/GEV-BUR-AKO-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of oil seeds (sesame, niger, castor, groundnut, safflower, soybean and linseed), millets and small millets (**Sunil S. Gomashe** and Dinesh Chand).

REGIONAL STATION, BHOWALI 10

Summary: About 375 accessions (unique landraces) of various crops *viz.,* wheat (40), barley (46), lentil (224), faba bean (19), pea (16), fenugreek (18) and mustard (12) were grown for seed multiplication, characterization / evaluation and demonstration during *Rabi* season 2018-19. Data on various descriptors approved for each crop were recorded for characterization and their subsequent registration. In *Kharif* season 2019 a total of 688 accessions of various crops *viz.,* paddy (77), millets (95), buckwheat (13), kidney bean (21), soybean (66), black gram (98), amaranth (264), horsegram (38) and maize (9) were grown for characterization / evaluation / seed multiplication. Vegetable crops *viz., Cucumis hardwickii* (12), *Cucurbita maxima* (12), *Cucumis sativus* (22) and medicinal & aromatic crops *viz., Artemisia* spp. (11) and *Achillia* spp., (09), comprising of total 66 accessions were sown for seed multiplication. Fruit crops (95 accessions) were characterized and superior accessions for different traits have been identified. A total of 81 accessions of various M&AP (8), WEUP (11) and temperate fruit (62) were collected from Arunachal Pradesh, Uttarakhand and Uttar Pradesh. A total of 11,316 accessions are being conserved in MTS and 1,251 accessions are maintained in field gene bank. A total of 276 accessions of various crops were supplied to different indenters under MTA. An "Agro-biodiversity fair-cum-seminar on conservation of local crop genetic resources" was organized on November 14, 2019 in Darkot Village, Block Munsyari of district Pithoragarh, Uttarakhand under TSP. Training on Preparation of People's Biodiversity Register' has been imparted to 32 participants in collaboration with GBPHED, Almora. Farmer's Field Days were organized at Bhowali, Someshwar and Niti Valley on Sept. 12, 2019, Oct. 04, 2019 and Oct.10, 2019 respectively under UNEP-GEF project. A sum of ₹99,953/- was generated through sale of planting material and other farm produces.

The ICAR-NBPGR Regional Station Bhowali was established in 1943, as Imperial Potato Research Station, since it was a "Hot Spot" for screening for various potato diseases especially brown rot disease (*Pseudomonas solanacearum*) testing. In 1956, with the commencement of Wheat Improvement Scheme under PL-480, it was transferred to Indian Agricultural Research Institute (ICAR) and renamed as "Wheat Research Station". In 1984, it was transferred to Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almora and remained under its administration for a period of two years. In April, 1986, it was transferred to National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Since then, it is catering to the needs of people residing in the hilly region, for conservation of biodiversity. Regional Station, Bhowali is situated at 29^0 20' N latitudes, 79^0 30' E longitudes and at an altitude of 1480 MSL in cold humid, sub-temperate climate with an annual rainfall of 1175.2 mm. Temperature ranges from 0.5^0 C to 27.1^0 C (mercury drops even upto - 2^0 C during January). The station is located 15 km away from the district headquarters, Nainital.

10.1 Exploration and germplasm collection

Three explorations were undertaken in the Western and Eastern Himalayas. A total of 81 accessions were collected including temperate fruit crops, wild economical species and medicinal & aromatic plants. During the exploration, unique germplasm like *Prunus jacquemontii* (Khursang), *Ribes orientale* (Darbag), *Allium humile* (Jangali lahsun) *Allium stracheyi* (Jimboo) *Prunus nemepalensis* (Bhang Bhalu), *Podophyllum hexandrum* (Ban Kakri) were collected from Dhauli Ganga valley and Johar valley. Details of the area explored and germplasm collected are given in Table 10.1.

10.2 Germplasm characterization and evaluation (Summary in Table 10.2)

10.2.1 Characterization of wheat

Fifty accessions of wheat, mostly indigenous landraces (from Uttarakhand) were characterized for various qualitative and quantitative traits.

Table 11.1: Germplasm collected during the exploration programmes of 2019

S.No.	Crop/Crop group	Period	Team	Collaborative institute	Areas Explored	Germplasm collected			
						M&AP	WEUP	Fruits	Total
	Under National exploration Plan								
1	Crop specific (Wild temperte fruits and economical useful species)	Aug. 19 to Aug. 30, 2019	Dr. K.M. Rai Dr. K.L. Kumawat	ICAR-CITH, Srinagar	West Kameng & Tawang	-	04	31	**35**
2	Crop specific (Local Banana)	Oct. 03 to Oct. 12, 2019	Dr. K.M. Rai	-	Bageshwar, Pithoragarh, Champawat	-	07	19	**26**
	Under Externally Funded projects (NASF project)								
3	Crops specific (*Costus speciosus* & *Hemidesmus indicus*)	July 16 to July 20, 2019	Dr. K M. Rai	-	Tarai region of Uttarakhand & Uttar Pradesh	05	-	-	**05**
	Re-exploration and collection from Niti valley								
4	Crop specific (wild temperate fruit crops)	Sept. 09 to Sept. 14, 2019	Dr. K M. Rai, Badal Singh	-	Dhauli Ganga area (Malari, Bampa, Gamsali & Niti)	03	-	12	**15**
	Total					**08**	**11**	**62**	**81**

Table 10.2: Characterization and evaluation of crop accessions

S. No.	Crop	No of accessions	Characterization/ evaluation
	***Rabi* 2018-19**		
1.	Wheat	50	Characterization
2.	Barley	51	Characterization
3.	Lentil	224	Evaluation & Characterization
4.	Mustard	12	Characterization
5.	Fenugreek	18	Characterization
6.	Pea	16	Characterization
7.	Faba bean	18	Seed multiplication
	Total	**375**	
	***Kharif* 2019**		
1.	Paddy	77	Characterization and seed multiplication
2.	Amaranth	264	Seed multiplication
3.	Soybean	66	Seed multiplication
4.	Maize	09	Seed multiplication
5.	Minor millets	95	Characterization and seed multiplication
6.	Buckwheat	13	Characterization and seed multiplication
7.	Sesame	07	Characterization and seed multiplication
8.	Horsegram	38	Characterization and seed multiplication
9.	Blackgram	98	Characterization and seed multiplication
10.	Frenchbean	21	Characterization and seed multiplication
	Total	**688**	

Moderate variation were recorded for most of the quantitative characters studied. However, the traits grain yield /plant and no. of effective tillers/plant recorded maximum variability. Days to 75% spike emergence and maturity exhibited least variation (Table 10.3). While substantial variability was recorded for some of the qualitative characters *viz.* awn type, awn colour and grain colour. For growth class, most of the landraces were either facultative or spring type; either erect or semi-spreading in growth habit, and predominantly with white glume colour.

10.2.2 Characterization of barley

Fifty one accessions of barley particularly land races from Uttarakhand were characterized for various qualitative and quantitative traits. Four varieties *viz.,* VL-01, VL-56, VL-64 and VL-85 were used as check. Six-rowed, four-rowed and two-rowed barley were represented. Maximum variation was found for grain yield per plant whereas minimum variation was found for days to maturity (Table 10.4).

10.2.3 Regeneration of fababean

Faba bean commonly known as broad bean has been an under utilized crop though rich in protein

Table 10.3: Range of variation in major quantitative traits among wheat germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Grain yield per plant (g)	5.19	26.77	10.68	37.11
Effective tillers per plant	5.60	15.00	9.06	26.74
Days to 75% spike emergence	140.00	169.00	146.44	03.06
Days to physiological maturity	182.00	190.00	186.96	01.30
1000 grain weight	29.00	73.80	38.86	18.12

Table 10.4: Range of variation in major quantitative traits among barley germplasm

Traits	Range		Mean	CV (%)
	Minimum	Maximum		
Effective tillers per plant	4.00	10.00	7.04	19.47
No. of grains per spike	27.20	87.00	59.76	19.48
Days to physiological maturity	169.00	184.00	172.57	2.04
1000 grain weight	26.70	52.90	37.99	14.64
Grain yield per plant (g)	5.03	30.35	13.98	33.06

content. In hills, the green pods are consumed as vegetable. In total, 18 accessions of fababean is being conserved at our regional station All the accessions were again grown in field during *Rabi* 2018-19 for regeneration and seed multiplication and have shown 80-90% germination. Healthy crop was raised and enough seed was obtained to grow next year for characterization and evaluation (Fig. 10.1).

Fig. 10.1. Field view of Fababean crop

10.2.4 Characterization of Paddy

Seventy seven accessions of paddy, all landraces from different parts of Uttarakhand were grown for characterization and seed multiplication. The accessions included both rainfed as well as irrigated types. Considerable diversity was observed for various characters *viz.,* no. of effective tillers per plant and plant height (Table 10.5). Variability for hulled grain colour was also observed with range varying from yellow, brown, red, and black.

10.2.5 Germplasm characterization, evaluation, regeneration and seed multiplication of horticultural and MA&P crops

A total of 110 accessions of horticultural crops *viz.*, peach (22), plum (06), apricot (14), kiwi (05), walnut (30), malta (12) and persimmon (06) were evaluated for different characters. Promising accessions for various quantitative and qualitative traits were identified (Table 10.6).

Table 10.5: Range of variation in major quantitative traits among paddy germplasm

Characters	Range		Mean	CV (%)
	Minimum	Maximum		
No. of effective tillers	5.2	13.00	7.70	29.00
Plant height (cm)	51.80	132.70	89.40	22.93
Days to 50% flowering	120.00	153.00	135.92	4.44
Days to physiological maturity	152	167	159.22	1.90

Table 10.6: Characterization and evaluation of horticultural germplasm during 2019

S. No.	Crops	No. of accessions	Characters	Promising accessions
1	Peach	22	Fruit maturity (<90 days) Fruit weight (>100g) Pulp stone ratio (<10%) Productivity	IC360683, IC360685, IC360695 IC360683, IC360695, IC360680 IC360683, IC360685, IC360695, IC247430, IC360693 IC360683, IC360685, IC360695, IC360680, IC360694
2	Plum	06	Fruit maturity (<90 days) Fruit weight (>60g) TSS (>15%) Productivity	IC247424, IC247426 IC247421, IC247422 IC247426, IC247422, IC247423 IC247421, IC247422
3	Apricot	14	Fruit maturity (<90 days) Fruit weight (>40g) TSS (>15%) Productivity	IC319186, IC247427, IC273865, IC360696, IC360701 - IC319186, IC273865 IC319186, IC247427, IC360696
4	Kiwi	05	Fruit maturity (<240 days) Fruit weight (>40g) TSS (>8%) Productivity	EC24672, EC64094 EC24672, EC64093, EC64090 EC64053, EC24672 EC24672, EC64090, EC64093
5	Walnut	30	Nut weight (> 20g) Kernel weight (> 3g) Kernel percentage (>50%) Kernel color (milky white) Kernel shell softness	EC469895 EC469895 EC467892, IC275057, EC469895 EC467892, IC275057, EC467893, EC469895 EC467892, IC275057, EC469895
6	Malta	12	Fruit weight (>50g) Juice percentage (>50%) TSS (>10%) Productivity	EC669068, EC669069, EC669075 EC669072, EC669068, EC669075, EC669073, EC669078, EC669079 EC669072, EC669073, EC669076, EC669078 EC669068, EC669079, EC669073
7	Persimmon	06	Maturity (<180 days) Fruit weight (>50g) Firmness Productivity	IC247438, Hachiya Hachiya, Fuyu, IC247438 Hachiya, Fuyu, IC247438, IC247438, Ramgarh Local Hachiya, Fuyu, IC247438

10.2.6 Seed regeneration of vegetable crops and medicinal & aromatic crops

A total of 66 accessions of vegetable crops *viz., Cucumis hardwickii* (12), *Cucurbita maxima* (12), *Cucumis sativus* (22) and medicinal & aromatic crops *viz., Artemisia* spp. (11) and *Achillia* spp., (09) were sown for seed multiplication.

10.3 Germplasm conservation

10.3.1 Germplasm conservation in MTS

A total of 11,266 accessions including cereals (3,345), pseudocereals (568), millets (552), pulses and legumes (3,782), oilseeds (540), vegetables (1,563), spices and condiments (716), medicinal and aromatic plants (180) and ornamentals (20) have been maintained in MTS module of the station (Table 10.7).

Table 10.7: Germplasm maintained in MTS facility

Crop group	Major crops	Accessions
Cereals	Wheat, barley, maize, rice, coix	3,384
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	-	1,203
Vegetables	Cucurbitaceous, leafy greens, okra, others	360
Spices & condiments	Coriander, fenugreek, *Perilla,* others	716
M & AP	*Ocimum*, *Datura*, lavender, *Artemisia* others	180
Ornamentals	Tagetes, *Achillea*	31
Total		**11,316**

Table 10.8: 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		**1,251**

10.3.2 Germplasm augmentation

A total of 62 accessions comprising of 17 accessions of *Persia americana*, 13 accessions of *Citrus aurantifolia* from Germplasm Exchange Unit, NBPGR, New Delhi, and 13 accessions of wild *Allium* species from Division of Plant Exploration and Germplasm Collection, NBPGR, New Delhi, 10 accessions of *Olea europaea*, and 11 accessions of *Fragaria ananassa* were augmented and being conserved in our field gene bank. Of 17 accessions of *Persia americana* and 13 accessions of *Citrus aurantifolia*, only 05 accessions of *Persia americana* are established and remaining accessions could not survive in screen house at station.

10.4 Germplasm exchange

- Eighteen accessions of *Cucumis sativus* were supplied to University of Horticultural Sciences, Bagalkot, Karnataka-587104 under MTA.
- Thirty accessions of chilli were supplied to Janta College, Bakewar, Etawah-206124 under MTA.
- One accession of *Artemisia annua* was supplied to University of Allahabad, Allahabad, UP-211002 under MTA.
- Seed samples of native landraces of paddy (8), fingermillet (3), barnyard millet (2) and amaranth (1) were supplied to ICAR-NBPGR Regional Station Shimla for quality analysis.
- Supplied a total of 10 accessions of Onion (*Allium cepa*) to ACSEN Hy Veg. Private Ltd., under MTA.
- Supplied a total of 13 accessions of Marigold (*Tagets minuta*) to HCRI, TNAU, Coimbatore.
- Twenty accessions of *Brassica juncea* were supplied to GBPUA&T Pantnagar.
- Supplied seed material of 10 accessions of *Allium cepa* to COH Mudigere (Karnataka) under MTA.
- Supplied 07 accessions of banana (*Musa balbisiana*) to GBPUAT, Pantnagar Uttarakhand under MTA.
- Supplied 50 plants of marigold to KVK, Kafligair (ICAR-VPKAS)
- Twenty accessions of lentil, 20 of barley and 50 accessions of wheat were provided to GBPUA&T, Pantnagar (Uttarakhand) under MTA.
- Scion wood of plum (04 accessions) & kiwi (06 accession) and runners of strawberry (10 accessions) were applied to TNAU, Regional Station, Kodaikanal (Tamil Nadu).
- Received 12 accessions of wild *Allium* collected from Arunachal Pradesh and Sikkim by NBPGR, New Delhi for conservation in FGB at Bhowali station.

Germplasm supplied to local farmer/indenters

A total of 4,135 live plants/rooted plant/grafted plant *viz*., kiwi (310), strawberry (800), malta (130), kagazi nimboo (100), passion fruit (120) MA&P (3,664), and other plants (270) were supplied to different indenters or local farmers.

10.5 Progress on externally funded projects

10.5.1 "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" under NASF

Exploration and collection of C. *speciosus* was done from Tarai region of Uttarakhand and Uttar Pradesh. During exploration, 02 populations of *Costus speciosus* K. and 03 population *Hemidesmus indicus* were collected. In *C. speciosus* seed propagation was found to be better (90-100 % germination) when compared to rhizome cutting (60-70%) and in case of *Hemidesmus indicus* soft wood cuttings (70-85% rooting) was found to be the best method for propagation. For identifying best treatment for maximum phyto-chemical and rhizome production, four treatments were laid down in randomized block design consisting of organic and inorganic nutrient management. Another treatment consisting of different spacing in randomized block design (20x10 cm, 30x10 cm, 40x10 cm for rhizome and 10x10 cm, 20x10 cm, 30x 10cm for seed) were also laid down for evaluation of rhizome production.

10.5.2 "Mainstreaming farmers' varieties in Himachal and Uttarakhand" under DST

In total, 222 local landraces of various crops *viz.,* paddy, wheat, barley, soybean, horsegram, mustard, fingermillet, barnyard millet, foxtail millet, maize, frenchbean, lentil, amaranth, etc. which were collected through three different explorations in the previous year were characterized and seeds were multiplied for distribution to the farmers. Twenty-four landraces of different crops are identified for registration with the PPVFRA. Local landraces of paddy (rainfed and irrigated), black seeded soybean, horsegram, wheat, barley, frenchbean, amaranth, buckwheat and fingermillet were distributed to farmers of village Suri (Almora), Gadsyari (Almora), Matila (Almora), Chanauli (Someshwar), Mawe (Someshwar), Malonj (Someshwar), Tolma (Chamoli), Malari (Chamoli), Doni (Tehri) and Munsyari.

10.5.3 "Mainstreaming agricultural biodiversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability" under UNEP-GEF

Five project sites are operating in Uttarakhand *viz*., Niti Valley (dist Chamoli), Tarikhet block and Someshwar Valley (Dist. Almora) under ICAR-NBPGR Regional Station Bhowali; Ramana Nyay Valley (Dist Almora) under NGO Lok Chetna Manch, Ranikhet and Bhilangna Valley under NGO Mount Valley Development Association, Doni. These sites represents different niche areas of the state and have been selected and finalized for on-farm conservation, rejuvenation of existing diversity and broadening of native crop diversity. Mother trials of selected landraces along with baby trials in the form of tricot methodology were conducted for all the target crops of *Kharif* 2019 and *Rabi* 2019-20 at all the five sites across the state. Farmer field days were organized to display the crop landrace diversity to the farmers of those areas. Unique landraces for registration with the PPVFRA have been identified along with heirloom landraces for promotion through value chain.

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

PGR/PGC-BHO-01.01: Management of genetic resources of field crops with emphasis on ethno botanical aspects (**Mamta Arya,** *P.S. Mehta*)

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

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

Externally Funded Project

14.1. "Chemotyping and molecular profiling of bioactive metabolites in Hemidesmus indicus and Costus speciosus, adopted to different phytogeographical zones" under NASF. CCPI: Dr. K.M. Rai (since 29.6.2017)[L1] .

14.2. "Mainstreaming Farmer's Varieties in Himachal and Uttarakhand" under DST. CCPI: Dr Mamta Arya (for Uttarakhand).

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

BASE CENTRE, CUTTACK 11

Summary: Three explorations were undertaken and 211 accessions comprising pigeon pea, cultivated rice, wild rice, wild relatives of cucurbits, *Solanum* and *Abelmoschus* and the fodder species such as *Bothriochloa pertusa, Brachiaria ramosa, Cenchrus ciliaris, Dichanthium annulatum, Chloris* sp., *Heteropogon contortous*, were collected from Odisha and West Bengal. Significant germplasm collections include *Oryza rufipogon*, *O. nivara,* crop wild relatives of *Solanum* and *Abelmoschus* spp. In addition, three accessions of pigeon pea viz. RCM/DD/59, 62 and 63 collected from upland habitat at Ajodhya hills are reported by the farmers having drought tolerance. A set of 3,798 accessions of various crops and crop wild relatives was grown and 425 accessions comprising cultivated rice, wild *Oryza* species, *Ocimum* spp., *Hibiscus sabdariffa* were characterized for different morpho-agronomic traits. Fifty four accessions of cultivated rice germplasm were evaluated for submergence tolerance and 14 accessions of rice germplasm were identified as probable donors for submergence tolerance. Essential oil samples of 36 accessions of *Ocimum* germplasm and three accessions of rhizome shred samples of *Hedychium* spp. were supplied to DGE, ICAR-NBPGR, New Delhi for evaluation of biochemical compounds. A set of 126 accessions including 37 acc of fodder plants, 9 acc of wild rice and 80 acc of vegetable crops were supplied to three ICAR-institutes and 1932 accessions were received from DGC, NBPGR, New Delhi. 1,629 accessions comprising 1,444 acc of cultivated rice and 185 acc of CWR were deposited in NGB for LTS; 519 accessions comprising M&AP, horticultural crops, tuber/aroid crops and various CWR are being maintained in the FGB and 1430 voucher specimens are preserved in the herbarium.

11.1 Exploration and germplasm collection

During the period under report, three explorations were undertaken and 211 accessions comprising pigeon pea, cultivated rice, wild rice, wild relatives of cucurbits, *Solanum* and *Abelmoschus* and the fodder species such as *Bothriochloa pertusa, Brachiaria ramosa, Cenchrus ciliaris, Dichanthium annulatum, Chloris* sp., *Heteropogon contortous*, were collected from Odisha and West Bengal. Wide range of inter and intra specific variability was recorded among collected germplasm accessions for various morpho-agronomic traits. The exploration wise details are given in Table 11.1.

Table 11.1: Details of exploration and germplasm collection during 2019

Crops/Species	Areas	Collaboration	Period of collection	Collection sites	No. of spp.	No. of acc
Pigeon pea landraces	East & West Medinipur, Jhargram, Bankura and Puruliya (West Bengal)	ICAR-IIPR, Kanpur	Feb. 19 to March 2, 2019	73	2	78
Cultivated and wild relatives of cucurbits, *Solanum*, *Abelmoschus* and other minor vegetables	Keonjhar and Mayurbhanj (Odisha)	ICAR-IIVR, Varanasi	Dec. 16-26, 2019	60	25	84
Wild rice and fodder species (*Bothriochloa pertusa, Brachiaria ramosa, Cenchrus ciliaris, Dichanthium annulatum, Chloris* sp., *Heteropogon contortous* etc.)	Murshidabad, Nadia and 24-Pargana (N) (West Bengal)	ICAR-NRRI, Cuttack and ICAR-IGFRI, Jhansi, UP	Oct. 30 - Nov 9, 2019	32	29	49
			TOTAL	**165**	**56**	**211**

11.1.1 Exploration and germplasm collection of pigeonpea from West Bengal

First exploration mission was undertaken for collection of pigeon pea germplasm from East Medinipur, West Medinipur, Jhargram, Bankura and Puruliya districts of West Bengal in collaboration with ICAR-Indian Institute of Pulses Research, Kanpur during February 19 to March 2, 2019 (Fig. 11.1-11.4). A total of 78 acc comprising of *Cajanus cajan* (77) and *Ocimum gratissimum* (1) was collected and wide range of variability of morphological traits among pigeon pea such as colour and size of flowers, pods and seeds was recorded. Three accessions viz. RCM/DD/59, 62 and 63 collected from upland habitats at Ajodhya hills are reported by the farmers having drought tolerance.

11.1.2 Exploration and germplasm collection of cultivated and wild relatives of cucurbits, *Solanum*, *Abelmoschus* and minor vegetables from Odisha

The second exploration mission was conducted for collection of cultivated and wild relatives of cucurbits, *Solanum*, *Abelmoschus* and other minor vegetable germplasm from Mayurbhanj and Keonjhar districts of Odisha in collaboration with ICAR-Indian Institute of Vegetable Research, Varanasi (U.P.) during Dec. 16-26, 2019 (Fig. 11.5-11.8). A total

Fig. 11.1. Variability in flowers and pods of *Cajanus cajan* collected from Jhargram, West Bengal

Fig. 11.2. Cultivation of red-seed landrace of pigeonpea at Chandra village, Puruliya, West Bengal

Fig. 11.3. Stripeless pod with white-seeded variety of *Cajanus cajan* collected from Puruliya, West Bengal

Fig. 11.4. Variability in pods of *Cajanus cajan* collected from West Bengal

of 84 acc. comprising of *Cucumis* spp. (26), *Luffa* spp. (15), *Trichosanthes* spp. (8), *Coccinea grandis* (3), *Diplocyclos palmatus* (2), *Abelmoschus* spp. (6), *Solanum* spp. (15), *Hibiscus sabdariffa* (1), *Canavalia gladiata* (1), *Dioscorea alata* (1), *Coix lacryma-jobi* (1), *Scleichera oleosa* (1), *Aristolochia indica* (1), *Costus speciosus* (1), *Ocimum citriodorum* (1) and *Thespesia lampas* (1) were collected from biodiversity-hot spot areas like Similipal biosphere reserve, high hills of Barehipani, Kolha in Mayurbhanj district and Gonasika, Thakurani and Gandhamardan hills in Keonjhar district along with Hadagarh reservoir catchment regions covering parts of Northern plateau of Odisha. Variability in fruit shape and size in cucurbits like *Cucumis sativus* var. *hardwickii*, *Trichosanthes bracteata*, *Luffa aegyptica* and flowers and fruits variability in *Solanum* spp. and *Abelmoschus* spp. were observed. During the exploration, information on traditional uses of wild *Solanum* spp., *Abelmoschus* spp., cucurbits like *Cucumis* spp., *Coccinea grandis, Luffa, Trichosanthes* spp. and *Diplocyclos palmatus* and other minor vegetables including leafy types were collected from tribal inhabitants and farmers who accompanied as local guide to the interior forest areas. About 35 specimens were collected and preserved as herbarium materials for future research/ reference.

Fig. 11.5. *Abelmoschus crinitus*, wild okra, collected from Similipal biosphere reserve, Mayurbhanj

Fig. 11.6. *Abelmoschus crinitus*, wild okra, collected from Similipal biosphere reserve, Mayurbhanj

Fig. 11.7. *Solanum erianthum*, collected from Nimasahi, Jashipur, Mayurbhanj

Fig. 11.8. *Solanum viarum* collected from Gonasika, Keonjhar

11.1.3 Exploration and germplasm collection of wild rice and fodder species from West Bengal

The third exploration mission was undertaken for collection of wild rice and fodder species (*Bothriochloa pertusa, Brachiaria ramosa, Cenchrus ciliaris, Dichanthium annulatum, Chloris* sp., *Heteropogon contortous* etc.) from West Bengal in collaboration with ICAR-National Rice Research Institute, Cuttack, and ICAR-IGFRI, Jhansi, UP during Oct. 30-Nov. 9, 2019. A total of 49 accessions under 28 species comprising *Avena sativa* (1), *Bracharia* (2), *Cenchrus ciliaris* (1), *Chloris barbata* (4), *Chrysopogon zizinoides* (1), *Clitoria tennatea* (1), *Coix lacrima-jobi* (4), *Digitaria ciliaris* (1), *Echinochloa colona* (2), *Eleusine indica* (4), *Lablab purpurea* (1), *Ocimum kilimandshcaricum* (1), *Oplismenus burmannii* (1), *Oryza nivara* (2), *Oryza rufipogon* (7), *Oryza pontanea* (1), *Panicum maximum* (2), *Panisetum pedecillatum* (4), *Setaria sphacelata* (4), *Solanum sysymbrillium* (1), *Sorghum bicolor* (3), *Themeda quadrivalvis* (1) were collected from 32 diverse collection sites of Murshidabad (Fig. 11.9), Nadia, 24-Pargana (North) (Fig. 11.10) and Burdwan districts of West Bengal. The district wise distribution of the germplasm collection was 16 accessions from Murshidabad, 24 accessions from Nadia, eight accessions from North 24-Parganas and one accession from Burdwan district of West Bengal. Rooted slips, live plants, inflorescences, panicles and freshly harvested seeds were collected from farmer's field, garden, range lands and waste lands of the explored region. Information about different crops cultivated during different seasons, their economic importance and genetic erosion of local primitive land races of field crops were also recorded during the exploration.

Fig. 11.9. Collecting *Oryza nivara* from Murshidabad, West Bengal

Fig. 11.10. Collecting *Sorghum bicolor* from 24-pargana (N), West Bengal

11.2 Supportive research

11.2.1 Morphological variability in *Mucuna* spp.

Forty-one accessions under four wild taxa of *Mucuna* viz. *M. gigantea, M. monosperma, M. nigricans,* and *M. pruriens* var. *pruriens* and one cultivated species *M. pruriens* var. *utilis* collected from different phyto-geographic regions of Odisha was studied for assessing pod and seed morphology. Variability in inflorescence, flowers, pods and seeds were observed. In *Mucuna* the inflorescence is generally a short or long-peduncled raceme, whereas *M. gigantea* has reduced pseudo-raceme or pseudo-umbellate. The flowers show inter specific variation in the colour of corolla, ranging from greenish yellow in *M. gigantea*, purple in *M. monosperma*, dark purple in *M. nigricans* and *M. pruriens* var. *pruriens* and white as in *M. pruriens* var. *utilis*. The pod surface varies from ornamented by lamellae with transversal and obliquely plaited in *M. nigricans* and *M. monosperma* to complete lack of ornamentation in *M. pruriens* var. *pruriens*, *M. pruriens* var. *utilis* and *M. gigantean.* The fruits are narrow, linear, obscurely

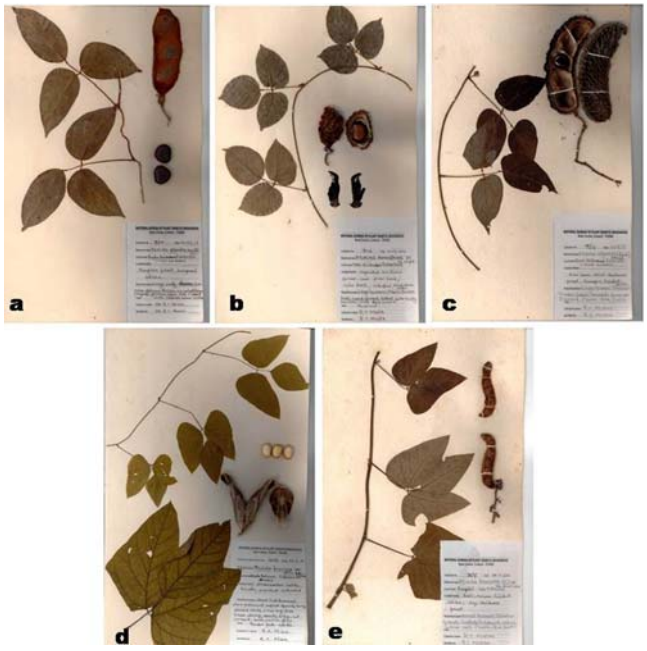


Fig. 11.11. Herbarium of *Mucuna* preserved at Base Centre, Cuttack

'S' shaped and without marginal wings in *M. pruriens*, whereas it is broad, flattened and with marginal wings in each suture in *M.gigantea*, *M. monosperma* and *M. nigricans* (Fig. 11.11). The number of seeds also varies from one in *M. monosperma* to 5-6 in *M. pruriens*. In addition, the information on seeds and hilum provided taxonomically informative characters. Seeds can be globose, reniform or discoid; the hilum extends to less than one-fourth of the seed circumference in *M. pruriens* var. *utilis*, about one-fourth in *M. pruriens* var. *pruriens*, two-third in *M. nigricans*, more than two-third in *M.gigantea* and about three-fourth of the seed circumference in *M. monosperma* (Fig. 11.12).

11.3 Germplasm characterization

A set of 3,798 accessions comprising cultivated rice (3,424), wild rice (235), *Hibiscus sabdariffa* (21), *Ocimum* spp. (49), *Cucumis* spp. (25), *Abelmoschus* spp. (20), other crops and their wild relatives (44) were grown/ transplanted in the experimental field for seed multiplication and preliminary characterization. Out of which, a set of 425 accessions comprising cultivated rice (269), wild rice (95),

Fig. 11.12. Seed structure of *Mucuna* germplasmcollected from Odisha

Ocimum spp. (43), *Hibiscus sabdariffa* (18) was characterized for different morpho-agronomic traits.

11.3.1 Cultivated rice

A set of 269 accessions of cultivated rice germplasm augmented from exploration mission in Odisha, West Bengal and Assam and from MTS, ICAR-NBPGR was characterized for 17 agro-morphological traits. The germplasm were grown in augmented design with 8 blocks and five checks (Swarna, Panidhan, Geetanjali, IR-64, Ketakijoha) with a spacing of 20X20 cm between plants and rows. Wide range of variability with respect to different quantitative and qualitative traits such as maturity duration, plant height, EBT, panicle length, panicle weight, 100 grain weight, sterility percentage including colour of basal leaf, leaf blade, internode, apiculos, seed coat and husk and type of panicle and awn were recorded (Table 11.2).

11.3.2 Wild rice

A set of 95 accessions of wild rice germplasm comprising *Oryza nivara* (84) and *Oryza rufipogon* (11) either received from Division of Germplasm Conservation, ICAR-NBPGR, New Delhi and/or collected during different exploration missions from Odisha and West Bengal was characterized for 17 agro-morphological traits. Each accession was maintained in three rows in a plot size of 3.84m^2 / entry following a spacing of 40x40cm between lines and plants. Observation on different qualitative and quantitative traits (17) was recorded and range of

Table 11.2. Variability and frequency distribution among qualitative traits in cultivated rice germplasm (269 acc)

Traits	Descriptor states	Frequency (%)	Descriptor states	Frequency (%)
Basal leaf color	Green P.P. lines	263 (97.8) 2 (0.7)	Light P.P.	4 (1.5)
Leaf Blade color	Green Dark green	263 (97.8) 4 (1.5)	Pale green	2 (0.7)
Internode color	Green	267 (99.3)	Light gold	2 (0.7)
Ligule color	White	269 (100)		
Collar color	Green	269(100)		
Auricle color	Pale green	269(100)		
Panicle type	Intermediate Open	241 (89.6) 1 (0.4)	Compact	27 (10.0)
Awning	Absent Short & partly	261 (97.0) 4(1.5)	Long & partly	4 (1.5)
Awn color	Absent	261 (97.0)	Straw	8 (3.0)
Apiculus color	Straw White	263 (97.7) 1 (0.4)	Purple Brown	4 (1.5) 1 (0.4)
Stigma color	White	264 (98.1)	Purple	5 (1.9)
Lemma palea color	Straw PP. furrow	265 (98.5) 1(0.4)	Brown Brown spot	2 (0.7) 1 (0.4)
Seed coat color	White Light brown	259 (96.3) 4 (1.5)	Brown	6 (2.2)

variation for various quantitative traits is given in Table 11.3.

11.3.3 *Ocimum* germplasm

Forty three accessions 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 corresponding species are mentioned in Table 11.4.

Table 11.3. Range of variability among quantitative traits in *Oryza nivara* germplasm (84 acc)

Traits	Range	
	Min.	Max.
Plant height (cm)	39.7 (W-37)	123.1 (W-83)
EBT	4.5 (W-12)	15.0 (W-83)
Panicle length (cm)	11.5 (W-37)	22.4 (W-83)
Leaf length (cm)	17.7 (W-37)	41.1 (W-119)
Leaf width(cm)	0.40 (W-87)	0.94 (W-28)
Ligule length(cm)	0.44 (W-35)	2.82 (W-78)

Table 11.4. Range of variability among quantitative traits in *Ocimum* germplasm (43 acc)

Species	Highest estimation of herbage yield/ plant (g)	Highest estimation of essential oil yield/ plant(ml)
Ocimum tenuiflorum	491.4 (IC599368)	2.3 (IC599368, IC599341)
O. gratissimum	612.0 (IC589184)	2.7 (IC599316, IC589184)
O. basilicum	527.5 (IC599326)	1.7 (IC599326, IC589222)
O. americanum	489.6 (IC599362)	1.4 (IC589200, IC599362)
O. kilimandscharicum	457.2 (IC627241)	2.7 (IC627241)
O. citriodorum	431.1 (IC626384)	2.3 (IC626384, IC599357)

11.3.4 *Hibiscus sabdariffa*

Twenty-one accessions of *Hibiscus sabdariffa* were characterized for 33 agro-morphological and economic traits in RBD with two replications and promising genotypes such as IC610799, IC610800, IC617966 and IC619334 were identified for multiple traits viz. plant height, fresh leaf yield/ plant, fresh calyx yield/ plant and number of fruits/plant and 100 seed weight.

11.3.5 *Mucuna pruriens*

Observations on different pod and seed characters such as pod length, pod width, number of pods/ cluster, number of seeds/ pod, seed length, seed width and 100 seed weight of 34 accessions of *M. pruriens* var. *pruriens* germplasm characterized prior to 2018 have been compiled to record extent of genetic variability. The range of variability indicating their minimum and maximum, average, standard error and coefficient of variation (CV) were recorded. High CV % was observed for number of pods/ cluster and seed weight which indicated wide variation among these traits. Similarly, wide variation was recorded among qualitative traits viz. pod pubescence varied from profusely dense hairy to moderately hairy; hair colour varied from light brown, reddish brown, dark brown, grey, dull red, brick red to straw coloured; shape of pods varied between sigmoid, curved at both ends with or without a prominent line. The colour of seeds varied from light green, off white, light brown, dark brown, grey, deep black, mottled dark grey, mottled yellowish brown to mosaic black. Based on multiple morpho-agronomic traits the accessions viz, IC599342, IC599358, IC589194 and IC599331 collected from coastal delta zone and central tablelands are found promising with respect to seed weight, seed size, number of seeds per pod and pods per cluster.

11.4 Germplasm evaluation

11.4.1 Evaluation of cultivated rice germplasm for submergence tolerance

A set of 54 accessions of cultivated rice germplasm collected from different flood prone regions of Odisha, West Bengal and Assam was evaluated for identification of donors for submergence tolerance in artificial screening facility in collaboration with ICAR-NRRI, Cuttack. The experiment was conducted in two replications with four checks viz, Swarna sub-1, FR-13 A (tolerant) and IR-42 and Swarna (susceptible). Twenty one days old seedlings were submerged for 2 weeks and then de-submerged after the susceptible checks died completely. Observations were recorded on survival percentage and internode elongation based on which 14 flood tolerant rice genotypes were identified as probable donors for submergence tolerance.

11.4.2 Biochemical evaluation of *Ocimum* and *Hedychium* germplasm

The essential oil samples of 36 accessions of *Ocimum* spp. germplasm and three accessions of rhizome shred samples of *Hedychium* spp. were supplied to the Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi for evaluation of biochemical compounds.

11.5 Seed multiplication

A total of 3,798 accessions comprising cultivated rice (3,424), wild rice (235), *Abelmoschus* spp. (25), *Hibiscus sabdariffa* (21), *Ocimum* spp. (49), *Vigna unguiculata* (6), *Cajanus cajan* (3), *Mucuna pruriens* (3), *M. monosperma* (1), *Cucumis sativus* var. *hardwickii* (1), *Luffa acutangula* (1) *Luffa aegyptiaca* (2) and *Trichosanthes tricuspidata* (1) along with *Dioscorea* spp. (18 acc), *Zingiber zerumbet* (1), *Costus speciosus* (4), *Hedychium* spp. (3) were grown for seed multiplication, preliminary characterization/ biochemical evaluation.

11.6 Germplasm exchange

A set of 126 accessions including 37 accessions of fodder plants, 9 accessions of wild rice and 80 acc of vegetable crops such as wild relatives of *Cucumis* (40), *Luffa* spp. (14), *Vigna* spp. (21), *Trichosanthes* spp. (2), *Coccinea grandis* (2) and *Abelmoschus tetraphyllus* (1) collected during various explorations in West Bengal and Odisha were supplied to ICAR-IGFRI, Jhansi, ICAR-NRRI, Cuttack and ICAR-IIVR, Varanasi, respectively for

multiplication, characterization and conservation. Besides, seed materials of *Cajanus cajan* (77 acc) collected during the exploration from five districts of West Bengal were supplied to ICAR-IIPR, Kanpur and 9 acc comprising *Vigna unguiculata* (6) and *Cajanus cajan* (3) were supplied to ICAR-NBPGR RS, Hyderabad for multiplication and conservation.

11.7 Germplasm conservation

A set of 1,629 accessions comprising 1,444 acc. of cultivated rice germplasm multiplied during *Kharif,* 2018 and 185 acc of CWR such as wild relatives of *Cucumis* spp. (40), *Luffa* spp. (14), *Cajanus cajan* (75) and *Ocimum gratissimum* (1), *Trichosanthes* spp. (2), *Coccinea grandis* (2), *Abelmoschus tetraphyllus* (1), *Abelmoschus ficulneus* (1), *Vigna* spp. (21), *Sesamum indicum* (16), *Diplocyclos palmatus* (3), *Ocimum gratissimum* (2), *Hibiscus sabdariffa* (3), *Echinochloa frumentacea* (2) and *Sorghum vulgare* (2) collected from Odisha and West Bengal were deposited for long term conservation in National Gene Bank, ICAR-NBPGR, New Delhi. In addition, *Costus speciosus* (1) and *Dioscorea alata* (1) collected from Odisha were added to the field genebank of the centre.

11.8 Germplasm maintenance

A total of 519 accessions comprising M&AP (241), horticultural crops (6), tuber/aroid crops (25), wild *Oryza* species (235), wild relatives of crops such as *Solanum* spp. (3), *Costus speciosus* (5), *Hedychium* spp. (3), *Zingiber zerumbet* (1), are being maintained in the FGB/experimental plots of the centre.

Some important species of medicinal and aromatic plants viz. *Aristolochia indica, Zingiber zerumbet, Costus speciosus*, *Abelmoschus moschatus, Hedychium coronarium, H. coccineum, H. flavescens, Mucuna pruriens, M. monosperma, M. nigricans, Ocimum basilicum, O. citriodorum, O. kilimandscharicum, O. americanum, O. tenuiflorum, O. gratissimum, Nicandra physalodes, Solanum viarum*, *Argyreia nervosa, Asparagus racemosus, Bacopa monnieri, Saraca asoca, Celastrus paniculata, Centella asiatica, Gardenia gummifera, Hibiscus panduriformis, Hemidesmus indicus, Litsea glutinosa, Mallotus philippensis, Nyctanthes arbortristis, Oroxylum indicum, Piper longum, Plumbago rosea, Pterocarpus santalinus, Rauvolfia serpentina, Scindapsus officinalis, Stevea rebaudiana, Strychnos potatorum, Solanum sisymbrifolium, Tinospora cordifolia, Watakaka volubilis* etc. are being maintained in the field gene bank of the centre for academic research purpose.

11.9 Herbarium preservation

The herbarium of the centre is harbored with about 1,430 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 moschatus*, *Abelmoschus angulosus* var. *grandiflorus*, *Abelmoschus tuberculatus* var. *deltoidefolius, A. tuberculatus* var. *tuberculatus*, *Abelmoschus crinitus*, *Abelmoschus tetraphyllus* var. *tetraphyllus, Mucuna pruriens* var. *utilis, Hedychium coronarium, Zingiber zerumbet, Hibiscus cannabinus*, *Solanum esculentum* var. *cerasiforme, Cajanus cajan* etc were augmented to the herbarium.

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

REGIONAL STATION, HYDERABAD 12

Summary: During the period under report a total of 26,744 samples (26, 552 imports; 23,904+2840 exports) were processed for quarantine clearance. 49 phytosanitary certificates were issued. *Fusarium solani*, *Stenocarpella maydis* (maize-USA), *Fusarium oxysporum, Rhizoctonia solani* and *Pestalotiopsis neglecta* (maize-Thailand), *Rhizoctonia bataticola* (sorghum-Argentina), *Stenocarpella maydis* and *Drechslera rostrata* (pearl millet-USA), *Colletotrichum* sp., *bean common mosaic virus* and *groundnut bud necrosis virus* (soybean-USA), *R. bataticola* (okra- Taiwan), *Colletotrichum dematium* and *Drechslera setariae* (bittergourd-Thailand); *Alternaria ricini* (castor-USA) were intercepted. Import samples (20,925) infested/ infected with pests/pathogens were salvaged and released (20,269). Remaining 656 sorghum samples with severe bacterial and fungal infection & NIL germination were rejected. Quarantine services were extended to 98 organizations in South India. Post-entry quarantine inspection was conducted on 16,371 samples of different crops grown at PEQIA of ICRISAT and AVRDC (1684), ICRISAT glasshouse (171), private industry (14250), public organizations (29) and NBPGR greenhouse (237). One collaborative exploration was undertaken, and 152 accessions of various crops including sorghum, millets and vignas were collected. A total of 716 accs. of different agri-horticultural crops belonging to black gram (3), brinjal (50), browntop millet (37), chillies (112), dolichos bean (40), field bean (37), finger millet (7), green gram (88), italian millet (65), kenaf (9), little millet (7), maize (129), okra (1), pearl millet (8), pigeon pea (1), roselle (6), sesame (54), sorghum (31) and tomato (31) were sown for field characterization/ evaluation/ screening/ multiplication/ rejuvenation as per standard descriptors and states. Under the AICRN-PC project 15 varieties of amaranths were characterised and evaluated during rabi 2018-2019. Under the RKVY Project 120 accessions of various cereals, millets, pulses in *rabi* 2018-2019 and both *kharif* 2019. 85 exploration voucher samples including *Corchorus* spp, (66), sorghum (13), *Hibiscus* spp (5) and *Crotalaria verrucosa* (1) were sent for long-term conservation in NGB. A total of 933 germplasm accessions were provided to 24 SAUs/ICAR institutes against 23 indents.

12.1 Germplasm quarantine

A total of 53,296 samples comprising 26,552 import samples and 26,744 export samples were received for quarantine processing as detailed below. In all, three international organizations, 63 public organizations (ICAR/CSIR institutes, universities/ state govt. organizations) and 32 private organizations received the quarantine service from this station.

12.1.1 Import quarantine

A total of 26, 552 samples including paddy-15,566; maize-5,623; wheat-4; sorghum-2,026; pearl millet-1,227; fingermillet-632; barley-139; chickpea-4; horsegram-1; cowpea-110; Yard longbean -104; common bean-72; sunflower-7; castor-133; mustard-11; groundnut-2; chilli-59; tomato-214;bitter gourd-270; sponge gourd-119; ridgegourd-23; pumpkin-5; okra-144; cabbage-2; *Cenchrus americanns* -3; *Cosmos bipinnatus* -16; Guria grass-1; *Celosia plumosa*-3; *Plectranthus scutellarioides*-21; coffee-1; and papaya-10; were imported from different countries.

12.2 Interceptions

12.2.1 Pathogens

During processing, *Fusarium solani*, *Stenocarpella maydis* on maize from USA, *Fusarium oxysporum, Rhizoctonia solani* and *Pestalotiopsis neglecta* on maize from Thailand; *Rhizoctonia bataticola* on sorghum from Argentina; *Stenocarpella maydis* and *Drechslera rostrata* on pearl millet from USA; *Colletotrichum* sp., *bean common mosaic virus* and *groundnut bud necrosis virus* on soybean from USA; *R. bataticola* on okra from Taiwan; *Colletotrichum dematium* and *Drechslera setariae* on bittergourd from Thailand; *Alternaria ricini* on castor from USA; Nematode, *Aphelenchoides besseyi* on paddy from Philippines were intercepted.

During processing, 656 sorghum seed samples from Kenya were rejected due to heavy incidence of seed borne bacteria and no germination.

12.2.2 Imports processed and released

Seed samples released (40,471) included paddy-16,428; maize-19,603; wheat-4; sorghum-1357; pearl millet-1,227; fingermillet-632; common bean-72; chickpea-4; cowpea- 110; sunflower-7; castor-133, mustard-7 ; groundnut-2 ; yardlong bean-104; chilli-159; tomato-222; bitter gourd-243; pumpkin-2; cucumber-4; cabbage-2; okra-144; coffee-1; *Brassica napus*-4 and after necessary mandatory treatments.

Seed ELISA was conducted on 13 accessions of groundnut from Niger (11) and Uganda (2) were tested against bacterial wilt, *Ralstonia solanacearum* and all were found free from the infection. Two groundnut seed samples from Uganda were ELISA tested against three seed borne viruses, *viz*., *Peanut stunt virus* (PSV), *Peanut stripe virus* (PSTV) and *Peanut mottle virus* (PEMOV) and found free from virus infection.

12.2.3 Import germplasm salvaging details

Total number of samples infected/infested	20,925
Fungi	20,705; (Pathogens-7,747; saprophytes- 12,958); Bacteria: 789; Viruses: 3; Nematodes: 37; Insects: Nil)
Number of samples salvaged	20,269
Number of samples detained:	Nil
Number of samples rejected:	656 (Sorghum samples with severe bacterial and fungal infection & NIL germination)

12.3 Post-entry quarantine observations

Post-entry quarantine inspection was conducted on **16,371** samples of different crops grown at PEQIA of ICRISAT and AVRDC (1,684), ICRISAT glasshouse (171), private industry (14,250), public organizations (29) and NBPGR greenhouse (237).

12.3.1 ICRISAT glass house

PEQ inspection of crop germplasm (171 accns) consisting of groundnut (2) from Uganda, chickpea (4) from Turkey, pearl millet from UK (52) and Niger (37); wild fingermillet (8) from UK, fingermillet from Kenya (60) and Zimbabwe (5); and maize (3) from Germany was conducted at ICRISAT glasshouse (Fig. 12.1). The weed, *viz*., *Digitaria ciliaris* was intercepted in finger millet accessions imported from Zimbabwe. The weed species was uprooted and incinerated.

Fig. 12.1. *Digitaria ciliaris*, weed species, observed in fingermillet consignment from Zimbabwe, grown in greenhouse at ICRISAT

12.3.2 ICRISAT field

PEQ inspection of finger millet (1,320 accns) from Kenya (688) and Zimbabwe (632) and pearl millet (50 accns) from Niger, grown in the fields of ICRISAT was conducted at regular intervals. Blast incidence (*Pyricularia setariae*) was observed in some fingermillet accessions. One plant suspected with *Ragi mottle streak virus* (Nucleorhabdovirus) from Kenya was uprooted and incinerated. Poor germination noticed in many accessions. Incidence of *Drechslera rostrata* on finger millet from Kenya and blast (*Pyricularia grisea*) from Zimbabwe was observed. It was found that there was an admixture of two accessions of barnyard millet and one accession of foxtail millet along with the fingermillet consignment.

Harvested produce (3,385 accns) consisting of sorghum from Mali (2,600) and Kenya (695); and pearlmillet from Kenya (90) was inspected at Plant Quarantine laboratory of ICRISAT (Fig. 12.2). Panicles showing severe mould infection were incinerated.

Fig. 12.2. Fingermillet plant from Kenya, suspected with *Ragi mottle streak virus* infection in PEQIA, ICRISAT

12.4.3 AVRDC

Post-entry quarantine inspection crop germplasm (314 accessions) consisting of brinjal (3), chilli (29), cucumber (6) and tomato consignments (10, 16, 19, and 08), vegetable cowpea (110) and yard long bean (104) from Taiwan, and bittergourd (9) from Thailand, meant for AVRDC and grown in the field of ICRISAT were conducted. Aphid infestation was noticed in two bittergourd accessions, while root grub damage was recorded in tomato accessions. Dry root rot (*Rhizoctonia bataticola*) incidence and root grub damage recorded in chilli accessions. Plants showing little leaf symptoms in chilli and brinjal were uprooted and incinerated.

12.4.4 PEQ NBPGR

Maize accessions from USA (24), meant for Directorate of Maize Research, Hyderabad were grown in isolation at this station under insect proof conditions for PEQ growing. Accessions were inspected at regular intervals and one plant exhibiting *Maize streak virus* symptoms was uprooted and incinerated.

Twenty-three accessions of maize, received from USA, meant for DMR, were sown in the polyhouse for PEQ growing. Germination was relatively poor in all the accessions. One plant suspected to be infected with *Maize streak virus* was uprooted and incinerated. The healthy accessions were released after harvest.

Soybean accessions from USA (40), meant for Inter University Centre for Genomics and Gene Technologies, University of Kerala were grown in isolation at this station in the QGH. Accessions were inspected at regular intervals and some accession showing virus symptoms were collected and sent to Head Quarters for further testing. One accession did not germinate, and rest of them were healthy and released.

Soybean accessions from USA (150), received from NBPGR, New Delhi for multiplication, were grown at this station under controlled conditions. Accessions were inspected at regular intervals. Some virus suspected samples were tested at this station and found infected with *Bean common mosaic virus* (2 accns), and *Groundnut bud necrosis virus* (2 accns). Anthracnose incidence was also noticed in some accessions. Leaf samples from accessions showing virus suspected symptoms were collected by a Virologist from, NBPGR, New Delhi. The multiplied seed from 144 accessions was sent to NBPGR, New Delhi. Of the remaining 6 accns, three accessions (PI506556; PI594614B; PI417159) did not germinate and two accessions were found infected with *Bean common mosaic virus*. One accession produced only one seed and is kept for sowing again for multiplication. The virus infected plants were uprooted and incinerated.

12.4.5 Public organizations

Post entry quarantine inspection of tomato mutant lines (5 out of 27) from USA, meant for Hyderabad Central University, grown in net house facility, HCU, Hyderabad was conducted. All samples were found healthy.

Post entry quarantine inspection of one maize consignment from USA (24) grown at IIMR Field Rajendranagar, Hyderabad was conducted. Suspected leaf samples were tested and found to be infected with *Drechslera maydis, D. rostrata* and *Curvularia lunata*. Plants infected with *D. maydis* were uprooted and incinerated.

12.4.6 Private industry

Post entry quarantine inspection of 14,250 samples consisting of maize (13,931) imported from Thailand (3,173), USA (2,539), South Africa (224), Philippines (2,970), Arica (4,490), Brazil (370), Italy (10), Mexico (125), Kenya (25), Zimbabwe (7) and Indonesia (79); okra (61) from USA; tomato (15) from Taiwan; bitter gourd (110) from Taiwan (29) and Thailand (81); castor (113) from USA were conducted at PEQ facilities of indenters sites during 2019. The details of observations and action taken were given in Table 12.1.

12.4.7 Pre-export crop inspection

Pre-export crop inspection was conducted to observe 2310 maize accessions, grown in 1.4 ha at ICRISAT, meant for export to Bangladesh, Nepal, Pakistan, Srilanka, Bhutan, Thailand, Vietnam, Indonesia, Philippines, Mexico, Kenya and Zimbabwe by CIMMYT. All were found healthy.

12.5 Export quarantine

12.5.1 Exports processed

Crop germplasm samples (23,904) consisting of maize (16,856) received from CIMMYT and sorghum (4168), pearlmillet (240), finger millet (80), foxtailmillet (150), kodo millet (75), littlemillet (56), proso millet (103), pigeonpea (73), chickpea (1292), groundnut (595) received from ICRISAT, and paddy (216) from ICAR-IIRR were processed and exported to different countries (Table 12.2). However, 427 samples consisting of 40 sorghum (28 Gram –ve; 12

Table 12.1: Details of post entry quarantine inspections (PEQI) undertaken at private industries during 2019.

Crop	No. of samples	Source Country	Name of the site	Observation and Action taken
Maize	217	Thailand	Pioneer Hi-Bred Private Limited, Hyderabad	Two accessions were found infected with *Drechslera maydis*, which were uprooted and incinerated. 12 plants in 09 accessions were suspected with *Maize streak virus* infection were also uprooted and incinerated
	229 10 115 236	Brazil Italy Mexico Thailand	M/S Pioneer Hi-Bred Private limited. Hyderabad	*Maize streak virus* suspected plants: One plant from Italy consignment and two plants from Brazil consignment were uprooted and incinerated. In addition, *Acremonium strictum*, *Alternaria alternata, Nigrospora* sp., *Phoma* sp., *Fusarium* spp., and *Periconia bessoides* were recorded.
	2,222 221	USA USA	M/S Pioneer Hi-Bred Private limited, Hyderabad	One plant suspected with *Maize streak virus* symptoms in EC974514 was uprooted and incinerated. It was also advised to uproot and incinerate plants exhibiting leaf blight symptoms due to *Drechslera maydis* in EC973218.
	11 16 30 29	USA USA South Africa South Africa	Pioneer Hi-Bred Private Limited, Bengaluru	Northern leaf blight (*Exserohilum turcicum*) was recorded on EC971073 and EC971045. Plants (15 no.) suspected with viral diseases in 9 accessions of South Africa were uprooted and incinerated. Symptomatic leaves revealed the presence of *Alternaria alternata, Nigrospora* sp., *Curvularia lunata, Phoma* sp., and *Periconia byssoides* in the incubation test.
	25 10 07	Kenya Mexico Zimbabwe	M/S Pioneer Hi-Bred Private limited. Bengaluru	All accessions were healthy. One plant with severe leaf drooping was uprooted and incinerated. Fall army worm incidence was noticed in the field grown accessions of Kenya and Zimbabwe.
	141	Brazil	M/S Pioneer Hi-Bred Private limited. Bengaluru	All samples were found healthy

Crop	No. of samples	Source Country	Name of the site	Observation and Action taken
	242 120	Philippines Thailand	M/S Pioneer Hi-Bred Private limited. Bengaluru	**Virus suspected plants:** 4 plants in EC979886 and EC979840 in Philippines consignment, and 2 plants in Thailand consignment. **Downy mildew**: 5 plants in EC979982, EC979892 and EC979878 accessions in Philippines consignment Downy mildew and virus suspected plants were uprooted and incinerated.
	79	Indonesia	M/S Pioneer Hi-Bred Private limited. Bengaluru	All plants of one accession (238468) were uprooted and incinerated as majority of plants were showing virus suspected symptoms. It was also advised to uproot and incinerate plants exhibiting leaf blight symptoms due to *Drechslera maydis* in 238424 and 238426.
	26 127 12	South Africa	M/S Pioneer Hi-Bred Private limited. Bengaluru	**Downy mildew:** 1plant in EC995511; **SCLB- *D. maydis:*** EC995416, EC995494, EC995428 and EC995413. These accessions were uprooted and incinerated. Other pathogens viz., *Curvularia, Drechslera rostrata, Exserohilum turcicum, Myrothecium* sp and *Phoma* sp. were recorded.
	69	USA	M/S Metahelix Life Sciences Ltd, Hyderabad	All the plants in an accession (EC963761), showing symptoms of *Maize chlorotic streak virus* (MCSV) and another accession (EC963779) showing symptoms of *Wheat streak mosaic virus* (WSMV), were uprooted and incinerated. In addition, 83 plants belonging to 25 accessions showing symptoms of *Maize chlorotic mottle virus* (MCMV), and one plant in an accession showing symptoms of *Wheat streak mosaic virus* (WSMV) were also uprooted and incinerated.
	2,728	Philippines	M/s. Syngenta India Limited Rice Research Farm,	Four plants infected with downy mildew in three accessions, six plants with Southern corn leaf blight in three accessions and six virus suspected plants in five accessions were uprooted Kurellagudem, and incinerated.Downy mildew (*Peronospora* sp) on EC941309 Amberpeta (V) Southern corn leaf blight (*Drechslera maydis*) on EC 942056, West Godavari EC941309, EC943410 and EC941175; It was advised to District, AP uproot and incinerate the DM and SCLB infected plants. Other pathogens recorded include, *Alternaria alternata, Curvularia lunata, D. sacchari, D. halodes, Fusarium oxysporum, F. semitectum, F. equiseti, Myrothecium roridum, Puccinia polysora* and *Setosphaeria turcica* (Syn. *D. turcicum*). Fall Armyworm (*Spodoptera furgiperda*) and red mite infestation was also noticed on several accessions.
	1,340 1,260 875 2,499 1,035	Thailand Thailand Arica (Chile) Arica (Chile) Arica (Chile)	M/s. Syngenta India Limited Rice Research Farm, Kurellagudem, Amberpeta (V) West Godavari District, AP	**Virus and downy mildew:** 84 plants in 32 accessions of Thailand consignment and 72 plants in 42 accessions of Arica (Chile) consignment **Fusarium stalk rot:** 650 plants in 68 accessions of Thailand consignment; and 11 plants in 07 accessions of Africa (Chile) consignment **Southern corn leaf blight** (*Drechslera maydis*) was isolated from 20 accessions. Other common pathogens recorded include, *Acremonium strictum, Alternaria alternata, Choanephora* sp., *Curvularia lunata, Fusarium semitectum, Nigrospora* sp., *Phoma* sp. and *Periconia byssoides.* Anthracnose, *Cercospora* leaf spot, northern corn leaf blight, rust and insect pest such as fall armyworm and aphids were also noticed on several accessions. Downy mildew, southern corn leaf blight, virus suspected, and *Fusarium* stalk rot affected plants were uprooted and incinerated.

Crop	No. of samples	Source Country	Name of the site	Observation and Action taken
Okra	61	USA	H M Clause (I) Pvt. Ltd. Bengaluru	All samples were found healthy.
Tomato	15	Taiwan	Seed works International Pvt. Ltd. Bengaluru	All samples were found healthy
Bitter gourd	81	Thailand	HM Clause (I) Pvt. Ltd. Bengaluru	**Begomovirus (leaf curl virus)** infected plants (19 no. In 12 accns) were uprooted and incinerated. The virus suspected plants were kept on observation and tested against viruses, *viz*., PRSV, ZYMV, CGMMV, CMV, CMV-1, CMV-2 using antisera and all were found negative against these viruses. However, five accessions (EC975406, EC975408, EC975409, EC975410, and EC975411) were found infected with leaf curl virus (begomovirus) in ELISA.
	29	Taiwan	Metahelix Life Science Ltd. Bengaluru	Total 16 virus-infected plants were uprooted and incinerated. The virus-infected plants (8 no.) were collected and tested against *Cucumber mosaic virus* (CMV) using antisera and all were found negative against CMV.
Castor	133	USA	Hi-yield Genetics (P) Ltd., Hyderabad	All were found healthy.

Table 12.2: Details of germplasm processed for export

Exports (ICRISAT)	Number of samples		
Crop	**Received**	**Rejected**	**Released**
Sorghum	4,168	40	4,128
Pearl millet	240	1	239
Finger millet	80	0	80
Foxtailmillet	150	0	150
Kodo millet	75	0	75
Littlemillet	56	0	56
Prosomillet	111	5	106
Chickpea	1,292	319	973
Pigeon pea	65	0	65
Groundnut	595	4	591
Exports (CIMMYT)			
Maize	16,856	0	16,856
Paddy	216	58	158
Grand total	23,904	427	23,477

Fusarium sp.); 1 pearlmillet and 4 groundnut with Gram –ve bacteria; 5 proso millet with smut; 319 chickpea (Gram –ve bacteria, nil germination, insect infestation and few samples were not in approved list) and 58 paddy with *Pseudomonas syringae* pv *syringae* were not found suitable for export, hence detained. In all, 49 Phytosanitary certificates were issued.

12.5.2 Svalbard global seed vault

Crop germplasm (2840 +392 duplicate samples for viability tests) consisting of sorghum (1,383), pearl millet (607), pigeonpea (66), chickpea (360) and finger millet (424), meant for export to Norway for conservation in the Svalbard Global Seed Vault, was visually examined on December 19, 2019 from seed health aspects. All the samples were found healthy and free from pests.

12.6 Screening germplasm for resistance against biotic stresses

A total of 201 accessions of okra germplasm comprising of *Abelmoschus esculentus* (137 accs.), *Abelmoschus* wild species (15 accs./four spp.) and inter-specific derivatives (49 accs.) were evaluated for their resistance reaction to root- knot nematode from 2017-19. During the reporting period, advance screening of promising accessions belongs to four wild species *viz., A. angulosus* (3 accs.), *A. enbeepeegeearensis* (2 accs.) *A. mizonagensis* sp.

nova. (2 accs.) and *A. tetraphyllus* (3 accs.) and interspecific derivatives (22 accs.) was taken up. Accessions belonging to *A. angulosus* (IC203863) and *A. tetraphyllus* (IC470742) manifesting galling in the range from 10- 17 galls/ plant and were identified as moderately resistant to root-knot nematode. In addition, germplasm of 38 accs. of brinjal wild species consisting of *S. aculeatissimum* (3 accs.), *S. incanum* (29 accs.), *S. indicum* (1 accn.), *S. macrocarpon* (1accn.), *S. viarum* (3 accs.) and *S. virginiacum* (1accn.) were also screened for their resistance reaction to root-knot nematode, (*Meloidogyne incognita*) and all were found susceptible based on number of root galls/ plant. Among six chilli accessions, EC402105, EC399535 and EC391083were found promising and are under advance screening to confirm the resistance to root-knot nematode.

12.7 Seed health testing

Seed health testing of 268 samples consisting of paddy (183 samples), maize (84 samples), meant for export, and one sample of *Mucuna bracteata,* meant for in house research, was also conducted.

Ten paddy samples were found infected with *Pseudomonas syringae* (55), *Cochliobolus carbonum* (07) and *Epicoccum nigrum* (08). Sixteen paddy samples were found infected with *Aphelenchoides besseyi.* Thirty-eight samples of maize were found infected with *Acremonium strictum* and three maize samples were infected with *Fusarium sporotrichoides.*

12.7.1 TSOP treatment

Germplasm seed samples (169) consisting of tomato (110) and chilli (59) from Taiwan were given mandatory Trisodium orthophosphate treatment against *Tobacco mosaic virus* before release.

12.8 Germplasm exploration and collection

An exploration was undertaken for the collection of Vigna species, sorghum and small millets from parts of Bidar (Karnataka) and Nanded and Hingoli districts (Maharashtra). The exploration was undertaken in collaboration with IIMR, Hyderabad and ARS, Badnapur, MULLARP, Kanpur. A total of 152 collections were made including *Sorghum bicolor* (54), *Setaria italica* (7), *Eleusine coracana* (1), *Pennisetum typhoides (9), Vigna mungo* (19), *Vigna radiata* (30), *Vigna unguiculata* (12), *Macrotyloma uniflorum* (1), *Corchorus fascicularis* (1), *Vigna aconitifolia* (3), *Abelmoschus esculentus* (3), *Lens esculentus* (1) and *Cajanus cajan* (3). Wild species collected included *Cajanus scarabaeoides* (4), *Rhyncosia rufescens* (1), *Vigna trilobata* (1), *Vigna sp.* (2). Good diversity was observed in Sorghum, green gram and cowpea wild species. Landraces collected in sorghum include*Talki jowari,*

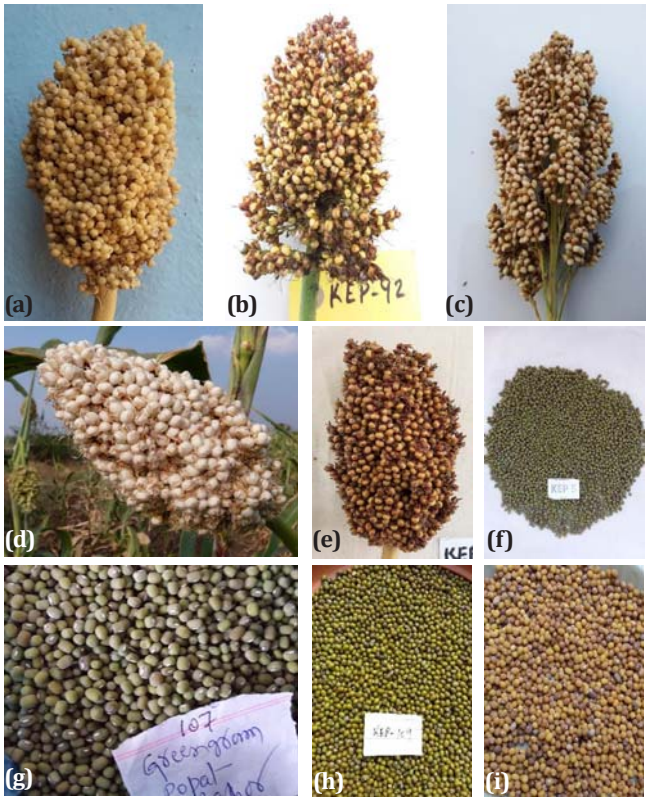


Fig. 12.3. (a) *Talki Jowar* (KEP 1) from Dharmabad, Nanded, Maharashtra; (b) *Hasiru jolla* (KEP 92) from Bidar, Karnataka; (c) *Aayi jolla* (KEP 120) from Humnabad, Bidar, Karnataka; (d) Dagdi sorghum (KEP 50) from Savarkheda, Hingoli; (e) Pivli jowari (KEP 72) from Pasadgaon Nanded, Maharashtra; (f) *Haramung* (KEP-5) from Billoli, Nanded, Maharashtra; (g) *Popat/Bandiri Hesaru* (KEP-107) from Hulsur, Bidar, Karnataka; (h) *Chamki mung* (KEP 109) from Hulsur, Bidar, Karnataka & (i) *Pili mung* (KEP 88), from Gopalaswadi, Nanded, Maharashtra

Kamalapuri jowari, Dukri jowari, Dagdi jowari, Pivli jowari, Safed Pivli, Gundu jolla, Hasiru jolla, Kempu jolla, Billa jolla and *Aayi jolla*. In green gram, landraces included *hara mung, pili mung, chamki mung* and *popat hesaru.*

12.9 Germplasm characterized and evaluated

A total of 564 accs. of different agri-horticultural crops belonging to black gram (3), brinjal (50), browntop millet (37), chillies, dolichos bean, field bean (37), finger millet (7), green gram (88), italian millet (65), kenaf (9), little millet (7), maize (129), okra (1), pearl millet (8), pigeon pea (1), roselle (6), sesame (54), sorghum (31) and tomato (31) were sown for field characterization/ evaluation/ screening/ multiplication/ rejuvenation as per standard descriptors and states. Under the RKVY project 120 accessions including sorghum, finger millet, foxtail millet and little millet germplasm were multiplied and processed for MTM/LTS. In addition, 15 varieties of Amaranths were also characterized and evaluated under the AICRN PC Project. Promising accessions were identified for important traits in different agri-horticultural crops as follows:

12.9.1 Brown top millet

Plant height (cm): IC613551 (135.7), IC617953 (131.3), IC613562 (131.3); Basal tillers (no.): IC613557 (38.0), IC617956 (37.0), IC613550 (35.3); Seed yield/ plant (g): IC613553 (39.9), IC617956 (70.0), IC617957 (42.5); Days to flowering: IC613553 (61.0), IC617957 (61.0), IC613550 (61.0), IC617953 (61.0).

12.9.2 Italian Millet

Plant height (cm): IC438725 (257.7), IC308936 (234.3), IC308934 (209.0); Panicle length (cm): IC308936 (36.7); Seed yield/ plant (g): IC308981 (78.5), IC599109 (73.0); Days to flowering: IC308861 (50)

12.9.3 Maize

Kernel rows (no): IC623879 (20.0), IC623876 (18.0), IC627707 (18.0); 100 Seed weight (g): IC336412 (33.6), IC332070 (33.2), IC611609 (31.6); Days to tasselling: IC332069 (36.0), IC332070 (37.0), IC623876 (41.0); Days to silking: IC332069 (37.0), IC332070 (39.0), IC623876 (43.0)

12.9.4 Black gram

Plant height (cm): IC335331 (56), IC413309 (52); Primary branches (no.): IC436910 (4.8), IC426769 (4.7), IC436597 (4.4); Pods/plant (no.): IC436597 (62), IC436910 (60), IC519678 (55); Seeds/pod (no.): IC335331 (7.3), IC519678, IC436910 (7); 100 seed wt (g): IC281989 (5.5), IC436675 (5.4), IC413309 (5.2)

12.9.5 Horse gram

Plant height (cm): IC426464 (179.0), IC426470 (172.0): Primary branches (no.): IC426531 (15.3), IC42647(15.0); Pod length (cm): IC426573 (6.0), IC426555 (5.8); Seeds/pod (no.): IC426550 (7.0); Pods/plant (no.): IC107214 (202.0), IC426531 (194.0), IC426470 (190.0)

12.9.6 Sesame

Plant height (cm): IC13878 (141.0); Days to 50% flowering: IC26309 (37.0), IC14082 (37.0), IC73518 (38.0): Capsule length (cm): IC110221 (3.9), IC73518 (3.8), IC132167 (3.7); Capsules/plant (no.): IC132167 (94.0), IC131936 (82.0), IC73518 (70.0); 1000-Seed weight (g): IC132167 (3.1)

12.9.7 Pillipesara bean

Clusters/plant (no.): IC550525 (25), IC550541 (19.2), IC550537 (22), IC553502 (21.6); Pod length (cm): IC553502 (5.5), IC550541 (5.23); Pods/plant (no.): IC550531 (87.4), IC550557 (65.8), IC553525 (84.1), IC553512 (78.7); Pods/cluster (no.): IC550540 (10.7), IC553517 (10.0), IC550557 (8.1); 100 seed wt (g): IC550532 (0.93), IC550529 (0.9), IC550557 (0.87)

12.9.8 Brinjal

Primary branches (no.): IC136309 (13.4), IC446654 (9.0); Days to 50% Flowering: IC89888 (68), IC136546 (83), IC136177 (84), IC136366 (85); Leaf blade length (cm): IC137751 (13.7), IC136182

Fig. 12.4. Variation in maize germplasm

Fig. 12.5. Maize accession IC332069 early to tassel (36 days) and silk (37 days)

Fig. 12.6. Variation in brinjal germplasm characterized at RS Hyderabad

(13.6): Fruit length (cm): IC136177 (17.1); Fruit breadth (cm): IC137751(9.6), IC136309(8.7), IC136258(7.1)

12.9.9 Chillies

Plant height (cm): IC610381 (120.0), IC572480 (108.0), IC610382 (104.3), IC363918 (101.7); Fruit length (cm): IC347044 (13.5), EC391083 (12.8), IC570484 (12.6), EC391082 (12.4); 25 dry fruit weight (g): IC076291 (92.5), EC391088 (63.0), IC-561614 (55.8), IC-570484 (55.5); Days to flowering: IC-561670 (51.0), IC561671 (60.0), IC528433 (63.0), IC-561655 (65.0)

12.9.10 Dolichos bean

Pod length (cm): IC427423 (18.9); Pod width (cm): IC427436 (3.0), IC427423 (2.4); 10 Fresh pod weight (g): IC427423 (106.9)

12.9.11 Field bean

Pod length (cm): IC261014 (15.8), , IC249526 (15.8), IC446556 (13.9); 10 Fresh pod weight (g): IC249526 (83.9), IC446556 (73.2), IC261257 (69.6); Seeds/ pod (no): IC249536 (5.7), IC446556 (5.7); 100 Seed weight (g): IC261257 (52.5), IC249526 (45.0), IC446556 (45.0), IC249536 (39.0).

12.9.12 Greengram

Accession IC-0614797 (NSJ/ NAIP/ 125) from Adilabad was identified to be a promising genotype in comparison to check varieties with respect to Seeds/ pod (14.0) [K-851-12.4, ML-267-12.0, LGG-460-13.0, PS-16-10.0]; 100- seed weight (6.5g) [K-851- 3.7, ML-267-3.1, LGG-460-3.2, PS-16-3.8] and Pod length (15.0 cm) [K-851-8.4, ML-267-10.0, LGG-460-8.3, PS16-7.7]

12.10 Germplasm multiplication

Wild *Arachis* spp, (59 accns) supplied by NBPGR, New Delhi were sown in the polyhouse for multiplication of the station. Of these, 46 accessions germinated and got established. However, two different plants of one accession (IC0338555) showed bacterial wilt (*Ralstonia solanacearum*) infection and *Peanut stripe virus* infection, which was confirmed by ELISA. Another accession (IC0420097) also showed bacterial wilt infection. Accessions are being inspected at regular intervals and 25 accessions have been harvested.

12.11 Germplasm conservation

12.11.1 Germplasm sent to NGB

A total of 85 exploration samples including *Corchorus* spp, (66), sorghum (13), *Hibiscus* spp (5) and *Crotalaria verrucosa* (1) were sent for long-term conservation in NGB. Multiplied exotic tomato seed samples (15) from Taiwan, received from Seed Works International Pvt Ltd Bengaluru, were sent to NBPGR, New Delhi for conservation in the National Gene Bank on November 14, 2019.

12.11.2 Germplasm shared with NAGS

Multiplied germplasm (112 accessions) of sorghum, finger millet, pearl millet, little millet,

barnyard millet, pigeonpea with RKVY project partners. Maize - Indian Institute of Maize Research, Hyderabad - 37 accs. along with passport data collected during collaborative exploration. A total of 108 accessions of Corchorus, Crotalaria and allied fibre species were shared with CRIJAF, Barrackpore, as collaborators during an exploration programme.

12.11.3 Medium term module

Germplasm (425) comprising voucher samples from explorations (152), and multiplied germplasm of blackgram (52), brown top millet (37), Italian millet (65), sesame (54), brinjal (50), and amaranths (15) were added to the MTM at the station. Germination and seedling vigour were tested in 500 accessions comprising blackgram, greengram, horsegram stored in the MTM for over 10 years.

12.12 Germplasm distribution

A total of 933 germplasm accessions were provided to 24 SAUs/ICAR institutes against 23 indents including brown top millet (1), chillies (295), blackgram (150), greengram (85), brinjal (185), Italian millet (5), little millet (1), tomato (147) and dolichos bean (66). Besides these, 27 accessions of wild species of different crops including *Solanum pennellii (2), Solanum pimpinellifolium (6), Solanum hirsutum (3), Solanum peruvianum (3) Capsicum baccatum(4)* and *Capsicum frutescens (4), Solanum incanum (4) and S. insanum (1)* were also distributed against various indents. In addition, three farmer's varieties registered with PPVFRA, including Erramachcha kandi (pigeonpea) and *Pelala jonna (sorghum) and Vayunowka jonna* (sorghum) were also distributed to tribal farmers for popularization, multiplication, sharing and to form a Cooperative for production, marketing and creation of a value chain. Further, shared multiplied germplasm (112 accessions) of sorghum, finger millet, pearl millet, little millet, barnyard millet, pigeonpea with RKVY project partners.

12.13 Germplasm released as varieties

12.13.1 Yardlong bean

Variety 'Mithra' was released by ARS Kalungal, Thiruvalla, Kerala Agricultural University using a pure line selection method. The original accession KV/TSA -27 / IC 582850 was collected from Jeypore, Koraput Odisha in 2011 (Fig. 12.7). This variety was found suitable for riverine alluvium of central Travancore. With a crop duration of 90-130 days, a shelf life of 5-6 days, attractive long light green pods with good cooking quality, an average pod length of 78.60 cm and average pod weight of 24.22 g, this variety also showed field tolerance to Fusarium wilt, Cercospora and Pythium rot. Yield was measured at 2.76 kg/plant and 21.66 t/ha.

Fig. 12.7. KV/TSA-27/IC582850 a NBPGR collection

Variety 'Kakatiya Kaluva' developed using a pure line selection method from the original accession IC582859 (KV/ TSA-35) (Fig. 12.8) was collected

Fig. 12.8. IC582859 (KV/TSA-35) collected originally by NBPGR

from Jeypore, Koraput Odisha in 2011, was recommended for release by Sri Konda Laxman Telangana State Horticultural University (SVRC), Telangana. The yield potential was measured at 2.5 kg./ plant.

12.13.2 Cluster bean

Variety Kakatiya Vaibhav/ Kakatiya Pragathi was recommended for release by Sri Konda Laxman Telangana State Horticultural University (SVRC) using a pure line selection method. The original accession is from an NBPGR collection IC103295 from Hisar, Haryana (Fig. 12.9). The yield potential was measured at 172.6 q/ ha.

Fig. 12.9. IC103295, orginal NBPGR collection

12.13.3 Coriander

Variety Kakatiya Ruchi developed using pure line selection from the original NBPGR accession IC512365 (NDCOR-1/ VG-0437) from Basti District, Uttar Pradesh was recommended for release by Sri Konda Laxman Telangana State Horticultural University (SVRC), Telangana. The yield potential was measured at 26.8 q/ ha (Leaf) (Fig. 12.10).

Fig. 12.10. IC512365 (NDWR-1/VG-0437) collected by NBPGR

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

PGR/PQR-BUR-HYD-01.01: Detection, identification and control of pests associated with import and export of seed/ plant material (**K Anitha,** B Sarath Babu, 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*)

REGIONAL STATION, JODHPUR 13

Summary: An exploration trip was conducted during the year under report in collaboration with NBPGR Headquarter and ICAR-IIVR Varanasi for collection of cultivated and wild species of round gourd from catchment area of Chambal river in UP, MP and Rajasthan. A total of 30 accessions of local landraces of round melon (tinda) were collected during exploration trip. The large variation in morphological traits was observed in round melon. During *Kharif* 2019, 1,358 accessions of different crops including cluster bean (466 acc.) mung bean (485 acc.) and moth bean (360 acc.) have been evaluated. The experiments were conducted in Augmented Block Design/ Randomized complete Block Design and the agro-morphological characters were recorded as per the minimal descriptors Published by ICAR-NBPGR. The trait specific promising germplasm accessions were identified in these crops. Three sets of 236 accessions of wheat mini core accessions have been sown during *Rabi* 2019-2020 for drought and terminal heat stress tolerance studies under NICRA project. A total of 35 accessions of Indian mustard and 15 accessions of fenugreek have been sown for morphological characterization as well as screening against biotic stresses during *Rabi* 2019-2020. During *Rabi* 2019, ten accessions of ber were screening against fruit fly infestation. Among the studied accession of ber germplasm IC0625848 shown absolute resistance to fruit fly. Twenty four accessions of pomegranate available in field gene bank characterized for various morphological and quality parameters during *Rabi* 2019-2020. 423 germplasm accessions of horticultural crops are being maintained in field genebank. 43,085 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.

13.1 Exploration and collection of germplasm

In collaboration with ICAR-NBPGR New Delhi and ICAR-IIVR Varanasi, an exploration for collection of landraces of round melon from different parts of Etawah (UP), Bhind, Morena, Sheopur (MP), Dholpur, Swaimadhopur and Karauli districts (RJ) was undertaken from 20.09.2019 to 30.09.2019. Thirty germplasm accessions of local landraces of round melon (tinda) were collected during exploration trip (Fig. 13.1). Generally farmers use seed of local landraces of round melon saved from healthy disease free fruits for raising next year crop. The crop is grown during *Kharif* season (July to Sept) in Dholpur, Etawah, Bhind, and Morena districts, while in summer season (March to June) in Sheopur, Swaimadhopur and karauli districts. The large variation in morphological traits was observed in

Fig. 13.1. Fruit collection and seed extraction of round melon

Fig. 13.2. Morphological variation in fruit shape, size and colour of collected germplasm of round melon

round melon (Fig. 13.2). One of the special features of fruits of local landraces are that they bear very small hairs on their skin and have mild smoky taste. The medium size fruits (average weight of 70g) have light or dark green colour, flat and round shape at marketable stage. The seed colour of round melon is brown or black having 75-100 seed/fruit.

13.2 Evaluation of germplasm during *kharif* season

The accessions of cluster bean (466), moth bean (360) and mung bean (485) had been evaluated following Augmented Block Design in most cases, and Randomized Complete Block Design in some cases. The promising accessions were identified for different traits.

13.2.1 Evaluation of guar (*Cyamopsis tetragonoloba*) germplasm

466 accessions of guar along with four checks were characterized and evaluated for agro-morphological traits of importance. All accessions have also been screened for different disease resistance. Some of the accessions have been identified to be superior in terms of yield, number of clusters per plant and number of pods per cluster. The performance of guar accession IC-38-1 (Fig. 13.3) was recorded early in days to 50 % flowering (37 Days) in compare to check varieties. The data of all characters were analyzed for mean performance *viz.,* plant height (73.2 cm), number of branches per plant (6.8), cluster length (5.0) and number of seeds per pod (7.2).

Fig. 13.3. Early maturing cluster bean accession (IC-38-1)

13.2.2 Evaluation of mungbean (*Vigna radiata*) germplasm

Four hundred and eighty-five accessions collected from arid region of Rajasthan and Gujarat and conserved at MTS were characterized for six qualitative and twelve quantitative traits in augmented block design. The mean performance of all the studied traits *viz.,* for plant height (56.23 cm), pod length (8.16 cm), number of seeds per pod (11.85) and days to maturity (62 days) was calculated. Promising accessions better than check value identified for days to 50% flowering were IC370714 (31 days), IC39276 (32 days), IC39432 (32 days) (Fig. 13.4); for number of clusters per plant

Fig. 13.4. Early maturing mung bean accession (IC-39432)

[IC39396 (25 clusters) and PLM-592 (24 clusters)]; for days to maturity EC520041 (54 days), IC39276 (55 days), IC39432 (56 days); for number of pods per plant IC488722 and IC1572/P1; number of primary branches per plant IC323988; number of seeds per pod IC8593.

13.2.3 Evaluation of mothbean (*Vigna acconitifolia)* germplasm

The 360 accessions of moth bean have been evaluated during *Kharif* 2019 for traits of agronomical importance. The data range for various characters *viz.,* days to 50% flowering was 34-52 days, plant height (7.2-58.64 cm), number of primary branches per plant (2.1- 9.1), pod length (3.3-8.7), number of seeds per pod (3.6-6.5) and number of pods per plant (32-178). The trait specific accessions identified for number of seeds per pod (IC35972), number of pods per plant (IC35920), number of clusters per plant (IC35920) and days to maturity (IC329037).

13.2.4 Evaluation of ber (*Ziziphus mauritiana*) germplasm against fruit fly

Ten ber germplasm accessions screened against fruit fly infestation. Data were recorded on infestation of fruit fly on the selected cultivars at the interval of 10 days in three trees during *Rabi* 2018-19. In all cases, 10 randomly selected fruits were examined carefully for oviposition marks, occurrence of exit hole in the fruits and number of larva present inside fruit through peeling of fruits with knife to confirm the stone and fruit fly damage and percentage of infested fruits was calculated. TSS of these fruits was also calculated. From data it was evident that a large genetic variation is present among cultivars for fruit fly resistance. IC-0625848 accession had shown absolute resistance to fruit fly. It also appears that concentration of TSS in the ber fruits is not having any impact on resistance or susceptibility for fruit fly.

13.2.5 Evaluation of pomegranate (*Punica granatum*) germplasm

Twenty four accessions of pomegranate being conserved in field gene bank were characterized for morphological characters as well as for qualitative and quantitative traits. Maximum diversity was recorded for fruits and aril colour (Fig. 13.5).

13.2.6 Screening of mustard (*Brassica* spp.) germplasm against white rust

The thirty five accessions of mustard have been screened under natural condition for identifying resistance level against white rust caused by *Albugo candida*. Out of 35 germplasm accessions 34 accessions gave susceptible reaction to white rust disease. One of the accession (IC 422166) was identified which gave complete resistance reaction against the disease (Fig. 13.6). Under favorable condition of disease when all other accessions found susceptible to white rust there was not a single spot appeared to this accessions. Thus, this accession shown absolute resistance and can be used in resistance breeding against white rust.

Fig. 13.5. Fruits and aril variability in 24 germplasm accessions of pomegranate

Fig. 13.6. A mustard accession (IC422166) identified resistance against white rust

13.3 Regeneration and multiplication of germplasm

During the period under report, a total of 520 accessions were grown for regeneration and multiplication. This includes cowpea (424), clusterbean (50) and 46 accessions collected from three districts of western Rajasthan.

13.4 Germplasm conservation

The 43,508 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 43,085 accessions of cereals & millets (14,524), legumes (16,321), oilseed (5183), plants of economic importance (943), medicinal plants (1519), Indian grasses (361), fiber and fodder plants (544), Indian fruits (1571), Indian spices (659) and Indian vegetables (1459) are being maintained in MTS. The 423 germplasm accessions of horticultural plants are being maintained as live plants in the fields.

13.5 Germplasm supplied

A total of 697 accessions of various crop species viz., mothbean (156), mungbean (150), pearlmillet (108), clusterbean (162), cumin (29), sesame (52) and cucurbits (40) were supplied to indenters under MTA.

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,** CoPIs and *Associates***)**

ICAR Code IXX10520- Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of field crops in arid and semi-arid regions. (Om Vir Singh, Neelam Shekhawat and Kartar Singh).- **Up to 30.09.2019.**

ICAR Code IXX10521- Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of horticultural crops in arid and semi-arid regions. (Om Vir Singh, Kartar Singh and Neelam Shekhawat).- **Up to 30.09.2019.**

ICAR Code yet to be provided- Management of genetic resources of agri-horticultural crops in arid and semi arid regions (**Kartar Singh** and Neelam Shekhawat).-**W.e.f. 01.10.2019.**

ICAR Code IXX15149- Evaluation of agri-horticultural crops germplasm against biotic stress tolerance in arid and semi arid regions (**Kartar Singh,** Neelam Shekhawat and Om Vir Singh).-**W.e.f. 01.10.2019.**

ICAR Code yet to be provided - Evaluation of agri-horticultural crops germplasm against abiotic stress tolerance in arid and semi arid regions (**Neelam Shekhawat** and Kartar Singh).-**W.e.f. 01.10.2019.**

REGIONAL STATION, RANCHI 14

Summary: Two exploration programmes were undertaken in Jharkhand and Bihar to collect accessions of minor fruits (43 acc.), vegetables and millets (50 acc.). A total of 254 accessions of horsegram (*Macrotyloma uniflorum* Lam) were evaluated for grain yield attributes. Besides, accessions of Jackfruit and Tamarind were characterized and/or evaluated for agro-morphological attributes to identify superior accessions. A total of 617 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank. Horsegram (*Macrotyloma uniflorum* L.) germplasm field day was organized on 10th December, 2019 under DBT funded project and a total of thirty members representing three State Agricultural Universities and four ICAR institutes participated in the programme.

14.1 Exploration and germplasm collection

14.1.1 Germplasm exploration

A total of 43 accessions of minor tropical fruits were collected from Chaibasa and West Singhbhum during June 5-14, 2019. The collected accessions includes Tamarind, Jamun, Kusum, Lakoocha and Kend. Subsequently, a total of 50 accessions of Cucurbits and other vegetables were collected from Katihar and Purnea districts of Bihar during Nov. 1-10, 2019. Details of collected germplasm are presented in Table 14.1.

Table 14.1: Details of collected accessions from Bihar

S. No.	Crop	Number of accessions
1	Amaranthus	2
2	Ash gourd	4
3	Basella	1
4	Bitter gourd	3
5	Bottle gourd	7
6	Coccinia	3
7	Cucumber	3
8	Janer	3
9	Laffa saag	1
10	Long melon	1
11	Maize	1
12	Methi	1
13	Musk melon	1
14	Okra	1
15	Pearl millet	1
16	Pumpkin	1
17	Ragi	1
18	Ridge gourd	3
19	Sem	3
20	Sorghum	4
21	Sponge gourd	5
	Total	**50**

14.2 Gemplasm characterization, evaluation and multiplication

14.2.1 A total of 254 horsegram (*Macrotyloma uniflorum* Lam) accessions were evaluated for six grain yield attributing traits. A wide spectrum of diversity across traits were recorded and are presented in Table 14.2.

Geo-referencing of their performance in order to prioritize germplasm collection and conservation efforts in the crop was done (Fig. 14.1).

Also identified accession bearing national identity IC0561047 that mature within 65 days. The accessions were evaluated at four locations and their performance is presented in Table 14.3.

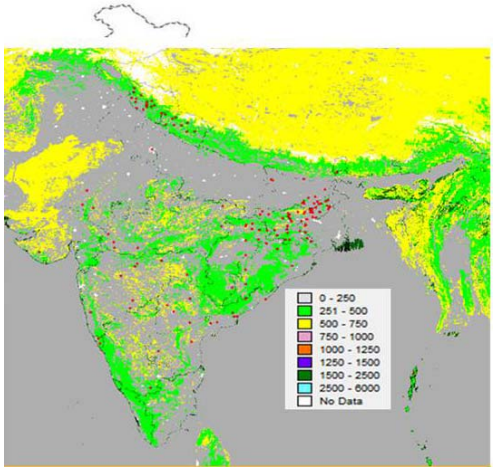
14.2.2 Jackfruit: Out of 246 accessions of jackfruit conserved in field gene bank at the station, a total of 110 accessions were characterized phenotypically for 27 qualitative and 21 quantitative traits. Wide range of variability was observed for all 27 qualitative traits across accessions (Table 15.4). Among them, maximum variable states were observed for fruit rind color (14) followed by fruit stalk at base (13), flake and seed coat color (8 each), crown, fruit and

Table 14.2: *Per se* performance of horsegram accessions for grain yield attributing traits

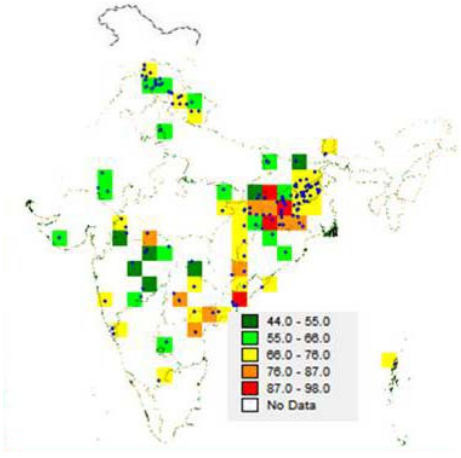
Sl. No.	Trait	Unit	Range	Mean	CV
1	Days to flowering	Days	32 - 98	61.635	20.187
2	Days to maturity	Days	60 - 166	115.344	21.169
3	Pod/plant	No.	5 - 160	49.189	52.170
4	Plant height	Cm	30 - 136	80.848	24.090
5	Hundred seed weight	G	1.08 - 4.98	2.961	22.728
6	Seed Yield / Plant	G	1.1 -39.53	8.121	88.868

Table 14.3: *Per se* performance of selected Horsegram accession at four locations

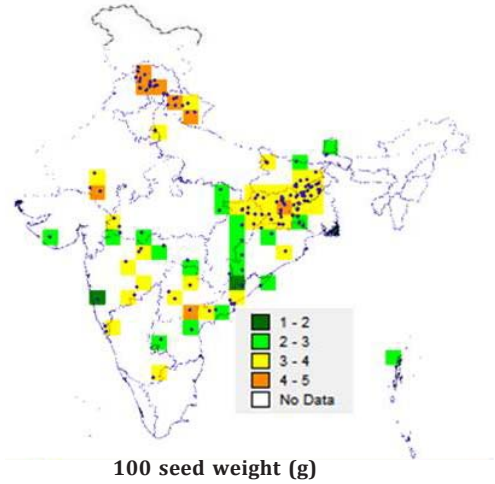
Sl. No.	Attribute	Palamu, Jharkhand	East Singhbhum, Jharkhand	Dumka, Jharkhand	Akola, Maharashtra
1	Days to maturity	54	63	57	51
2	Yield/plant (g)	9.7	11.8	10.4	9.6



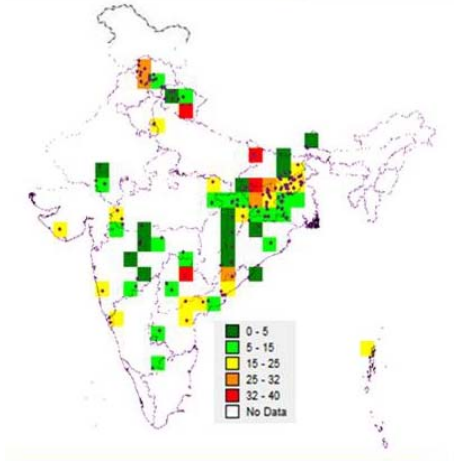
Distribution along altitude gradient



Days to 50% flowering



100 seed weight (g)



Seed yield/plant (g)

Fig 14.1. Geographical distribution of horsegram accessions in relation to important traits

Table 14.4: List of selected qualitative traits assessed in Jackfruit (*Artocarpus heterophyllus* L.) (N=110)

Sl. No.	Trait Variable name	Variable state	Variable Morphotypes
1	Tree vigor	3	High (62) , Low (13), Medium (35)
2	Crown shape	7	Broadly pyramidal (20) , Elliptical (21) , Irregular (11) , Oblong (8), Pyramidal (3), Semicircular (14), Spherical (33)
3	Tree growth habit	3	Erect (26), Semi-erect (43), Spreading (41)
4	Branching density	3	Dense (44), Medium (40), Sparse (26)
5	Branching pattern	5	Erect (24), Horizontal (17), Irregular (11) , Opposite (25), Verticillate (33)
6	Leaf blade shape	6	Broadly elliptic(5), Elliptic(56), Narrowly elliptic(11), Oblong(8), Obovate(29), Other(1)
7	Leaf apex shape	4	Acuminate(42), Acute(40), Obtuse(26), Other(2)
8	Leaf base shape	4	Cuneate(15), Oblique(60), Rounded(11), Shortly_attenuate(24)
9	Leaf blade margin	2	Entire (100), Undulate (10)
10	Leaf color	3	Dark green (50), Green (56), Light green (4)
11	Petiole shape	2	Flattened (70), Rounded (40)
12	Grooves on petiole	2	Absent (38), Present (72)
13	Fruit color (rind)	14	Brown (3), Brownish yellow (4), Dark brown (1), Dark green (11), Green (32), Greenish brown (7), Greenish yellow (24), Light brown (3), Light green (3), Reddish brown (1), Reddish green (3), Reddish yellow (6), Yellowish brown (10), Yellowish green (2)
14	Fruit shape	7	Clavate (12), Curved (4), Ellipsoid (39), Irregular (6), Obloid (3), Oblong (30), Spheroid (16)
15	Fruit base color	13	Black (8), Brown (32), Brownish green (1), Dark brown (6), Dark green (1), Green (24), Greenish brown (2), Greenish yellow (1), Light green (8), Light yellow (3), Reddish brown (1), Yellowish brown (4), Yellowish green (19)
16	Flake color	8	Coppery Red(1), creamish (1) , creamish white (22), Creamy White (9), Deep Yellow (26), Light Yellow (4), White yellow (46)
17	Flake shape	7	Intermediate (1), Irregular (27), Oblong (17), Obovate (5), Rectangular (30)), Spheroid (4), Twisted (17)
18	Juiciness	3	Juicy (60), Not juicy (20), Very juicy (30)
19	Latex in rachis	6	Absent (34), Less (17) , Moderate (50), More (8), Very less (1)
20	Stalk attachment	3	Depressed (49), Flattened (41), Inflated (20)
21	Seed coat color	8	Bluish brown (1), Brown (37), Creamish (17), Dark brown (3), Dull brown (46), Golden(2), Light brown (2), Off white (2)
22	Seed shape	5	Ellipsoid (4), Elongate (3), Irregular (47), Oblong (16), Reniform (40)
23	Vivipary in seeds	2	Absent (71), Present (39)
24	Flavour	4	Intermediate (63), Present (11), Strong (15), Weak (21)
25	Flake texture	5	Coarse (2), Fibrous (12), Firm (26), Melting (36), Soft (34)
26	Cluster nature	3	Two fruit in each cluster (29), Three fruit in each cluster (7), Only one fruit in each cluster (74)
27	Fruit bracteole	2	Absent (9), Present (101)

flake shape (7 each). A total of 21 quantitative traits were assessed in the population, among which high coeffficient of variation (CV) was noticed for number of fruits per trees (121), rachis weight (66.62), number of seed/fruit (62.52), flake weight (60.89), seed weight (60.22), pedicel length (53.44) and rind weight (52.13) (Table 14.5).

14.2.3 A total of 47 accessions of tamarind were evaluated for yield attributing traits. Their performance presented in Table 15.6. Accession IC 209896 and IC594356 were identified as unique, having maximum (13) and minimum (1) seed per fruit, respectively. Similar performance of both the accessions had been recorded during last three years.

Table 14.5: *Per se* performance of Jackfruit (*Artocarpus heterophyllus* L.) for 21qunatitative traits (N=110)

Sl. No.	Attribute	Unit	Range	Mean	SD	CV
1	Leaf blade length	cm	8.9 - 17.1	13.15+ 0.18	1.89	14.34
2	Leaf blade width	cm	3.1 – 10	7.07+ 0.11	1.12	15.85
3	Petiole length	cm	0.8 - 2.7	1.56+ 0.04	0.37	23.68
4	Fruit length	cm	18 – 53	36.20+ 0.72	7.59	20.95
5	Fruit diameter	cm	10.5 – 29	19.20+ 0.35	3.66	19.05
6	Pedicel length	cm	1 - 63.1	16.69+ 0.85	8.92	53.44
7	Fruit base length	cm	1 - 11.2	5.44+ 0.17	1.76	32.34
8	Fruit base diameter	cm	1.2 - 4.2	2.37+ 0.05	0.55	23.16
9	Flake length	cm	3.6 - 8.44	5.86+ 0.12	1.27	21.60
10	Flake width	cm	2 - 4.54	3.36+ 0.06	0.61	18.08
11	Rachis length	cm	6.4 - 42	25.73+ 0.65	6.84	26.58
12	Rachis width	cm	2 - 11.7	5.87+ 0.17	1.77	30.24
13	Number of seed / fruit	-	3 - 663	169+ 10.00	105.83	62.52
14	Seed test weight	g	20.4 - 116.65	57.11+ 1.65	17.26	30.23
15	Number of fruit/tree	-	4 - 107	12+ 1.34	14.10	121.00
16	Fruit weight	Kg	1.03 - 22.23	7.79+ 0.38	3.97	50.95
17	Rind weight	Kg	0.74 - 12.34	3.52+ 0.17	1.83	52.13
18	Rachis weight	kg	0.1 - 21.8	4.53+ 0.82	2.18	66.62
19	Flak weight	Kg	0.16 - 7.5	2.64+ 0.15	1.61	60.89
20	Seed weight	Kg	0.04 - 3.09	0.93+ 0.05	0.56	60.22

Table 14.6: *Per se* performance of tamarind accessions (N=47)

Sl. No.	Attributes	Range	Mean	SE	SD	CV
1	Pod length (cm)	7.25 -20.11	13.49	0.33	2.25	16.72
2	Pod width (mm)	5.26 - 8.04	6.71	0.08	0.57	8.56
3	Fruit weight (g)	7.5 - 27.79	16.64	0.58	3.94	23.70
4	Epicarp weight (g)	5.43- 21.02	12.28	0.44	3.04	24.76
5	No. of seeds	1 - 13	8	0.21	1.47	18.25
6	Fruit weight/tree (kg)	0.62 - 57.55	14.15	2.04	13.96	98.66

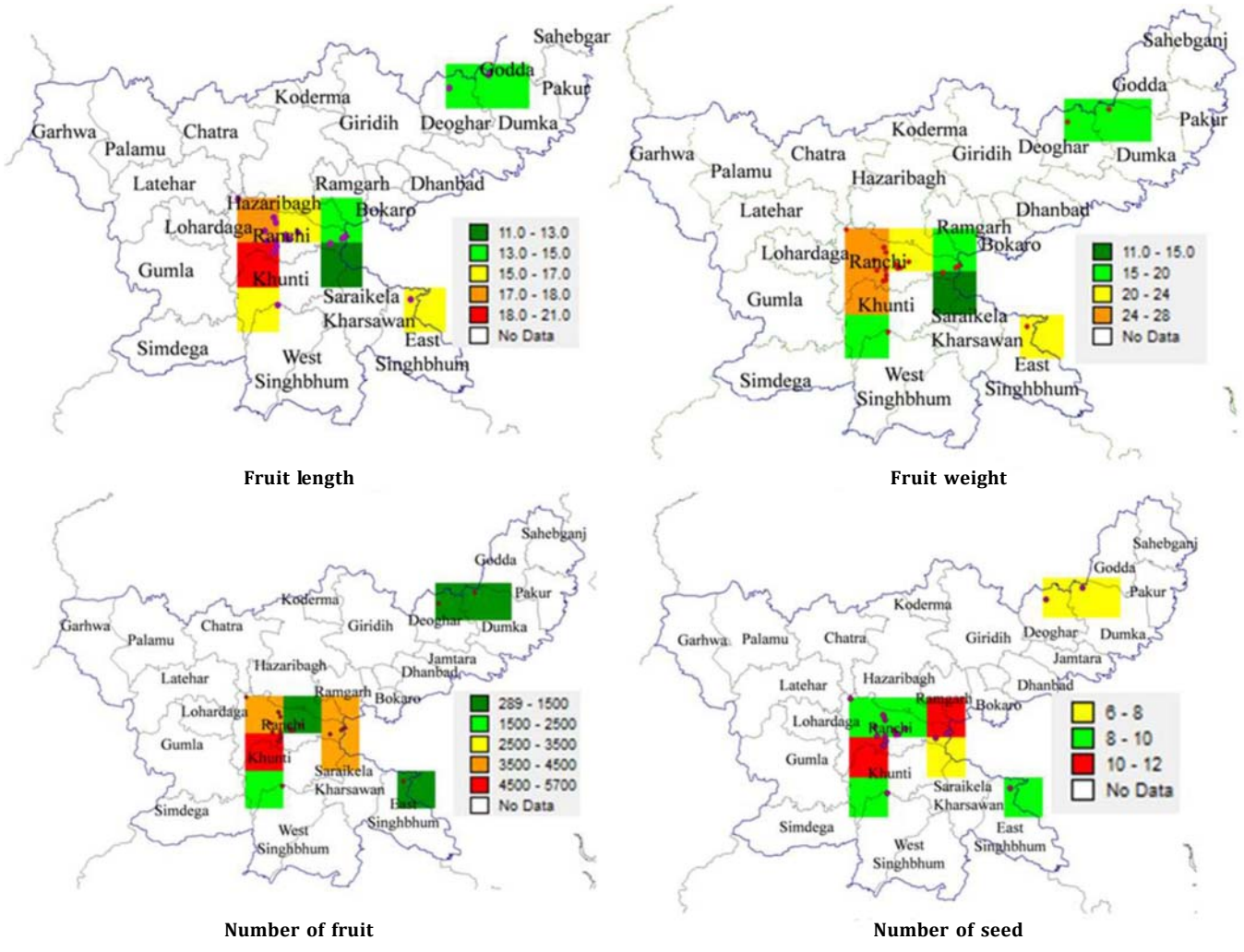


Fig. 14.2. Geo-referencing of tamarind accessions (N=47) for their yield attributing traits

Their performance had been geo-referenced and is depicted in Fig 14.2.

14.3. Germplasm multiplication and maintenance

14.3.1 A total of 617 accessions of fruits/ vegetables/ natural dye yielding plants are being conserved in field genebank of the station (Table 14.7).

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

Table 14.7: Details of accessions conserved in field gene bank

S. No.	Crop		No. of accession
	Common name	Botanical name	
1	Jamun	*Syzygium cumini*	52
2	Bael	*Aegle marmelos*	162
3	Jackfruit	*Artocarpus heterophyllus*	246
4	Aonla	*Phyllanthus emblica*	19
5	Banana	*Musa* species	34
6	Lakoocha	*Artocarpus lacucha*	14
7	Mehandi	*Lawsonia inermis*	25
8	Drumstick	*Moringa oleifera*	14
9	Tamarind	*Tamarindus indica*	51
	Total		**617**

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

Research Projects (Project Code, Title, **PI,** Co-PI & *Associates***)**

(PGR/PGC-BUR-RAN-01.01): Management of PGR of agriculture crops, their wild relatives and economic species including medicinal plants (**SB Choudhary;** Reshmi Raj KR (from Feb. 11, 2019) and *AK Gupta*)

(PGR/PGC-BUR-RAN-01.02): Management of PGR of horticultural crops and perennial medicine (**SB Choudhary;** Reshmi Raj KR (from Feb. 11, 2019) and *AK Gupta*)

Externally funded projects:

Characterization, Evaluation of Genetic Resources for Genetic Enhancement and Improvement of Minor Pulses" (SB Choudhary)

REGIONAL STATION, SHILLONG 15

Summary: Two explorations were conducted, one in Khasi and Garo Hills of Meghalaya and another in Serchip, Lunglei and Hnathial districts and bordering areas of Lawngthalai, Aizwal and Mamith districts of Mizoram. A total of 171 germplasm accessions of different crops were collected. Characterization of cucumber (14), sohphlang (*Flemingia procumbens),* and coix (49) was taken up for different agro-morphological traits. A total of 2,155 accessions of agri-horticultural crop germplasm comprising maize (700), rice (414), coix (49), buckwheat (800), chilli (60), mustard (66), yard long bean (15), ash gourd (24) and cucumber (27) are maintained at MTS. In addition to these crops, in field gene bank (FGB) banana (45), ginger & turmeric (352), *Colocasia* (84), *Dioscorea* (30), and fruit crops crops like *Citrus* (10) and guava (7), and M&APs are also being maintained. A total of 176 accessions of various crops including rice (120), maize (50), ricebean (04) and *Kaempferia* sp. (02) were supplied to indenters as per MTA. The Regional Station organised two workshops, under TSP at Mawpun village of Ri-Bhoi District, Meghalaya and under UNEP- GEF Project at Dangdhora, Jorhat, Assam.

15.1 Germplasm exploration

An exploration was undertaken to cover five districts of Meghalaya *viz*. East Garo Hills, West Garo Hills, West Khasi hills, East Khasi Hills and Ri-Bhoi. These districts represents agro-climatically diverse and biodiversity rich area of Meghalaya which are inhabited by different tribes. The region also exhibited great diversity with respect to minor fruit crops. A total of 65 germplasm samples of minor fruit crops were collected. The collected crops include *Rubus* spp. (03), *Prunus* spp. (07), *Pyrus* spp. (08), *Garcinia* spp. (02), *Citrus* spp. (10), *Bursera serrata* (04), *Syzygium* spp. (03), *Calamus erectus* (01), *Elaeagnus latifolia* (01), *Dimocarpus longan* (02), *Elaeocarpus floribundus* (01), *Psidium guajava* (01), *Passiflora edulis* (01), *Artocarpus* spp. (05), *Haematocarpus validus* (01), *Rhus chinensis* (02), *Tamarindus indica* (01), *Persea americana* (01), *Dillinea pentagyna* (01), *Myrica* spp. (02), *Ficus roxburghii* (01), *Holboellia latifolia* (02), *Duchesnea indica* (01), *Docynia indica* (01), *Phyllanthus emblica* (01), *Baccaurear amiflora* (02).

An exploration was conducted in association with RS Thrissur to collect vegetables and CWR's from parts of Mizoram with special emphasis on *Abelmoschus mizoramensis* covering, Serchip, Lunglei and Hnathial districts and bordering areas of Lawngthalai, Aizwal and Mamith districts. A total of 106 samples in 42 species/taxa of targeted crops and crop wild relatives including 12 collections of *Abelmoschus pungens* var *mizoramensis* were collected.

15.2 Characterization of germplasm

15.2.1 Characterization of cucumber germplasm

Fourteen cucumber accessions from different North-eastern states of India were analysed for variations by means of agro-morphological traits and palynological characteristics. Phenotypic variations

Fig. 15.1. *Bursera serrata*

Fig. 15.2. Fruits of *Pyrus pashia* and *P. pyrifolia*

Fig. 15.3. *Rubus moluccanus*

Fig. 15.4. *Citrus reticulata* plantation

Fig. 15.5. *Prunus nepalensis*

Fig. 15.6. *Artocarpus altilis*

Fig. 15.7. *Rhus chinensis*

Fig. 15.8. Passion fruit collections from Serchhip, Mizoram

Fig. 15.9. Fruits of avocado collected from Serchhip, Mizoram

Fig. 15.10. Variability in *Abelmoschus mizoramensis*

Fig. 15.11. Variation in shape and size of avocado

Fig. 15.12. Fruit morphology and cross section of fruit showing number of locules of different accessions. a - b) IC-3613467, c-d) IC-595510, e-f) IC-395514, g -h) IC-613461, k - l) 618083

Fig. 15.13. Seed morphology of different accessions of rice. a) IC613457, b) IC613458, c) IC613460, d) IC613461, e) IC613462, f) IC595510, g) IC618083, h) IC595508-A, i) IC595517, j) Shillong-52, k) Shillong-51, l) PUSA Uday, m) IC613466, n) IC613467, o) IC595514

in fruit length (19.20 cm – 28.33 cm, fruit width 5.0 cm – 7.3 cm), number of locules (3 – 4/fruit), seed length (0.8 cm – 1.2 cm), seed width (0.3 cm – 0.43 cm) and 100 seeds (weight 1.0 gm – 3.4 gm/ accessions) were observed. Variations were also observed in pollen characteristics among the accessions. Size of pollen varied from 40.00 (41.33) 44.00 µm x 46.00 (47.56) 48.70 µm to 48.00 (48.30) 48.60 µm x 52.00 (52.86) 53.40 µm. Variations in P/ E (ratio pore diameter and interporal distance) was also observed among the accessions. Cucumber genotypes with superior agro-morphological traits were observed to have bigger pollen size, larger pore diameter and interporal distance, indicating a positive correlation between the two. The study provided useful information which can assist in efficient utilization and improvement of cucumber germplasm.

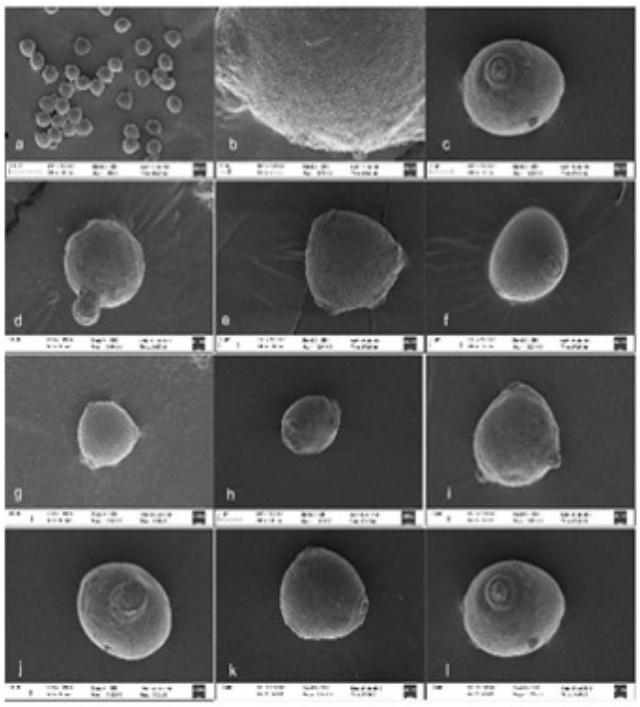


Fig. 15.14. Pollen morphology of cucumber under SEM. a) Pollen in monads, b) View showing reticulate sculpturing, c) Pore with distinct annulus, d) Germinating pollen, e) IC-613466 - polar view with pores, f) IC-613466 - equatorial view with pores, g) IC-613461 - polar view with pores, h) IC-613461- equatorial view with pores, i) IC-618083 - polar view with pores, j) IC-618083- equatorial view with pores, k) PUSA Uday - polar view with pores and, l) equatorial view showing pores with annulus.

15.2.2 Characterization of *Flemingia procumbens* (sohphlang) germplasm

Five diverse accessions of *Flemingia procumbens* were selected to study the effect of seed rhizome size on growth and yield. Three different seed sizes were considered based on their weight and were grouped as Large (20-25g), Medium (10-15g) and Small (3-5g). The accessions were evaluated for eleven different agro-morphological traits. Superior accessions were identified for various traits plant-cover, plant height, no. of nodes/stem (IC0627410; 61.66cm, 54cm, 12.11), leaf length, leaf width, single tuber weight (IC0627404; 2.54cm, 2.33cm, 24.44g), tuber weight/plot, tuber weight/plant, no of tubers/ plant (IC0627425; 1165g, 216.33g, 33) and tuber length, tuber-width (IC0627415; 7.7g, 5.27g).

Fig. 15.15. *Flemingia procumbens* in vegetative stage

15.2.3 Characterization of *Coix lacryma-jobi* germplasm

Forty-nine accessions of *Coix lacryma-jobi* were evaluated for different agro-morphological traits. Accession IC521338 recorded highest for number of tillers/plant (6), IC604159 for plant height (3.24m), IC540256 for seed length (11.03mm), IC614051 for seed width (8.83mm), IC89385 for 100 seed weight (19.61g), IC540181 for seed weight/ plant (80g) and IC629196 for total seed weight/plot (1271g).

Fig. 15.16. Diversity in *F. procumbens* tubers

Fig. 15.17. *Coix lacryma-jobi* germplasm

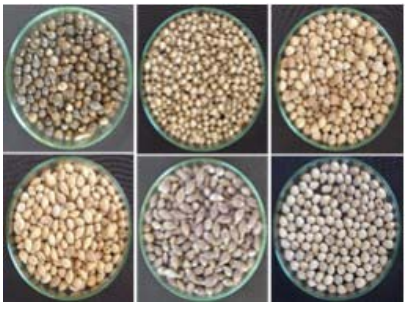


Fig. 15.18. Variability in *Coix lacryma-jobi* seed shape, size and colour

15.2.4 Germplasm evaluation

Under DST funded project "Study on nutraceutical properties, genetic variability analysis and agro-technique development of the edible Aroids from Borail Hill Range of Assam, India" out of 32 collected germplasm five nutritionally rich accessions of *Colocasia esculenta* (IC0631527,

Fig. 15.19. Promising *Colocasia* accessions selected based on Nutritional/ Nutraceutical /Anti nutritional properties

Table 15.1: Promising *Colocasia* accessions selected based on nutritional/ nutraceutical /anti nutritional properties

Nutritional properties				Nutraceutical properties						Anti-nutritional content	Promising accessions
Caloific value(kcal/ 100g) (Bomb calorimeter)	Total crude fiber (%)	Ascorbic acid (mg/ 100 gm)	Total mineral content (%)	Total phenolic content (µgGAE/mg)	Antioxidant Activity IC50 (µg/ml)	Flavonoid Content (µgQE/ mg)	Micronutrients (mg/100g)			Oxalates (mg/100g)	
							Zn	Ca	Fe		
365.10	**2.15 (± 0.61)**	30.83 (±0.39)	4.72 (±0.03)	25.32 (±0.10)	**145.73 (±0.16)**	8.43 (±0.03)	5.83	153.98	6.60	61.89	IC0631527
361.82	4.25 (±0.12)	29.43 (±0.06)	3.05 (±0.1)	**18.34 (±0.13)**	112.53 (±1.03)	**6.26 (±0.17)**	9.07	**202.85**	**1.81**	57.52	IC0631529
360.74	2.50 (±0.23)	**27.02 (±0.04)**	**1.72 (±0.11)**	24.53 (±0.02)	**107.32 (±0.11)**	**8.48 (±0.10)**	**34.12**	**36.21**	**38.12**	61.17	IC0631536
359.49	4.76 (±0.56)	28.56 (±0.25)	5.80 (±0.12)	20.04 (±0.10)	136.90 (±0.11)	8.40 (±0.02)	5.32	61.10	8.87	**62.73**	IC0631544
357.78	**4.89 (±0.03)**	**38.56 (±0.04)**	**6.30 (±0.23)**	**27.32 (±0.05)**	143.54 (±0.76)	7.38 (±0.42)	**4.72**	102.77	10.49	**56.78**	IC0631546

Table 15.2: Promising *Colocasia* accessions (traditionally preferred) selected based on nutritional/ nutraceutical /anti nutritional properties

Nutritional properties				Nutraceutical properties						Anti-nutritional content	Promising accessions
Caloific value(kcal/ 100g) (Bomb calorimeter)	Total crude fiber (%)	Ascorbic acid (mg/ 100 gm)	Total mineral content (%)	Total phenolic content (µgGAE/mg)	Antioxidant Activity IC50 (µg/ml)	Flavonoid Content (µgQE/ mg)	Micronutrients (mg/100g)			Oxalates (mg/100g)	
							Zn	Ca	Fe		
351.19	**1.35 (±0.32)**	**10.81 (±0.23)**	4.81 (±0.12)	**28.10 (±0.02)**	121.06 (±0.34)	**5.08 (±0.14)**	**9.74**	**29.32**	**6.62**	**65.54**	IC0631528
349.71	**6.05 (±0.17)**	21.32 (±0.42)	**2.46 (± 0.04)**	**19.36 (±0.03)**	**110.56 (±0.02)**	5.18 (±0.15)	-	-	-	63.94	IC0631535
347.99	3.49 (±0.14)	**30.05 (±0.13)**	**10.3 (± 0.15)**	26.37 (±0.13)	**124.10 (±0.10)**	**6.35 (±0.01)**	**3.14**	**99.21**	**3.82**	**56.16**	IC0631547

Fig. 15.20. Purple fleshed *Colocasia* germplasm collected from Mawkyrwat village of South West Khasi Hills, Meghalaya

IC0631529, IC0631536, IC0631544, IC0631546) (Table 15.1) were identified along with three farmers varieties (IC0631528, IC0631535, IC0631547) (Table 15.2) consumed and preferred by the local tribes of Borail Hill Range (Dima Hasao).

Unique germplasm identified

Under DST funded project "Study on nutraceutical properties, genetic variability analysis and agro-technique development of the edible Aroids from Borail Hill Range of Assam, India" five accessions of *Colocasia* (HAR-1, HAR-2, HAR-3,HAR-4& HAR-5) showing characteristic purple fleshed tuber were collected from Mawkyrwat village of South West Khasi Hills (Meghalaya) collected samples are being analysed for estimation of anthocyanin. Also multi-location trials is being conducted at Thrissur and Shillong.

Fig. 15.21. Upland rice germplasm field view

Fig. 15.22. Buck wheat germplasm field view

Fig. 15.23. *Colocasia* germplasm field view

Fig. 15.24. Turmeric germplasm field view

15.3 Germplasm regeneration/maintenance and conservation

A total of 2,155 accessions of agri-horticultural crop germplasm comprising maize (700), rice (414), buckwheat (800), chilli (60), mustard (66), yard long bean (15), Coix (49) ash gourd (24) and cucumber (27) were regenerated. In addition to these crops, in field gene bank (FGB) banana (45), ginger & turmeric (352), *Colocasia* (84), *Dioscorea* (30), and fruit crops crops like *Citrus* (10), guava (7) and M&APs are also being maintained

15.4 Germplasm supply

A total of 176 accessions of various crops including rice (120), maize (50), ricebean (04) and *Kaempferia* sp. (02) were supplied to indenters under MTA (Table 15.3).

Table 15.3: List of different germplasm supplied

Institute name	Germplasm name	Number of germplasm
Meghalaya; Department of Botany, USTM, Meghalaya	Kaemferia	2
CPGS-AS, CAU, Umiam; Meghalaya; Department of Botany, USTM, Meghalaya	Maize	50
ICAR Research Complex for NEH Region, Umiam, Meghalaya; Department of Botany, USTM, Meghalaya	Rice	120
ICAR Research Complex for NEH Region, Umiam, Meghalaya	Ricebean	40
	Total	176

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

On-going Projects

PGR/PGC-BUR-SHL-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of plant genetic resources in north-eastern India (**Harish G.D**)

Research Projects (Code: Title, **PI,** CoPIs**)**

PGR/PGC-BUR-SHL-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural crops (paddy–low land/upland, maize and mustard) and their wild relatives. (**Harish GD**and S Hajong)

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)

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**and S Hajong)

REGIONAL STATION, SHIMLA 16

Summary: Two explorations were undertaken to collect genetic resources of various agri-horticultural crops from different parts of Meghalaya and Uttarakhand. A total of 121 accessions comprising of fruits (83), cereals (24), pseudocereals (3), pulses (4) and medicinal plants (7) were collected. Eighty seven accessions of buckwheat and 27 of kiwi germplasm were introduced from the gene bank of North Central Regional Plant Introduction Station, USDA-ARS, USA. A total of 1,361 germplasm accessions of various field crops were characterized and evaluated against important traits. Remarkable variability was observed for important agro-morphological traits. Several promising accessions were identified in grain amaranth, buckwheat, french bean, soybean, rice bean and field pea. Furthermore, a total of 350 field pea germplasm accessions were also screened against powdery mildew tolerance under natural epiphytotic condition, which had resulted into the selection of some tolerant genotypes against the target pathogen. Screening of french bean germplasm (208 accessions) against *Uromyces appendiculatus* var *appendiculatus* resulted into the scoring of 26 accessions found resistant against the rust disease. Another set of 180 accessions of french bean was screened against white mold resulted into the identification of 7 resistant genotypes against the disease. Traditional paddy landraces belonging to Himachal and Uttarakhand was assessed for their nutrient and mineral composition, the results revealed that Bamkua dhan and Lamgudi dhan of Almora region had highest starch (29-71%) and protein (12-15 g/100g) contents as well as nutrient contents (2.3-132 mg/100g). Likewise in horticultural crops, 179 germplasm accessions comprising of apple (31), pear (40), plum (15), peach (39), apricot (30) and *Physalis* (24) were characterized and evaluated for important pomological traits. Total nine accessions of persimmon was also assessed for important macro and micro elements. The average P, K, Zn, Fe, Cu, Mn, Ca and Mg were 0.12 %, 0.81 %, 50.48 ppm, 43.78 ppm, 27.51 ppm, 14.20 ppm, 2227.58 ppm and 440.94 ppm respectively. A PGR awareness programme in collaboration with Krishi Vigyan Kendra (KVK) Taboo-II was organized at Tabo, Lahaul & Spiti Himachal Pradesh to facilitate the registration of Farmers' Varieties with PPV&FR A.

16.1 Germplasm exploration & collection

Two collaborative germplasm explorations were undertaken, first trip in which 67 germplasm samples of minor fruit crops were collected from East Garo hills, West Garo hills, East Khasi hills, West Khasi hills and Ri-Bhoi districts of Meghalaya (Fig 16.1). The collected accessions comprised *Rubus* spp. (03), *Prunus* spp. (09), *Pyrus* spp. (08), *Garcinia* spp. (02), *Citrus* spp. (10), *Bursera* sp. (04), *Syzigium* spp. (03), *Calamus erectus* (01), *Elaeagnus latifolia* (01), *Dimocarpus longan* (01), *Elaeocarpus floribundus* (01), *Passiflora edulis* (01), *Artocarpus* spp. (05), *Haematocarpus validus* (01), *Rhussimi alata* (02), *Tamarindus indica* (01), *Persea americana* (01), *Dillinea pentagyna* (01), *Myrica* spp. (02), *Wild fig* (01), *Holboellia latifolia* (02), *Duchesnea indica* (01), *Docynia indica* (01), *Phyllanthus emblica* (01), *Bacaurrea ramiflora* (02), Soh puinbri rid (khasi,01). Besides, 30 herbarium specimens were also made. Second exploration was undertaken for the collection of temperate fruits and wild *Triticeae* (*Elymus, Eremopyrum*, *Leymus*, *Aegilops*), *Allium* spp. from high altitude areas of Nelang and Gangotri valleys in Uttarkashi (Fig. 16.2). In this exploration, 14 villages were covered *i.e* Sankri, Osla, Jakhol, Jaspur Bhatwadi, Darali, Gangotri, Harsil, Bhairon Ghati, Nelang, Jadung, Sonam & Naga. A total of 54 accessions were collected from different villages of Nelang, Gangotri and Gobind National Park in Uttarkashi district and all these collections were primitive cultivars, semi domesticated or wild types.

16.2 Germplasm introduction

During the reporting period, 87 accessions of buckwheat and 27 of kiwi fruit were introduced from USDA-ARS, North Central Regional Plant Introduction Station and National Clonal Germplasm Repository for Tree Fruit, Davis California, USA, respectively.

16.3 Germplasm characterization and evaluation of field crops

A total of 1361 germplasm accessions comprised 318 of grain amaranth, 261 of buckwheat, 66 of chenopod, 200 of rice bean, 100 of french bean, 52 of soybean were sown during *Kharif* season of 2019 and 364 accessions of field pea in *Rabi* season of 2018-19, along with standard checks in Augmented Block Design (Table 16.1). The observations were recorded as per the minimal descriptor of NBPGR for important agro-morphological traits and impressive variability was observed among germplasm accessions. Promising accessions were also identified against important traits through range, mean and coefficient of variation (Table 16.2).

Table 16.1: Germplasm of various field crops evaluated

Crop	Accessions	Checks
Grain amaranth	318	Durga, PRA-2, Annapurna, PRA-3
Buckwheat	261 Shimla B-1	PRB-1, Himpriya, VL-7,
Chenopod	66	EC-507741, NIC-22503, PRC-9801
Rice bean	200	PRR1,PRR2,RBL1,RBL6
French bean	100	PLB-10-1, PLB-14-1, Triloki, Kailash, Baspa, Jawala
Soybean	52	Grown for multiplication
Pea	364	Arkal, Azad Pea, DMR-11, DMR-7, HFP-4, IC279125
Total accessions	**1361**	

16.3.1 Assessment of genetic variability of field crops

In Grain amaranth, the average plant height was 227.87cm, while it ranged from (90.4-299.4 cm), mean inflorescence length 59.59 cm (25.8-94.7cm), mean days to maturity 152 days (111-178 days), 1000 seed weight 0.69g (0.4-0.9g) and average seed yield/plant 56.13 g (8.11-199.64g). The substantial data resulted into the identification of some promising accessions for elite traits such as, EC351945 (plant height, 299.4 cm), EC519527 (infl. length, 94.7cm) IC35367 (seed yield/plant, 199.64g) (Fig 16.3). Likewise in buckwheat, variation ranged from 84-149 maturity days, mean no. of Infl./plant 19.89, mean 1000-seed weight 20.62g, while it ranged from 11.16-44.8g and mean seed yield/plant 1.87g ranged from 0.66-14.77g. Accessions of buckwheat namely Shimla/nmr-1 (early maturity, 84 days); IC24299 (no. of inflorescence/plant, 52) and EC216635 (higher 1000- seed wt., 44.8g) found promising (Fig. 16.4). Another set of 131 accessions were also analysed for rutin content; a range of rutin content was noted in seeds varying from 0.01 to 2.88% (dry weight). Maximum rutin content was found in *F. tataricum* (0.90-2.88%), followed by *F. cymosum* (1.45%) and *F. esculentum* (0.01-0.62%) in mature seeds on dry weight basis. Promising accessions were identified with high rutin content (>2%) were EC104036, EC278738, EC18740, EC18173, IC14889, EC18629 and IC42423. In Chenopod, mean days to maturity were 137 days which ranged from 100 to 164 days, average infl. length was 48.15 cm and ranged from 32.3-66.1cm, mean seed yield/plant was 36.80g. The promising accessions were identified *viz*., IC341697(early maturing, 100 days), IC341700 (plant height, 298.6cm), NIC22532 (higher seed yield/plant, 94.4 g) and NIC22512 (higher 1000- seed wt., 1.3 g). In french bean, mean pod length was 12.80 cm and it ranged from (8.90-18.75 cm), no. of pods/plant was 21.82 (4.50-46.50), days to maturity 107.63 days (77-141days) and 100-seed wt. 30.34g (14.28-50.80g). The french bean accessions, JCR-2071 and JCR2072 showed high no. of pods/plant and high no. of seeds/pod respectively (Fig. 16.5). In soybean, plant height had mean value 104.14 cm and ranged from (41.15-192.1 cm), no. of pods/plant was 55.69 (30.5-71.5), days to maturity 176.37 (137-206 days) and 100-seed weight 9.40g (4.42-20.98g). Accessions IC2062, IC11746 and TRS/RKS/210 showed superiority for no. of pods/plant and days to maturity. In field pea, mean pod length was 5.84 cm and ranged from (3.25 to 8.25 cm) and mean 100-seed weight was 14.16 g (5.0 to 24.80g). The promising accessions identified namely, IC277567 and EC269301 showed superiority for days to maturity and pod length (Fig. 16.6). In rice bean, pod length ranged from 6.3 to 13.8 cm and mean pod length was 11.39 cm, 100-seed weight ranged from 4.71 to 14.19g and mean

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

Character	Range	Mean±SE	CV%	Promising accessions
Grain amaranth				
Days to flowering	39-108	80.73±0.83	18.44	IC583625, IC38758, EC345797
Days to maturity	111-178	152.16±0.76	8.90	IC38758, EC338959,EC289384
Plant height (cm)	90.4-299.4	227.87±2.61	20.40	EC351945, EC38567, IC17936
Infl. length (cm)	25.8-94.7	59.59±0.76	22.88	EC519527, IC38269,IC35363
Seed yield/plant(g)	8.11-199.64	56.13±1.83	58.33	IC35367,EC289385,IC36832
1000-seed wt. (g)	0.4-0.90	0.69±0.004	11.74	EC33345,IC582934,IC35432
Buckwheat				
Days to flowering	28-73	49.26±0.48	15.80	IC599211, IC521302,IC447576
Days to maturity	84-149	113.81±0.89	12.59	Shimla/nmr1, IC329570, IC341647
Plant height (cm)	50.7-200.6	121.62±1.97	26.12	IC381048, IC49668, IC107988
No. of infl./plant	7.5-52	19.89±0.37	29.82	IC24299,IC547346,EC216627
Seed yield/plant(g)	0.66-14.77	1.87±0.10	87.68	IC341674,IC24299,EC216627
1000- seed wt. (g)	11.16-44.8	20.62±0.27	20.87	EC216635, EC323723, IC341674
Chenopod				
Days to flowering	39-118	79.61±1.62	16.52	IC415494,IC341697,IC381078
Days to maturity	100-164	137.64±1.86	10.96	IC341697,IC341713,IC415494
Plant height (cm)	112.1-298.6	253.71±5.53	17.72	IC341700, IC341715, NIC22517
Infl. length (cm)	32.3-66.1	48.15±0.82	13.84	IC599554, NIC22517,IC7213
Seed yield/plant(g)	10.08-94.4	36.80±2.10	46.43	NIC22532, KP/SC1568, IC343192
1000-Seed wt. (g)	0.45-1.30	0.80±0.03	26.96	NIC22512, NIC2206, EC359451
Soybean				
Days to flowering	61-147	140.43±2.44	16.34	SKY/SNS/489, RKS/UKP422
Days to maturity	137-206	176.37±2.22	8.80	TRS/RKS/210, SNS486, EC113775
Plant height (cm)	41.15-192.1	104.14±5.81	39.06	EC114524, SAW/JS/BB852, IC10038
No. of pods/plant	30.5-71.5	55.69±1.31	16.46	IC2062, EC113775, EC113779
Seed yield/plant (g)	3.51-27.68	13.03±0.94	50.66	EC113775, EC127507, EC171179
100-seed wt. (g)	4.42-20.98	9.40±0.63	46.63	TRS/RKS/210, EC127507, EC118308
Pea				
Days to flowering	56-150	119.31±0.91	14.53	5426/P2098, P3167, P2516
Days to maturity	154-194	181.08±0.50	5.28	IC277567, IC279013-1, EC269307
Plant height (cm)	35.35-155	93.69±1.30	26.45	IC219028, IC109808, EC838236
No. of pods/plant	2.50-42.00	15.68±0.35	42.86	IC208392, EC838181, IC107452
Seed yield/plant(g)	0.44-30.93	8.45±0.27	60.33	IC208391, IC109554, IC98606
100- seed wt. (g)	5.00-24.80	14.16±0.19	25.11	IC109409, EC385246, IC243201
French bean				
Days to flowering	34- 82	53.31±1.17	21.91	JCR/JV20, JCR/JV02, EC894831
Days to maturity	77-141	107.63±1.46	13.60	JCR2117, EC894826, JCR2114
Pod length (cm)	8.90-18.75	12.80±0.21	16.12	EC894826, EC-894828, JCR/JV-2
No. of Pods /plant	4.50-46.50	21.82±1.07	48.87	JCR2071, RO15, EC845821
No. of seeds / pod	3.50-8.50	5.36±0.11	20.54	JCR2072,NRO61,NRO63
Seed yield/plant(g)	8.07-91.23	34.95±2.05	58.70	JCR2069, RO16, NRO51
100-seed wt.(g)	14.28-50.80	30.34±0.93	30.71	EC894831, JCR/JV02, JCR2069
Rice bean				
Days to flowering	79-117	87.75±0.37	4.20	IC969187, IC520962, IC521141
Days to maturity	128-198	152.96±0.83	9.08	IC361364, IC360363, IC520968
Pod length (cm)	6.30-13.80	11.39±0.14	12.01	IC520958, IC342220, IC469197
No. of seeds /pod	6-10	7.39±0.09	12.40	IC469197, IC342220, IC521013
Seed yield/plant(g)	8.33-181.60	69.28±2.69	38.81	IC394537, IC520966, IC394201
100-seed wt. (g)	4.71-14.99	8.06±0.16	20.08	IC419489, IC342238, IC423291

Fig. 16.1. Collection of wild *Rubus ellipticus* from Khasi hills of Meghalaya

Fig. 16.2. Collection of *Allium* sp. from Nelang valley of Uttarakhand

Fig. 16.3. IC38758: superior for early maturity

Fig. 16.4. EC216635: superior for high seed weight

Fig. 16.5. EC894526: superior for early maturity

Fig. 16.6. IC208392: superior for high no. of pods/plant

100-seed weight was 8.06g. The promising accessions identified IC520958 (pod length, 13.8 cm) and IC419489 (100-seed wt., 14.99 g) IC-361364 (early maturity, 120 days).

16.3.2 Agro-morphological evaluation of F_6 derivatives of grain amaranth

In grain amaranth, 228 F_6 derivatives of VL44 x PLP-1 cross alongwith their parental cultivars were evaluated for important traits. A wide range of variation was observed among derivatives with respect to useful traits such as seed yield/plant (10.14-120 g), days to maturity (129-153) Infl. length (26.4-68.1 cm) and plant height (133.4-256.1cm). Some derivatives were reported early types as compared to their parents. The overall performance revealed transgression for important traits studied (Table 16.3).

16.3.3 Field screening of pea germplasm against powdery mildew

A total of 350 field pea accessions were screened against powdery mildew tolerance under natural epiphytotic conditions at the experimental farm of NBPGR Shimla. The screening data resulted that, 33 accessions were found moderately tolerant and 17 accessions, EC838163, EC838179, EC838180, EC838186, EC838190, EC838209, EC838233, EC838240, EC838241, EC838242, P3518, NIC17568, IC342036, IC342044, IC342045, IC411719 and IC411732 were found to be completely tolerant in the real field condition. The results are unambiguous as the screening was done under heavy infection conditions where white powdery mass on leaves, pods and stems as well as tissue necrosis was seen in susceptible plants.

16.3.4 Screening of common bean germplasm against key biotic stresses

A total of 208 common bean accessions were screened against rust (*Uromyces appendiculatus* var *appendiculatus*) under controlled condition at ICAR-Indian Institute of Wheat and Barley Research, Regional Station, Shimla, Himachal Pradesh. These accessions showed different disease reaction and grouped into various classes using 1-9 rating scale.

Table 16.3: Performance of F_6 derivatives of grain amaranth

Parent/cross	Character	Mean±SE	Range	CV %
P_1	Days to 50% flowering	87.13±0.95	83-90	3.09
	Plant height (cm)	244.26±1.64	239.14-252.6	1.90
	Infl. length (cm)	42.94±0.66	40.7-46.7	4.34
	Days to 80% maturity	153.50±0.19	153-154	0.35
	Seed yield/plant (g)	33.88±2.04	29.11-43.8	17.03
	1000- seed wt. (g)	0.77±0.01	0.75-0.80	3.37
	10 ml seed wt.(g)	8.10±0.04	7.92-8.26	1.34
P_2	Days to 50% flowering	58.13±1.06	55-62	5.16
	Plant height (cm)	191.75±3.11	181.1-209.4	4.59
	Infl. length (cm)	39.23±0.56	36.4-41.4	4.06
	Days to 80% maturity	137.63±0.32	137-139	0.67
	Seed yield/plant (g)	35.38±4.07	25.02-60.31	32.53
	1000- seed wt. (g)	0.67±0.01	0.65-0.70	3.41
	10 ml seed wt.(g)	7.85±0.06	7.56-8.13	2.18
F_6	Days to 50% flowering	57.59±0.25	51-68	6.64
	Plant height (cm)	185.28±1.56	133.4-256.1	12.68
	Infl. length (cm)	43.94±0.44	26.4-68.1	14.95
	Days to 80% maturity	133.64±0.21	129-153	2.38
	Seed yield/plant (g)	40.32±1.00	10.14-120	37.58
	1000- seed wt. (g)	0.68±0.00	0.5-0.85	7.69
	10 ml seed wt.(g)	7.46±0.02	6.14-8.96	4.20

Out of these accessions, twenty six (EC25504, EC271528, EC285581, EC500505, EC530898, IC14945, IC17916, IC18121, IC328664, IC354451, IC354463, IC356008, IC395442, IC405494, IC519580, EC12432, EC755307, EC755311, EC755332, EC755333, EC755334, EC755342, EC755421, EC755430, EC755289, and EC755433) were rated as resistant against the rust. Likewise, another set of 180 accessions of common bean was also screened against white mold (*Sclerotinia sclerotiorum*) disease under controlled condition in the Department of Plant Pathology at CSKHPKV Palampur and a total of seven accessions IC278744, IC278709, IC278731, EC271515, EC271475, EC271523, and EC271528 were rated as resistant against the pathogen.

16.3.5 Nutritional profiling & mineral composition of paddy landraces

Traditional landraces of paddy are well known to possess rich nutritional content. Total seven paddy landraces collected from Himachal Pradesh and Uttarakhand were analyzed for the presence of various nutrients (fat, starch and protein) as well as minerals (Zn, Cu, Fe, Mn and Mg). The results revealed that Bamkua dhan and Lamgudi dhan of Almora, Uttarakhand had highest starch (29-71%) and protein (12-15 g/100g) contents as well as nutrient contents (2.3-132 mg/100g).

16.4 Characterization and evaluation of horticultural crops

In horticultural crops, total 179 germplasm accessions comprising of apple (31), pear (40), plum (15), peach (39), apricot (30) and *Physalis* (24) were characterized and evaluated for various pomological traits, which resulted into the identification of following accessions carrying important traits of interest (Table 16.4).

16.4.1 Apricot (*Prunus armeniaca* L.)

In apricot, total 30 accessions were characterized for various pomological traits. Days to fruit harvest, fruit length, fruit width, fruit weight, TSS varied from 63 – 164 days, 30.17 – 55.73 mm, 31.29 – 52.03 mm, 10.2 – 64.6 g, 10.08 – 24.09 % respectively. An accession EC552701 found promising with respect

Table 16.4: Promising accessions identified for important pomological characters

Crop	Characters	Range	Mean ± SE	CV %	Promising accessions
Apple	Days to fruit harvest	80-154	100.67±3.05	16.88	EC37137, EC539447, IC349921
	Fruit wt. (g)	25.34-147	93.15±5.91	35.33	EC102254, Cherry Gala, EC043973
	TSS %	5.40-19.50	12.23±0.53	24.41	IC566137, EC144106, Cherry Gala
	Fruit pressure (lbs)	5.30-15.30	8.80±0.45	28.93	IC349914, EC200360, Super Chief
Pear	Days to fruit harvest	95-141	123.95±2.41	9.33	IC209705, IC538508, IC447993
	Pedicel length (mm)	9-45	25.65±1.42	35.15	IC20808, IC447940, IC557989
	Fruit length (mm)	22.07-95.64	53.14±2.68	31.95	EC732218, IC415344, EC552671
	Fruit width (mm)	28.13-73.64	51.80±1.95	23.87	IC415344, IC556145
	Fruit wt. (g)	15-166	79.21±6.67	53.31	EC732215, EC732218, EC552671
	TSS %	6.08-24.03	13.99±0.61	27.70	IC557989, IC566102, IC20818
Plum	Days to fruit harvest	89-153	106.13±4.11	15.02	IC557989
	Pedicel length (mm)	7.3-16.5	11.20±0.75	26.06	EC539001, EC117604
	Fruit length (mm)	19.43-45.36	30.85±1.81	22.78	EC538999, Frair, IC555306
	Fruit width (mm)	18.28-42.27	30.38±1.88	24.05	Frair, Kala Amritsari
	Fruit wt. (g)	13.0-49.7	27.35±2.75	39.02	Frair, EC538999
	TSS %	11.03-20	14.46±0.61	16.38	EC117604, IC20085
Peach	Days to fruit harvest	82-138	101.94±1.91	11.74	IC555306, EC117604
	Fruit length (mm)	32.05-70.03	51.89±1.35	16.27	EC280767, Independent
	Fruit width (mm)	26.87-68.24	51.52±1.33	16.19	EC552643, EC732228
	Fruit wt. (g)	23.6-134.6	74.19±4.41	37.14	IC349928, Ec556443
	TSS %	3.7-19	10.05±0.52	32.11	IC432142, EC732226
Apricot	Days to fruit harvest	63-114	77.23±1.86	13.21	EC552699, NIC58127
	Fruit length (mm)	30.17-55.73	40.55±1.22	16.52	EC552701, IC20092
	Fruit width (mm)	31.29-52.03	40.32±1.05	14.38	EC552701, Nugget
	Fruit weight (g)	10.2-64.6	36.87±2.69	39.91	EC552701, IC20092, Sahib
	TSS (%)	10.08-24.09	15.36±0.47	16.92	EC552702, Kaisha, EC552701
Physalis	Plant height (cm)	65-144	97.64±4.04	20.29	EC467436, EC467438
	Number of primary branches	2.0-3.7	2.51±0.10	19.98	EC467438, EC467452
	Number of lateral branches	7.0-29.50	16.00±1.04	32.01	EC467435, EC467438
	Berry length (mm)	21.56-32.34	27.35±0.64	11.57	EC467439, EC467455
	Berry width (mm)	25.90-40.98	31.95 ±0.82	12.63	EC467439, EC467442
	Berry weight (g)	8.60-35.50	15.77±1.33	40.60	EC467439, EC467442
	TSS (%)	3.50-7.20	5.46±0.20	17.96	EC467438, EC467449

Fig. 16.7. EC539003: a regular & heavy bearing accession of Apricot

to fruit size, fruit weight and TSS. An accession EC539003 found regular and heavy bearer (Fig. 16.7).

16.4.2 *Physalis* (*Physalis* spp.)

In *physalis*, total 24 accessions were characterized for various pomological traits. Plant height, number of primary branches, number of secondary branches, berry length, berry width, berry weight, TSS ranged from 65 – 144 cm, 2.0- 3.7, 7.0 – 29.50, 21.56 – 32.34 mm, 25.90 – 40.98 mm, 8.60 – 35.50 g, 3.50– 7.20 % respectively. An accession EC467438 found promising with respect to plant height and TSS.

16.5 Nutritional analysis of persimmon germplasm accessions

The macro and micro nutrient analysis of nine persimmons accessions were carried out at the Crop Production laboratory of ICAR-CPRI, Shimla. The nutrients were analyzed on dry weight basis. The whole fruit was sliced and oven dried at 55 °C. After that the dried slices were grinded to form powder. Then the powder were used for further nutrient analysis. For phosphorous meta-vanadate method used and the reading was recorded in spectrophotometer; after di-acid digestion the observation for potassium was recorded in flame photometer whereas, other six elements were determined by di-acid digest method using Atomic absorption spectrophotometer. The average P, K, Zn, Fe, Cu, Mn, Ca and Mg were 0.12 %, 0.81 %, 50.48 ppm, 43.78 ppm, 27.51 ppm, 14.20 ppm, 2227.58 ppm and 440.94 ppm respectively. Accession EC552665 recorded highest K (1.10 %) and Fe (62.45 ppm) content and accession IC558057 recorded with highest P (0.16 %) and Zn (57.60 ppm) whereas, all other element *i.e.* Cu (32.37ppm), Mn (15.92 ppm), Ca (4170.35 ppm) and Mg (685.20 ppm) were highest in accession IC349965 (Table 16.5). The morphological variability of nine persimmon accessions for fruit shape and size is presented in Fig. 16.8.

Fig. 16.8. Variability in fruit shape & size in persimmon germplasm

16.6 Germplasm conservation

16.6.1 Germplasm sent to LTS

A total of 109 accessions of various crops comprising of amaranth (79), rice bean (30) were sent to the National Gene Bank for long term storage. In fruit crops, 27 accessions were sent to Cryo gene bank.

Medium term storage: A total of 12,565 accessions of various seed propagating crops are conserved in MTS.

Table 16.5: Estimation of macro and micro nutrients in persimmon germplasm accessions

Accession	P (%)	K (%)	Zn(ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Ca (ppm)	Mg (ppm)
EC552665	0.15	1.10	55.80	62.45	30.23	12.19	2123.60	559.55
EC552664	0.12	0.75	39.22	43.99	22.71	12.27	2089.30	381.60
EC120289	0.10	0.82	53.70	41.83	23.64	14.01	1779.10	338.45
IC415417	0.12	0.78	53.51	41.63	21.84	14.45	1766.60	343.50
EC732219	0.10	0.66	51.43	40.29	27.71	15.91	1997.30	343.95
IC566131	0.11	0.73	52.14	39.68	28.83	13.45	2070.05	376.45
IC558057	0.16	0.96	57.60	41.83	29.37	14.53	1726.40	391.80
D. lotus (Church)	0.11	0.78	44.22	35.22	30.90	15.11	3225.55	547.95
IC349965	0.11	0.74	46.68	47.06	32.37	15.92	4170.35	685.20
Average	0.12	0.81	50.48	43.78	27.51	14.20	2327.58	440.94
Min	0.10	0.66	39.22	35.22	21.84	12.19	1726.40	338.45
Maximum	0.16	1.10	57.60	62.45	32.37	15.92	4170.35	685.20

Crop	No of acc.
French bean	4353
Amaranth	3270
Buckwheat	1000
Pea	705
Wheat	642
Finger millet	410
Rice bean	332
Foxtail millet	278
Chickpea	258
Cowpea	228
Chenopod	199
Adzuki bean	169
Proso millet	160
Horse gram	150
Soybean	144
Paddy	108
Barnyard millet	71
Meetha karela	42
Urd bean	30
Cuphea	16
Total	**12,565**

Field gene bank: A total of 1,023 germplasm accessions of various perennial crops such as fruits, medicinal and aromatic plants including other economic plants conserved in the field gene bank at NBPGR 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			1,023

16.6.2 Germplasm supply

Germplasm comprising 3,804 seed samples of agricultural crops and 233 scion wood/ rooted plants of fruit crops were supplied to researchers/indenters across the country.

- **Seed crops**: Chenopod (294), Kidney bean (432), Buckwheat (1222), Amaranth (421), Pea (310), Ricebean (533), Adzukibean (282)
- **Bud sticks/ scion woods:** Grape (11), Apple (156), Apricot (18), Persimmon (02), Plum (23), Peach (20) and Walnut (02)

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

PGR/GEV/BUR/SHM-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of pseudo cereals, pulses, and other lesser known hill crops (**Mohar Singh,** Rahul Chandora and Narender Negi)

PGR/GEV/BUR/SHM-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of temperate fruits, vegetables and medicinal and aromatic plants. (**Mohar Singh,** Narender Negi and Rahul Chandora)

REGIONAL STATION, SRINAGAR 17

Summary: One exploration and germplasm collection programme on faba bean (*Vicia faba*) was undertaken by the station in the areas of Anantnag, Budgam, Pulwama and Shopian districts in Kashmir division of UT of Jammu & Kashmir. 28 diverse accessions of faba bean showing variability in seed size, shape and color, were collected. 228 germplasm accessions comprising of wheat (106), barley (108) and *Aegilops tauschii* (14) were characterized for their agro-morphological traits as per the minimal descriptors during *rabi* 2018-19 under rainfed conditions and trait specific superior genotypes were identified. *Aegilops tauschii* germplasm collected earlier by the station has been characterized for first time. Besides, a set of 48 common bean genotypes collected from different parts of Jammu & Kashmir were evaluated for resistance to bean common mosaic virus (BCMV) during *kharif* 2019. Eight accessions of kala zeera (*Bunium persicum*) and three accessions of garden cress (*Lipidium sativum*) collected by the station were also evaluated for morphological traits. 40 accessions of different crops were supplied to different indenters for research purpose.

17.1 Exploration and germplasm collection

An exploration and germplasm collection programme of faba bean (*Vicia faba*) was undertaken by the station in the areas of Anantnag, Budgam, Pulwama and Shopian districts in Kashmir division of UT of Jammu & Kashmir during the months of October and November, 2019. Twenty eight diverse accessions of faba bean showing variability in seed size, shape and color were collected (Fig. 17.1). All the three seed size classes recognized internationally *viz*., small, medium and large have been collected. Generally mixture of these classes is cultivated particularly at higher altitudes in some remote areas. Some interesting and unique collections include SHEIKH/SR-900 with purple medium sized seeds; SHEIKH/SR-911 with small purple seeds; SHEIKH/SR/SA/SS-913 with large purple seeds and SHEIKH/SR/SA/SS-922 and SHEIKH/SR-926 with small blackish seeds. Out of these, 21 accessions with sufficient seed quantity have been sent for LTS at NGB ICAR-NBPGR, New Delhi while seven accessions with insufficient seed quantity need multiplication. All the 28 accessions have been sown for characterization during *rabi* 2019-20.

Fig. 17.1. Variability collected in faba bean (*Vicia faba*)

17.2 Characterization of Germplasm

17.2.1 Characterization of wheat and barley germplasm: A total of 214 germplasm accessions comprising of wheat and barley were characterized for their agro-morphological traits as per the minimal descriptors during *rabi* 2018-19 under rain fed conditions and based on different traits, superior genotypes were identified in both of these crops (Table 17.1). In wheat, 106 germplasm accessions were characterized in augmented block design using five checks (WR-544, HD-2967, C-306, Raj-3765 and local check HS-240) whereas in barley, 108 germplasm accessions were characterized in augmented block design using two checks Jyoti and DL-36.

17.2.2 Characterization of *Aegilops tauschii* germplasm: Fourteen accessions of *Aegilops tauschii* were characterized first time by the station for their morphological traits as per NBPGR descriptors during *rabi* 2018-19 using randomized block design and based on different traits superior genotypes were identified (Table 17.2). *Aegilops tauschii* is an important wild relative of wheat, and the germplasm

Table 17.1: Superior accessions identified for some important traits in wheat and barley

Crop/traits	Range	Mean	Best check value	Superior accessions
Wheat				
Plant height (cm)	44.0-159.6	100.8	112.1 (C-306)	IC535518, EC10596, IC423451, IC0031405A
Flag leaf length (cm)	14.8-33.0	24.4	24.9 (HS-240)	IC493711, EC0598087, IC423451, IC539316
Flag leaf width (cm)	1.2-2.6	1.9	1.7 (HS-240)	IC529526, IC529521, IC539315, IC539314
Days to 80% maturity	212-229	223	221 (WR-544)	IC530063, IC104647, EC576832, IC533960
Spike length (cm)	6.7-20.0	12.4	13.8 (HS-240)	IC539314, IC539316, KV5, EC178631
Seed yield/plant (g)	6.183-49.950	20.157	31.689 (Raj-3765)	IC529521, IC554659, EC514809, IC530063
100-seed weight (g)	2.200-7.400	5.121	5.200 (Raj-3765)	IC539315, IC539318, IC539316, IC47482
Barley				
Plant height (cm)	38.3-112.6	83.2	85.2 (Jyoti)	EC578707, EC328964, IC445980, EC578460
Days to 80% maturity	202-214	207.8	208 (DL-36)	IC138114, IC138009, IC547712, SHEIKH/NEGI-870
Seed yield/plant (g)	6.433-63.660	29.236	39.150 (Jyoti)	IC138143, EC578677, EC578672, IC445542
100-seed weight (g)	2.800-7.400	4.930	5.200 (Jyoti)	EC492317, EC492331, IC113057, IC138120

accessions characterized were earlier collected by the station from different parts of Kashmir and conserved in the National Gene Bank.

17.2.3 Evaluation of common bean germplasm for resistance to bean common mosaic virus: A set of 48 common bean genotypes collected from different parts of Jammu & Kashmir were evaluated for resistance to bean common mosaic virus (BCMV) along with two local checks Shalimar Rajma-1 and SKUAST-R-91 during *kharif* 2019. Based on the symptoms of curling, puckering and yellowing, we could identify collections namely Kulgam rajma, L-7, SD-7 and L-4 as resistant ones. Interestingly, Kulgam rajma collection was one among the heavy pod bearing genotypes and was almost free from most of the common diseases of beans. BCMV virus infection in collection SD-44, a genotype with severe leaf puckering was confirmed by DAS ELISA. Common bean genotype L-9 was found to be earliest to flower. This genotype has a bush-type plant and was at least 10 days early in flowering compared to the early flowering local check SKUAST R-91.

17.2.4 Characterization of *Bunium sativum* and *Lipidium sativum* germplasm: Eight accessions of kala zeera (*Bunium persicum*) and 3 accessions of garden cress (*Lipidium sativum*) collected by the station were also evaluated for morphological traits. In case of kala zeera (*Bunium persicum*), NBPGR farm collection exhibited maximum plant height, number of primary branches per plant, number of umbels per plant and umbel diameter. Maximum number of umbelets per umbel was recorded in Gurez-2 accession. Gurez-1 accession exhibited maximum number of seeds/umbelet. KD Farm

Table 17.2: Morphological characterization of *Aegilops tauschii* germplasm

Trait	Range	Mean	Superior accessions
Plant height (cm)	45.9-61.9	56.2	IC0628103 (61.9), IC0628104 (61.5)
Days to 50% flowering	176-183	178.4	IC0628105 (176), IC0628108 (176)
Days to 50% maturity	213-215	214	IC0628095 (213), IC0628096 (213)
Spike length (cm)	7.5-10.1	8.9	IC0628098 (10.1), IC0628097 (10)
No. of spikelets/spike	8.9-11.0	10.2	IC0628098 (11), IC0628097 (10.9)
No. of seeds/spikelet	2.0-2.3	2.1	IC0628100 (2.3), IC0628105 (2.3)
Seed yield/plant (g)	2.095-3.818	2.823	IC0628097 (3.818), IC0628096 (3.483)
100-seed weight (g)	1.164-1.697	1.332	IC0628103 (1.697), IC0628099 (1.483)

Fig. 17.2. *Aegilops tauschii* in the field (left) and harvested mature spikes (right)

Fig. 17.3. Characterization of common bean germplasm, resistant 'Kulgam rajma' accession (middle) and *Lipidium sativum* (right) in the field

accession has longest seeds while that collected from Wasturvan area has the shortest sized seeds. In case of *Lipidium sativum*, maximum plant height was recorded in early flowering accession IC0629133, while maximum number of leaves, leaf length and highest number of flowers in terminal inflorescence were recorded in IC0629138.

17.3 Germplasm conservation

Forty one germplasm accessions including faba bean (21 accessions) and other crops germplasm (20 accessions) and have been sent for LTS at National Gene Bank.

17.4 Supply of Germplasm

During the period under report four accessions of oat belonging to three different species viz., *Avena sativa*, *Avena fatua* and *Avena strigosa* were supplied through MTA. One climbing type accession of soybean was supplied to ICAR-Indian Institute of Soybean Research, Indore. Ten accessions of *Bunium persicum* were sent to TCCU, ICAR-NBPGR New Delhi.

Fig. 17.4. A: *Dioscorea deltoidea*, B: *Allium ampeloprasum*, C: *Cotoneaster* sp., D: *Corylus jacquemontii*, E: *Prunus tomentosa* and F: *Prunus cerasus* maintained at the station

Six accessions of *Vicia faba* and two accessions of *Lens culinaris* were supplied to DARS, SKUAST (K). A minimum number of eight cuttings, each of 15 different mulberry genotypes with diverse fruit characteristics were sent to Issapur Farm of ICAR-NBPGR for rooting and establishment of plants. 134 rooted apple plants belonging to 61 germplasm accessions including exotic ones were received from ICAR-NBPGR, RS Shimla for evaluation at the station. 66 faba bean accessions together with 11 checks were received from Coordinator, All India Coordinated Research Network on Potential Crops, ICAR-NBPGR New Delhi and have been sown for characterization under IVT/AVT trial during *Rabi* 2019-20.

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

PGR/PGC–BUR-SRI-01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of germplasm resources of various crops from Jammu & Kashmir region (**Sheikh M Sultan**; Susheel Kumar Raina)

REGIONAL STATION, THRISSUR 18

Summary: During this year, 409 samples of germplasm were collected in three exploration missions, covering North Sikkim and Nicobar. A total of 490 collections comprising 25 of okra, 115 of bitter gourd, 123 of yard-long bean, 72 of cucumber, 83 of brinjal and 72 of mango, were characterized. Germplasm of 695 collections and 554 of multiplied germplasm comprising various crops and their crop wild relatives/ medicinal plants were sent for conservation under LTS. RS-Thrissur has a germplasm holding of 9,057 accessions of various crops/ perennial horticultural plants and their wild relatives of which 7,182 are in the MTS and 1875 in the FGB. A total of 1250 accessions in various species/taxa were supplied to 20 users agencies under MTA. A Germplasm exchange day with farmers and a mango diversity day were organized to outreach with farmers. Organised three training cum planting material distribution programmes in tribal hamlets of Wayanad district. The station has facilitated visit of 245 students and 200 farmers.

18.1 Germplasm exploration and collection

A total of three explorations were conducted and 409 samples collected as detailed below:

Two exploration and collection mission were undertaken for crop wild relatives in Great Nicobar Biosphere Reserve and Nancowrie group of islands in Nicobar, in collaboration with ICAR-CIARI, Port Blair. Great Nicobar Biosphere Reserve (including Little Nicobar and Kondul Island), Kamorta, Katchal, Teresa, Trinket, Champin, Munak and Hitui were surveyed. A total of 319 samples comprising species diversity in important tropical crop genera like *Garcinia, Mangifera, Artocarpus, Piper, Zingiber, Curcuma, Dioscorea, Amorphophallus, Amomum, Alpinia, Syzygium, Musa* and *Vigna* were collected. Unique / first time collections include *Alpinia nigra* (AJJPN/19-121, 135), *Amorphophallus muelleri* (AJJPN/19-108), *Artocarpus pedunculariss* (AJJPN/19-151, 174), *Citrus reticulata* (AJJPN/19-123), *Etilingeria megalocheilos* (AJJPN/19-173), *Garcinia speciosa* (AJJPN/19-161), *Musa acuminata* (AJJPN/19-145), *M. indandamanensis* (AJJPN/19-107, ~179, ~180), *Piper clypeatum* (AJJPN/19-99), *P. pedicellosum* (AJJPN/19-93, 102), *Syzygium gratum* (AJJPN/19-115), *Zingiber zerumbet* (AJJPN/19-178), *Mangifera nicobarica* (JPJ/19-254), *Champeiria manillana* (JPJ/19-253), *Colocasia esculenta* (JPJ/19-262) and *Musa balbisiana* var. *andamanica* (JPJ/19-313). Landrace diversity in taro, giant taro, greater yam, potato yam and lesser yam were collected from Nicobari tuhets. Potential underutilized/wild edible plants include *Gnetum gnemon, Champeiria manillana* (leafy vegetables) *Garcinia speciosa* (fruit) and *Alpinia nigra* (rhizomatous spice). Critical taxonomic study of the collected germplasm is expected to lead to new distribution records in the genera, *Dioscorea, Musa, Piper, Syzygium, Curcuma* and *Sida*.

Reported five taxa new to A&N Islands namely *Cucumis melo* sub sp. *agrestis*, *Ipomoea littoralis*, *Solanum insanum*, *Tragia involucrata*, *Vigna stipulacea* and two species *Ziziphus subquinquenervia* and *Dioscorea piscatorum* new to country from Great Nicobar.

Another exploration and collection trip was executed to North Sikkim and adjoining areas for collection of wild relatives of wheat, *Allium* spp. and *Fagopyrum* spp. A total of 90 accessions belonging to about 54 taxa were collected, with 9 accessions of *Elymus* (5 spp.), 12 of *Allium* (4 spp.) and 9 of *Brachypodium* (2 spp.). Maximum collections were made in *Allium wallichii* (8 acc.), barley (7), *Brachypodium sylvaticum* (7) and *Elymus nutans* (4). About 75 herbarium specimens of cultivated plants/ wild relatives/minor economic plants were collected along with field notes and ethnobotanical information. First time collections include *Brachypodium pinnatum* (PRV/19-33), *Elymus duthiei* (PRV/19-58), *E. sikkimensis* (PRV/19-12), *Musa sikkimensis* (PRV/19-72), *Rorippa elata* (PRV/

19-56), *Rubus alexeterius* (PRV/19-20), *Rubus andersonii* (PRV/19-43) and *Tupistra clarkei* (PRV/19-81).

Three landraces of mango *Nambiar*, *Bappari* from Kasaragod and *Ninachen* of Kuttanad were collected. Bappari was found to be a synonym of *Komanga/Vattan* and *Ninachen* a synonym of *Kolambu.*

18.2 Herbarium deposited in NHCP, NBPGR New Delhi

A total of 36 specimen comprising *Trichosanthes,* and 25 specimens collected from Andaman and Nicobar Islands including *Tupistra clarkei, Abelmoschus moschatus, Ziziphus javanensis, Trichosanthes quinquangulata, Senna sophera, Sesbania sericea, Rhynchosia suaveolens, Garcinia speciosa* were deposited with a duplicate set at the station.

18.3 Germplasm characterization

Okra (*Abelmoschus esculentus*): A total of 25 accessions and four check varieties were evaluated for 24 morphological traits in Randomized Block Design with three replication. Fruit colour variability was observed and documented as follows: Light green colour (15 accessions), green (8), light red (EC930102 and EC930118), red (IC624180) and purple (EC930121) accession, and two accessions with reddish purple streaks on green fruits . Ridgeless fruits were observed in three accessions (EC901970, EC930081 and IC522273). Analysis of variance indicated that all the quantitative characters exhibited significant differences in their mean values across genotypes. IC624180 and IC621457 were found to be promising for the early flowering trait, attaining 50% flowering 39 days after sowing, on par with Pusa Sawani and Parbhani Kranti. First fruiting node, another character determining the earliness of the genotype was lowest in Kashi Pragati (5.67). Leaf blade length and width, both having implications on the yield were recorded a maximum in EC930121. Fruit length, a major determinant of the yield, was recorded highest in Parbhani Kranti (19.90 cm), followed by 19.07 cm in IC621457. Though, genotypic coefficient of variation was lower than phenotypic coefficient of variation as expected, for all the quantitative characters studied, the difference was meagre, indicating lesser environmental influence . Heritability was high for majority of the characters, except width of leaf blade, petiole length, internode length and single fruit weight. IC621457 outyielded all the control varieties for yield per plant by recording an yield of 514.91 g per plant, being an early bearing type is a promising candidate for further evaluation trials.

Bittergourd (*Momordica charantia*): Sixteen exotic collections of bitter gourd introduced from AVRDC, Taiwan were characterized for five quantitative and seven qualitative characters (Table 18.1). Quantitative characters include fruit weight, fruit length, fruit diameter, peduncle length and number of seeds per fruit. Maximum fruit weight was observed in EC919576, which recorded a fruit length of 26.75 cm. Fruit length, an important yield contributing character was more than 25 cm in EC919579, EC919558, EC919577, EC919583, EC919568 and EC919576. EC919568 produced broad fruits with a diameter of 7.80 cm. Seed number per fruit was observed maximum in EC919579. Majority of the accessions has prominent tubercles which were forming continuous ridges.

Ninety-nine indigenous collections of bitter gourd along with two control varieties Arka Harith and Priyanka were characterized for five quantitative and seven qualitative characters. Fruit weight and length were recorded maximum in IC264770 whereas minimum in IC550113 (38.33 g). IC50524A produced maximum seeds per fruit (43 seeds).

Cucumber (*Cucumis sativus*): A total of 32 exotic collections of cucumber were characterized for five quantitative and 12 qualitative characters. Eight accessions, *viz* EC888575 (42.20 cm), EC888567 (41.50 cm), EC888565 (39.00 cm), EC888557 (38.25 cm), EC888558 (36.25 cm), EC888569 (34.00 cm), EC888571(32.30 cm) and EC888566 (32.00) produced long fruits (more than 30.00 cm). Single fruit weight was maximum in EC888575 (450 g),

Table 18.1: Statistical and genetic parameters for yield contributing traits in okra

Characters	Range			PCV	GCV	h^2	Genetic	Genetic
	Minimum	Maximum	Mean	(%)	(%)	(%)	advance	gain (%)
Days to 50% flowering	38.67	102.00	52.30	24.092	23.83	97.81	25.39	48.54
First fruiting node	5.67	19.60	9.38	42.45	39.95	88.59	7.27	77.47
Leaf blade length (cm)	30.27	37.53	34.53	7.14	4.85	46.04	2.34	6.78
Leaf blade width (cm)	34.00	43.27	39.97	7.96	4.64	33.91	2.22	5.56
Petiole length (cm)	23.00	38.13	29.86	11.94	8.09	45.86	3.37	11.29
Fruit length (cm)	5.95	19.90	13.15	28.63	25.68	80.43	6.24	47.45
Fruit diameter (cm)	1.75	6.40	2.41	38.92	37.27	91.72	1.78	73.53
No. of locules in fruit	4.967	8.867	6.26	22.06	19.14	75.22	2.14	34.19
Internode length (cm)	7.4	16.933	12.20	29.58	22.65	58.63	4.36	35.73
Fruit weight (g)	16.667	35	25.92	22.26	10.85	23.74	2.82	10.89
No of fruits per plant	2.067	16.733	6.21	81.92	69.74	72.47	7.60	122.30
Yield per plant (g/plant)	42.8	514.907	166.79	90.92	77.32	72.32	225.92	135.45

Variability parameters in exotic collection of bittergourd

Characters	Max	Accession	Min	Accession	Mean
Fruit weight (g)	300	EC919576	69	EC919572	179.21
Fruit length (cm)	32	EC919568	13.17	EC919545	22.71
Diameter (cm)	7.8	EC919568	3.6	EC919572	5.161
Fruit stalk Length (cm)	11.5	EC919570	4.5	EC919583	7.021
No. of seeds/fruit	35	EC919579	15	EC919568	23.58

Variability parameters in indigenous collection of bittergourd

Characters	Max	Accession	Min	Accession	Mean
Fruit weight (g)	385	IC264770	38.33	IC550113	134.18
Fruit length (cm)	34	IC264770	7.5	IC541250	19.28
Diameter (cm)	7.0	IC433635	3.5	IC536670,IC541435, IC599424	4.77
Fruit stalk Length (cm)	22.5	IC505626	3	IC085603	9.07
No. of seeds	43	IC50524A	7.33	KP/PKS 1202	23.90

EC888567 (370 g), and EC888557 (345 g).The fruit skin colour was cream in two accessions, light green in six and green in 23 accessions. Majority of the accessions had either netted (15 accns.) or rough (11 accns) skin surface except 6 accessions, where smooth skin type were recorded. Fruit mesocarp was white in 19 accessions, whereas light green in 13. EC888572, EC888574, EC888579, EC888535 and EC888528 possessed mealy fleshed fruits, which is not a preferred quality attribute. Elliptical elongate shaped fruits were observed in 27 accessions, cylindrical in 3, oblong in one and oval in one accession. Ribbed fruits were observed in 28 accessions and non-ribbed in four accessions. EC888569 having an average fruit length of 34 cm with green and smooth skin and elliptical elongate shape, that can be used as a promising genotype from consumer point of view.

Fig. 18.1. Wild mango-*Mangifera camptosperma* from Great Nicobar

Fig. 18.2. A wild edible fruit khoon phal-*Haematpcarpus validus* from South Andaman

Fig. 18.3. CWR of jackfruit - *Artocarpus peduncularis* from South Andaman

Fig. 18.4. Wild *Garcinia- Garcinia nervosa* from Great Nicobar

Fig. 18.5. *Garcinia speciosa* from Nancowrie group of islands – a potential wild edible fruit

Fig. 18.6. Landscape of Teresa islands, Nicobar

A total of 40 indigenous collections of cucumber were characterized for five quantitative and 12 qualitative characters. Fruit length was maximum in JJNS/15-05 (21.10 cm) and fruit weight in JB-12-207 (270 g). Six accessions had creamy white, 22 had light green and nine had green fruit skin colour. Majority of the accessions possessed cylindrical fruit shape (25), remaining elliptical (8 accns), oblong (4 accns) and globose (1 acc) shapes. JB-12/207 and JRPH-15/112B were two promising accessions with fruit length of 18.00 cm and having green fruits with smooth skin texture. The flesh was crispy and firm in 29 accessions and the remaining had mealy fleshed fruits.

Fifteen accessions of cucumber exhibited yellow to orange colouration in the fruit flesh. IC613271, IC613461 and IC613467 recorded the total carotenoid content (µg/100g) of 1371.16, 1823.59 and 1870.65 respectively (Table 18.2).

Yard long and catjang bean: A total of 123 accessions were evaluated in a Randomized Block Design in two replications for 11 quantitative and 8 qualitative traits. Nineteen accessions; ICs 622559, 622565, 622573, 622575, 622578, 622579, 622580, 622581, 622586, 622588, 622598, 622599, 622600, 622602, 626138, 630377, 626159, 626162, 626167 and 626173 were superior with single pod weight more than 15 g compared to best check Arka Mangala (12 g.). Seventy accessions were field tolerant to yellow mosaic disease. Good varaibility for seed coat colour was observed. The descriptive statistics with respect to quantitative traits is presented in Table 18.3.

Table 18.2: Total carotenoids in cucumber

Sl. No.	Accn. No.	Carotenoids (µg/100g)
1	KP/SC-1642	200.89
2	JB/11-155	302.48
3	JB/11-182A	286.59
4	JB/11-120B	998.97
5	JB/12-217A	341.34
6	IC613466	634.13
7	JB/12-183A	161.99
8	JB/12-207	473.26
9	JB/12-203	1371.16
10	IC613461	1823.59
11	JRPH/15-93	225.64
12	IC613462	352.92
13	IC613467	1870.65
14	JB/12-185	581.64
15	IC595514	485.98
16	JB/11-182B	64.80
17	KP/SC-1642	175.49
18	KP-1293	725.51
19	DOPPA	161.99

These accessions were analysed for biochemical traits namely percentage of protein, total sugar, total phenol, reducing sugars, non-reducing sugar, peroxidise and poly-phenol activity .

Seven accessions; ICs 626143, 626157, 626173, 626163, 20482, 622591 and 622566 recorded high protein content of more than two percentage. ICs 630383, 626142, 626161, ICS 626173, 20482, 614769, 622579and 630404 were found to be rich in peroxidise activity (EU/g) which plays role in resistance mechanism in plants (Table 18.4).

Mango (*Mangifera indica*): Seventy-two accessions of local mango germplasm (comprising of 29 distinct landraces) augmented from West Coast area were characterised for 17 qualitative and 10 quantitative characters. All character states were present in the germplasm collections for the

Table 18.3: Variability parameters in yard long bean

Characters	Range	Mean	SD	CV (%)
Days to 50% flowering	36.0-62.0	45.51	22.91	50.34
Leaf length (cm)	7.6-19.7	13.33	1.83	13.71
Leaf width (cm)	4.6-11.9	8.64	1.13	13.07
Single green pod weight (g)	1.14-28	10.32	5.40	52.35
Peduncle length (cm)	6-14.8	9.28	1.94	20.88
Pod length (cm)	10.1-57.2	28.26	10.04	35.52
No. of seeds per pod	8.6-23.8	16.44	2.77	16.83
100 seed weight (g)	4.43-24.59	14.10	3.56	25.22

Table 18.4: Data of biochemical evaluation of yard long bean pod (Fresh weight basis)

Traits	Mean	Range	SD	CV (%)
Protein (%)	1.24	0.21-4.07	0.80	64.44
Total phenol (%)	0.12	0.03-0.34	0.06	47.85
Total sugar (%)	3.70	0.55-13.28	2.57	69.39
Reducing sugar (%)	1.08	0.25-1.63	0.29	26.64
Non-reducing sugar (%)	2.62	0.05-12.21	2.50	95.24
Peroxidase activity (EU/g)	18.43	0.33-106.33	21.62	117.36
Polyphenol oxidase (Activity for 1g)	0.03	0.004-0.71	0.09	260.16

characters – fruit shape (14 states), fruit beak (4), fruit apex (4), fruit base (8), stalk insertion (5) and fruit shoulder (9), while seven out of eight character states were present in fruit skin ground colour. This indicates the vast diversity present in the field collections. Two third accessions possessed oblique pedicel insertion in fruit base, while three fourth had not developed blush colour over fruit skin during ripening. Out of 72 accessions, 11 had mammiform beak shape in fruit; 22 were possessing low fibrous fruits; and 14 were adjudged as sucking/juicy types.

Minor variation exhibited between trees w.r.t. fruit shape, weight and fruit skin blush colour in accessions within the same landrace (e.g. *Vellari, Kolambu, Moovandan*). High TSS (>20%) was

Fig. 18.7. Wild mango-*Mangifera nicobarica* from Katchal

Fig. 18.8. *Manilkara littoralis* – a wild relative of sapota from South Andaman with salinity tolerance

Fig. 18.9. *Musa acuminata* – a wild relative of *Musa* from Great Nicobar

Fig. 18.10. *Musa kattuvazhana* – a wild relative of *Musa* from South Andaman

Fig. 18.11. *Piper clypeatum* – a wild relative of *Piper* from Great Nicobar with ornamental value

Fig. 18.12. *Piper miniatum* – a wild relative of *Piper* from Great Nicobar

Table 18.5: Characterization data of mango germplasm in FGB

Characters	Min	Max	Mean ± SE	CV (%)	CD
Fruit length (cm)	4.63	14.3	7.69 ± 0.22	24.81	0.38
Fruit width (cm)	3.95	9.68	6.01 ±0.14	19.50	0.23
Fruit thickness (cm)	3.58	8.38	5.40 ±0.12	19.05	0.20
Fruit weight (g)	41.1	436.38	145.69 ±9.00	52.42	15.04
Fruit skin thickness (mm)	0.70	4.50	1.48 ±0.06	36.31	0.11
TSS (° Brix)	11.00	24.55	16.55 ±0.36	18.61	0.61
Stone length (cm)	3.85	10.85	6.11 ±0.19	26.08	0.31
Stone width (cm)	2.40	5.09	3.44 ±0.06	14.85	0.10
Stone thickness (cm)	1.28	3.47	1.96 ±0.04	15.41	0.06
Stone weight (g)	7.00	48.00	21.74 ±0.92	35.93	1.54

possessed by accessions – IC470678-A (*Pulimanga*; 24.55%), IC470614 (*Vellari*; 24), IC470615 (23.4), IC202206 (22.5), IC470653 (21.67), IC470625 (*Kolambu*; 21.33) and IC470655 (*Pazhamanga*; 20.5). Accessions with high fruit weight (>300 g) include IC470667 (*Mallusseri manga*; 436.38 g), IC470673 (*Naattumavu*; 346.00), IC470621(*Valiyakilichundan*; 323.60), IC470614 (*Vellari*; 312.67) and IC470621 (*valiyakilichundan*; 309.00). Very thin skinned (<1 mm) fruits were observed in IC202217, IC202203, IC470660 (*Moovandan*), IC470633, IC470677 (*Pulimanga*), IC202174 and IC212569 (*Chunayan*). Low proportion of stone to fruit (<10%) was exhibited by IC470673 (*Naattumavu*; 6.36), IC470667 (*Mallusseri manga*; 7.16), IC470616-C (*Kilichundan*; 8.35) and *Mundappa* (9.70). While landrace '*Kolambu*' (IC470625, IC470630) had excellent eating quality, some promising accessions with good eating quality and high productivity status are IC470614 (*Vellari*), IC470625 (*Kolambu*), IC470632(*Kitto*) and IC470621 (*Valiyakilichundan*). IC470678 (*Pulimanga*) is adjudged as the best mango owing to its thin fruit skin, good eating and keeping quality (7 days).

Of 72 accessions, a set of 30 local mango germplasm (comprising of 15 landraces) were characterised for 15 vegetative and floral morphological characters. These polyembryonic mangoes exhibited substantial variation with respect to the colour of emerging leaves (pale green/ brown/ brownish-red/ reddish pink), leaf shape and the nature of leaf margin (flat/ wavy/ twisted/ folded) and distal tip (acute/ subacuminate/ acuminate). Blade length and width ranged from 13.30 (*Ollor*) to 27 cm (*Vattan*) and 3.25 (*Nalla Puliyan*) to 7.45 (*Valiya Kilichundan*), respectively. Two third accessions showed spreading (out-held) leaf arrangement with twig. Early flowering landraces/ accessions (flowering completed by January end) under Thrissur conditions are *Vellari, Ullitholiyan, Kunjumanga*, IC470633, IC470632 and *Kottamanga*. About half the accessions had the tendency of late flowering (flowering over by February end or March first week). The landrace '*Kottamanga*', exhibited prolific fruiting and the fruits are available for almost three months, from first week of April to June end. Regarding inflorescence characters, pyramidal and broad-pyramidal shaped panicles are prevalent, while conical inflorescence was exhibited by only 3 accessions. Number of primary rachis per inflorescence, one of the yield-contributing character, ranged from 10 (IC202179) to 25 (*Kottamanga*). Besides variation in hairiness and panicle colour was evident in the germplasm collection.

Greater yam (*Dioscorea alata*): Greater yam germplasm collected from A&N Islands, JPJN/19-7, JPJN/19-10 were found highly susceptible to anthracnose disease whereas collections from North-East were found to be field resistant under natural epiphytotic conditions.

Brinjal and its wild relatives: With the twin objectives of characterization of brinjal collections from South & NE India maintained at the station and also for developing working keys to distinguish its wild relatives in field, a total of 130 accessions were characterized using modified NBPGR descriptor. Apart from brinjal, its wild relatives belonging to subg. *Leptostemonum*, namely *S. insanum*, *S. incanum*, *S. torvum*, *S. aethiopicum* (syn. *S. gilo*), *S. macrocarpon*, *S. lasiocarpum*, *S. violaceum* (syn. *S. indicum*, *S. kurzii*), *S. virginianum* (syn. *S. surattense*, *S. xanthocarpum*), *S. viarum* and *S. exarmatum* were included in the study. The characters used for distinguishing *S. insanum* from *S. melongena*, as mentioned in recent works, such as lamina size, no. of flowers per inflorescence, no. of prickles on calyx, fruit pedicel length and no. of prickles on pedicels were found untenable in the study, however, the characters - fruit shape and size, and mesocarp morphology might be of help in distinguishing this progenitor species. Concept of parallel variation was evident among these two species with respect to characters such as pigmentation, corolla colour, spininess over stem, leaf, calyx and pedicel, no. of flowers per inflorescence, etc. Further, efforts are on to augment remaining wild relatives of brinjal for taxonomic studies. Besides, adaptability studies of one fruit species new to Kerala, *S. lasiocarpum*, collected from Nicobar, indicated that this species is

Fig. 18.13. *Vanilla andamanica* from South Andaman

Fig. 18.14. *Vigna trinervia* from Katchal, Nicobar

Fig. 18.15. Wild Ashgourd from Teresa islands, Nicobar

Fig. 18.16. Training programme under TSP at Wayanad district, Kerala on 10 March 2019

Fig. 18.17. *Elymus* species collected from Sikkim

Fig. 18.18. Natural habitat of *Allium wallichii*

highly susceptible to virus under Thrissur conditions.

Eighty-three accessions of brinjal were characterized for 19 qualitative and 13 quantitative characters. For seven characters, all character states were present in the germplasm collections, while five out of six character states in the character 'fruit curvature' and seven out of ten in 'fruit colour'were present. This indicates the vast diversity present in the germplasm collections. 'Light violet' and 'bluish violet' coloured corolla predominated in the collections. Thirteen had unarmed calyces while eight had calyces with > 10 spines. Regarding fruit shape, 'long', 'round', 'oblong' and 'oval' character states were possessed by 11, 23, 24 and 25 accessions, respectively. About half the germplasm had 'green' fruit colour at marketable stage. It was observed that colour of spine corresponds to that of stem, petiole and midrib. Some quantitative characters studied are presented in Table 18.6.

Two accessions; IC090931 and IC023962 were early-flowering (<25 days) while IC354651 and IC618044 exhibited simultaneous anthesis of all flowers in a cluster. IC545919, IC350885 and 375858 bore fruits weighing 255, 220 and 216.7g, respectively. IC324775 and IC203607 had upright growth habit, linked with pale green, weakly-lobed leaves and small-sized flowers. Collections from Nagaland (KP/SC-1578, KP/SC-1651, JRPH/15-103) are unarmed and had purplish pigmentation in stem, petiole and midrib, weak leaf-lobing, longer petiole, large solitary flowers and long curved fruits. Owing to the often cross-pollinated nature, genetic admixture was found in some accessions (of germplasm collections), which are under purification.

Table 18.6: Characetization data of brinjal germplasm

Characters	Min	Max	Mean ± SE	CV (%)	CD
No.of primary branches	2.0	6.6	4.02 ±0.10	23.01	0.17
Leaf blade length (cm)	9.6	19.0	15.04 ±0.19	11.39	0.31
Leaf blade width (cm)	6.5	13.6	10.52 ±0.16	13.96	0.27
Days to 50% flowering	21	71	41.72 ±1.26	27.49	2.09
Fruit pedicel length (cm)	2.3	7.0	4.33 ±0.12	24.73	0.20
Fruit length (cm)	2.4	24.6	9.69 ±0.49	45.71	0.81
Fruit breadth (cm)	2.0	8.2	4.83 ±0.14	26.65	0.24
Fruit weight (g)	25.0	255.0	78.72 ±5.18	60.00	8.63

Wide hybridization in okra: The wild taxa used for hybridization included *Abelmoschus enbeepeegearensis*, *A. moschatus* variant (JJK-11/3, *mizoramensis* sp. nova), *A. pungens* variant (JRPH-15/14), *A. pungens* variant (JRPH-15/12), *A. moschatus* variant (EC306750, a new entity), *A. moschatus* variant (JP-17/35) *A. tetraphyllus* and *A. manihot* (EC306748). Pusa Sawani, Arka Anamika, Kashi Vibhuti, Kashi Pragati, Kashi Satadhari, Parbhani Kranti and Punjab Padmini were the maternal parents. Out of the 20 cross combinations, seeds of only 11 crosses germinated (Table 18.7).

Fig. 18.19. *Allium victorialis* wild in field boundaries at Kupup

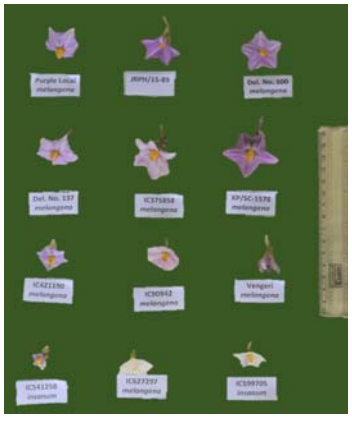


Fig. 18.20. Variability in brinjal flowers

Fig. 18.21. *Curcuma roscoeana* collected from A&N Islands had orange floral sheath can be of ornamental value

Fig. 18.22. Variability in okra germplasm

Fig. 18.23. Variability in carotenoid rich cucumber (Candy from cucumber in inset)

Fig. 18.24. Variability in melon

Table 18.7: Status of newly attempted distant crosses in okra

S. No.	Crosses	No. of seeds germinated	No. of plants seedlings survived after colchicine treatment
1	Punjab Padmini x *A .enbeepeegeearensis* (JRNR/2009-25)	3	Nil
2	ParbhaniKranti x *A .enbeepeegeearensis* (JRNR/2009-25)	3	Nil
3	Arka Anamika x EC306750 (*A. moschatus* variant)	20	9
4	Arka Anamika x *A. pungens* variant (JJK/2011-3)	20	Nil
5	Arka Anamika x *A. pungens* variant (JRPH-15/14)	25	16
6	Arka Anamika x *A. moschatus* variant (EC306750)	20	9
7	Pusa Sawani x EC306750 (*A. moschatus* variant)	11	Nil
8	Pusa Sawani x *A. pungens* variant (JRPH-15/14)	25	20
9	Pusa Sawani x *A .enbeepeegeearensis*(JRNR/2009-25)	8	Nil
10	Pusa Sawani x *A. pungens* variant (JRPH-15/12)	18	10
11	Pusa Sawani x *A. moschatus* variant (JP-17/35)	4	Nil

Fig. 18.25. Mango diversity day

Fig. 18.26. Variability in characterized Mango germplasm

Fig. 18.27. Germplasm exchange day with farmers

Among the wild species used, *A. enbeepeegeearensis*, showed the lowest survival status. Out of this, only five crosses, namely Pusa Sawani x *A. pungens* variant (JRPH-15/12), Pusa Sawani x *A. pungens* variant (JRPH-15/14), Arka Anamika x *A. pungens* variant (JRPH-15/14), and Arka Anamika x EC306750 (*A. moschatus* variant) could withstand colchicine treatment undertaken during seedling phase. The selfed seeds are being harvested separately from each plant from the C_1 generation and pedigree of each backcross progeny recorded and seed stored for developing back cross progeny.

Non-polyploidized hybrids (11 cross combinations) as depicted in the above table, were also evaluated for occurrence of YVMV symptoms. All hybrids except Arka Anamika x *A. manihot* (EC306748) were found to be tolerant to YVMV under field epiphytotic conditions. As colchicine treatment was not undertaken in these hybrids, the percentage success of seed set was very less.

18.4 Germplasm conservation and regeneration

A total of 7,182 accessions comprising cereals (3140), millets (125), pulses (1196), vegetables (1613), medicinal plants (76) and crop wild relatives (977) were conserved in the MTS facility of the station. In the field gene bank, currently 1575

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 and 80 of other economic plants.

For long term storage, 695 samples consisting of collected (141 voucher samples) and multiplied (554 samples) germplasm were deposited at NGB, which comprises okra (448), yard long bean (41), cucumber (12), *Eclipta alba* (15), African okra (15), Wild *Abelmoschus* (2), amaranth (1), melon (2), *Gossypium barbadense* var. *acuminatum* - Nicobari cotton (1), Mesta (3), Small bitter gourd (1), Foxtail millet (1), Sida (5), Sorghum (1), Cowpea (3), Wild *Vigna* (2) and Green gram (1).

One accession each of *Capsicum chinense* and *Musa balbisiana* var. *andamanica* were sent for cryo-preservation; 21 samples comprising *Zanthoxylum acanthopodium, Rubus paniculatus, Rubus alexeterius, Rubus andersonii, Rubus lineatus, Rubus rugosus, Rosa macrophylla, Rosa sericea, Prunus cornuta, Sorbus microphylla, Ribes himalense, Ribes griffithii, Hippophae salicifolia, Zanthoxylum oxyphyllum, Podophyllum hexandrum, Choerospondias axillaris, Musa sikkimensis, Toddalia asiatica* collected from Sikkim were deposited for cryo-conservation. Seventeen collected samples of *Triticum* spp. and *Brachypodium* sp.were sent to IARI Regional Centre, Wellington, Ooty, Tamil Nadu for further maintenance.

***Gnetum gnemon*:** Collections from Nicobar islands JPJ/19-315 and JPJ/19-232 were found to have nearly 9-10 months seed dormancy. Freshly collected ripe berries were depulped and sown in nursery beds in February 2019. It is used as leafy vegetable across Nicobar and South East Asian countries by indigenous people.

18.5 Germplasm exchange

Supply to user agencies: Under Material Transfer Agreement (MTA), 1250 accessions of germplasm of various crops/ species were supplied to 20 user agencies, comprising four ICAR institutes (478 accs.), seven State Agricultural Universities (590 accs.) and seven other agencies (182 accs.).

Germplasm receipt: A total of 48 landraces in various crops comprising *Kodalimulaku* (Chilli), *Kantharipadarppan* (Cassava), *Peruvilathink - izhangu*, *Mukkachil/Mullan kachil*, *Vazhakkachil, Kadumneela kachil, Kaduvakkayyan (purple), Kaduvakkayyan (white), Manja-neela kachil, Injikkonam kachil, Kavalakuthi, Paarakkachil, Vellakkachil, Neela-urulan, Rose-kamban kachil, Bharanikkachil, Kallan kachil, Neendikkachil, Wayanadan neelakachil, Parassikkodan, Sugandhakachil* (Greater yam), *Wayanadan karkkonthal payar*, *metre payar* (long poded yard long bean), *Vengeri vazhuthina* (Brinjal), *Neelavenda, Maravenda, Karappuram venda , Anakomban venda* (Okra), *Unda vellari* (Melon), *Thondi*, *Kuzhinirayan*, *Thamarakkannan, Kottachembu, Podichembu, Kulachembu, Vettuchembu, Kodavazha chembu, Kannan, Chemban, Karuthakannan, Velutha kannan, Veluthalu, Pindalan, Muttachembu, Karimchembu, Kudamalaran, Kappachembu, Cheerachembu* (Taro) were received from farmer conservators.

Three accessions each of flood survived rice landraces were received from Shri Praseed Kumar of Wayanad and Smt. Mariyam Umma of Quilandy, Kozhikode for its conservation under LTS.

18.6 Feedback on supplied germplasm received from indenters based on supply

- JPJ/19-313 (IC630992) *Musa balbisiana* var. *andamanica* seedlings were found resistant to Panama wilt race-1 in sick plots in Kerala. Further the results were confirmed under lab conditions at Banana Research Station, KAU, Kannara.
- Fifteen accessions of rice were reported to be resistant to blast by TNAU, AC & RI, Killikulam, Tamil Nadu.
- Bittergourd germplasm IC599423 was reported for superior yield and yield contributing traits by Telangana State Horticultural University, Hyderabad.

18.7 New initiatives and success stories

Simulated *in situ* plot were raised for *Benincasa hispida* f. *pruriens* (wild ashgourd) collected from Teresa Island of Nicobar, A & N Islands.

An additional plot for the germplasm collected from Andaman & Nicobar Islands was established in West Upper block which comprised 70 accessions belonging to genera *Musa*, *Citrus*, *Garcinia, Mangifera, Etlingera, Syzygium, Artocarpus*, *Myristica,* and *Champeiria*.

18.8 On-farm conservation

On-farm conservation of eight promising *Citrus* (lime and lemon from Andaman and Nicobar Islands) was initiated. A full set was planted and established at NBPGR farm, Thrissur. Surplus seedlings of eight accessions were distributed to six growers hailing from different districts of Kerala and records maintained.

A network of custodian farmers across Kerala, cultivating and maintaining landrace diversity in rice, taro, greater yam, mango, jackfruit, banana, cassava, vegetables, native and exotic fruit trees and medicinal plants were developed. Volunteer farmers were supplied germplasm of their choice for augmenting diversity in home gardens. Two farmers were supplied 25 accessions of *in vitro* taro germplasm retrieved from TCCU, NBPGR, New Delhi for adaptability studies.

A total of 39 tissue culture regenerated Taro were characterized for preliminary yield data upon harvest from pots. Data were taken on number of cormels, length, breadth and average weight of cormels, length and breadth of mother corm and total weight of cormels excluding mother corm. Number of cormels were maximum (78 nos) in IC427607 whereas minimum in IC87124 (10 nos). Cormel length of 9 cm (maximum) in IC87182 and 2.10 cm in IC343040. Broadest cormel was produced by IC264975. Longest mother corm with length of 18 cm long was produced by IC264918. The same set of accessions were supplied to a farmer in Thuravoor village of Alappuzha district. The farmer was asked to rate the accessions based on the cooking quality of the tubers as average, good and very good. Seven accessions (IC256996, IC343040, IC312200, IC278228, IC317585, IC70160 and IC136701) were rated very good with flesh of tuber turning soft on cooking. None of the supplied accessions were acrid.

18.9 Identification of potential economic plants

Garcinia speciosa (table fruit), *Alpinia nigra* (rhizomatous spice), *Musa balbisiana* var. *andamanica*, *Macaranga nicobarica* (Leaf dining plates) and *Curcuma roscoeana* (ornamental flower) were identified as potential economic plants based on current year's observation in the field. *Garcinia speciosa* plus tree (AJJPN/19-161) grafted to native species flowered within an year. *Macaranga nicobarica,* two year old seedling produced leaves of about 70 cm diameter which can be used as dining plates. *Curcuma roscoeana* produced beautiful orange spikes with high ornamental value.

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

(PGR/GEV-BUR-THR-01.00): Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Plant Genetic Resources in Southern India including Goa and Andaman & Nicobar Islands (includes 3 Projects) **Dr. Joseph John K**, Principal Scientist & Officer-in-charge

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

Project-1: Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Genetic Resources of Field Crops and their Wild Relatives (**M Latha**; K Pradheep, A Suma, *S Mani* and *A Indiradevi*)

Project-2: Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Genetic Resources of Tropical Vegetable, Fruit and Tuber Crops and their Wild Relatives (**Suma A**, Joseph John K, M Latha, K Pradheep, *S Mani* and *A Indiradevi*)

Project-3: Augmentation, Characterisation, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Genetic Resources of Spices and their Wild Relatives, Medicinal and Other Economic Plants (**K Pradheep**, Joseph John K., M Latha, A Suma, *S Mani* and *A Indiradevi*)

TRAININGS AND CAPACITY BUILDING 19

19.1 Trainings organized in 2019

S. No.	Title of programme	Duration	Venue
1.	Workshop on 'Bioinformatics in wheat genome analysis'	Feb. 27- March 2	ICAR-NBPGR, New Delhi
2.	Brainstorming session on 'Indigenous oil seed crops improvement initiative'	April 27	ICAR-NBPGR, New Delhi
3.	PGR conservation awareness workshop cum diversity fair	April 29	Jadi, Dehradun, Uttarakhand
4.	A workshop on 'Plant genetic resources conservation of Arunachal Pradesh'	June 11-12	Naharlagun, Papum Pare, Arunachal Pradesh
5.	Training programme on 'Herbarium management: Methods and current trends' (For agriculture scientists, Government of Iraq)	July 15-20	ICAR-NBPGR, New Delhi
6.	Training workshop on 'Value chain development in heirloom crops and varieties'	August 19-21	ICAR-NBPGR and Bioversity International, New Delhi
7.	National training on 'Plant genetic resources management and utilization', for PG students organized under NAHEP-CAAST sponsored short-term training programme	Sept. 30 – Oct. 11	ICAR-NBPGR, New Delhi
8.	Brainstorming Workshop on 'Mainstreaming rice landraces diversity in varietal development through genome predictions	Nov. 1	ICAR-NBPGR, New Delhi
9.	Five-day training program on 'DNA fingerprinting and transgenic crop seed testing' for the officers of Directorate of Agriculture and Farmers Welfare, SAS, Nagar, Punjab	Dec. 9-13	ICAR-NBPGR, New Delhi
10.	Brainstorming session on 'Enhancing the productivity and quality of dual purpose legumes in dryland areas using integrated genetic and genomic approaches'	December 24	ICAR-NBPGR, New Delhi
11.	8th International Training on *in vitro* & cryopreservation approaches for conservation of Plant Genetic Resources	Nov. 5-19	ICAR-NBPGR, New Delhi

19.1.1 Brainstorming meeting on 'Improvement of potential crops and development of value chain' was organized by the All India Coordinated Research Network (AICRN) on Potential Crops (PC), ICAR-NBPGR, New Delhi, at NASC, New Delhi on June 20, 2019. Dr Trilochan Mohapatra, Secretary, DARE & DG, ICAR was the Chief Guest of the meeting. Dr SK Malhotra, Agricultural Commissioner, DAC&FW, Mr. Ashwani Kumar, Joint Secretary (Seed), DAC&FW and Dr AK Singh, DDG (Horticulture & Crop Science), ICAR, were the Guests of Honour (Fig. 19.1). Over 150 participants from ICAR, SAUs, private industries and farmers participated in the meeting. In his welcome address, Dr. Kuldeep Singh, Director, ICAR-NBPGR, New Delhi highlighted the main aim and objectives of the meeting. He briefed about the activities and progress of the AICRN on PC and also outlined the global scenario. He urged for focusing on the agricultural diversity in order to use these crops for eliminating hunger and poverty from the country. He also stressed the need for more international linkages for these crops.

Fig. 19.1. Brainstorming meeting on 'Improvement of potential crops and development of value chain

19.1.2 Quinquennial Review Team (QRT) meeting

Quinquennial Review Team (QRT) meeting of ICAR-NBPGR stations (Shimla, Bhowali, Jodhpur & Shillong) & AICRN-PC was organized at ICAR-NBPGR Regional Station Shimla from Sept. 16-17, 2019 (Fig. 19.2 & 19.3). QRT meeting was also held at NBPGR Regional Station, Hyderabad during October 10-11, 2019. Regional station Heads of RS Hyderabad, Akola, Cuttack, Ranchi and Thrissur presented the significant achievements of the station during the last five years before the QRT team.

19.1.3 International training on '*In vitro* and cryopreservation approaches for conservation of plant genetic resources'

The eighth International training course on '*In vitro* and cryopreservation approaches for conservation of plant genetic resources' was jointly organized by ICAR-NBPGR and Bioversity International, New Delhi, India, in collaboration with the Asia-Pacific Association for Agricultural Research Institutes (APAARI) Bangkok, Thailand under its program Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) (Fig 19.4). The 15-day long course was held from Nov 5-19, 2019 at the Tissue Culture and Cryopreservation Unit (TCCU) of ICAR-NBPGR, New Delhi. The TCCU was designated as a Centre of Excellence (CoE) in 2006 under the NBPGR-Bioversity International workplan, for undertaking international training programmes to enhance the capacity of national programs especially in the developing countries.

The training was inaugurated on Nov. 5, 2019 by Dr RC Agrawal, DDG (Agric. Education), ICAR, National Director, NAHEP & Registrar General, PPV&FRA in the presence of Dr DK Yadava, ADG (Seed), ICAR, Dr RK Tyagi, Coordinator, APCoAB, APAARI, Thailand and Dr JC Rana, National Coordinator, UN-GEF Project, Bioversity International-India. The training was attended by 22 trainees from 13 countries, including Pacific Region (Fiji, PNG, Samoa), South and East Asia (Bangladesh, Chinese Taipei, India, Philippines), Central Asia (Uzbekistan, Kazakhstan, Ukraine) and Africa (Algeria, Madagascar, Senegal). The training was structured to cover all the aspects of *in vitro* and cryopreservation of germplasm, through 21 lectures and 14 practical sessions. Lectures were delivered by resource persons from within NBPGR along with four International faculty, namely, Dr Hugh Pritchard (Royal Botanic Gardens, Kew, UK), Dr Bart Panis (Bioversity International, Leuven, Belgium), Dr Takao

Fig. 19.2. Quinquennial Review Team (QRT) meeting at ICAR-NBPGR Regional Station Shimla

Fig. 19.3. QRT meeting held at NBPGR Regional Station Shimla

Fig. 19.4. Faculty and participants of Eighth International Training on '*In Vitro* and Cryopreservation Approaches for Conservation of Plant Genetic Resources', Nov. 5-19, 2019

Fig. 19.5. Brainstorming meeting on 'Enhancing the productivity and quality of dual purpose legumes in dryland areas using integrated genetic and genomic approaches'

Niino (Japan) and Dr Kanchit Thammasari (Mahidol University, Bangkok, Thailand). Trainees got a hands-on experience of handling vegetatively propagated crops and difficult to conserve recalcitrant plant species. In addition, lectures were also delivered by the co-organizers namely Dr RK Tyagi (APCoAB, APAARI, Thailand), Dr NK Krishna Kumar and Dr JC Rana, (Bioversity International-India). Apart from the lectures and practicals, trainees also visited the National Genebank and the National Herbarium of Cultivated Plants (NHCP), both housed within the ICAR-NBPGR Campus. The training concluded under the chairmanship of Dr RS Paroda former DG, ICAR & Secretary, DARE, on Nov 19, 2019. Dr Anuradha Agrawal, Officer-in-Charge, TCCU & Course Coordinator presented the report of the training. The training ended on a high note, with appreciation by all the 22 participants from 14 countries.

19.1.4 Training on Establishment of nursery of horticultural crops: Training on "Establishment of nursery of horticultural crops" was organised at NBPGR, Exp. Station Issapur, New Delhi on Kisan Diwas December 23, 2019. Around 150 local farmers belonging to Issapur, Samaspur, Looksar, Dhansa, Mudela, Gummanheda were participated in the training. Dr. Vijay Singh Meena, Scientist & Training coordinator, briefed about training and welcomed all the trainees Dr. Kuldeep Singh urged farmers to share their local varieties and perennial plant resources with the bureau. Dr. Gurenderjit Randhawa, Nodal Officer, SCSP briefed activities under SCSP. On this occasion seed kit, gardening kit and fruit plants were distributed to trainees. Scientist from NBPGR also discussed farmer's problems and advised them for the use of suitable practices.

19.1.5 Brainstorming meeting

Brainstorming meeting on "Enhancing the productivity and quality of dual purpose legumes in dryland areas using integrated genetic and genomic approaches" was organized on Dec 24, 2019 at ICAR-NBPGR, New Delhi with participation of various scientists from ICAR, NBPGR, IGFRI, SAUs, DBT and ICARDA (Fig. 19.5).

19.1. 6 Symposia organized

- Satellite symposium on *'Dryland Agrobiodiversity for Adaptation to Climate Change'*, organized by Indian Society of Plant Genetic Resources, New Delhi, Bioversity International, New Delhi, Asia-Pacific Association of Agricultural Research Institutes, Bangkok, held at Jodhpur, Rajasthan, India, Feb. 13, 2019. Convenor - Dr Kuldeep Singh, Director, ICAR-NBPGR, Co-Convenor - Dr Anuradha Agrawal, General Secretary, ISPGR, New Delhi.
- *Progressive Horticulture Conclave (PHC-2019) on Futuristic Technologies in Horticulture,* held at ICAR-Indian Institute of Sugarcane Research, Lucknow, Dec. 8-10, 2019 in which Dr. Sandhya Gupta was co-organizer.

19.1.7 Hindi Parangath course

Hindi Parangath course was organized at RS Hyderabad by the Department of Official Language, Ministry of Home Affairs. This course was for four months (January-April, 2019). A total of 18 staff members attended the course.

19.2 Trainings undertaken during 2019

Name of employee	Title of training programme	Place and Period
M Latha	Geospatial analysis using QGIS and R	ICAR-NAARM, Hyderabad Feb. 1-6
S Mani	Farm management	ICAR-IIFSR, Modipuram Feb. 13-19
Narender Negi	Training on ToT on "Biodiversity governance"	HIPA, Fiarlawn Shimla Mar. 11
K.K. Gangopadhyay	Science administration and research management	ASCI, Hyderabad July 1-12
Rahul Chandora	Value chain development for heirloom crops and varieties organized	ICAR-NBPGR, New Delhi Aug. 19-21
Neelam Shekhawat	CAFT training programme on 'Advance statistical analysis of breeding data'	IASRI, New Delhi. Aug. 27- sept 16
Rahul Chandora	*e*-Office	ICAR-CPRI, Shimla Sept. 11-12
Pardeep Kumar	Advances in applications of nanotechnology	ICAR-CIRCOT, Mumbai Sept. 23-27, 2019
T Boopathi	Ecological and molecular approaches for host plant resistance to insect pests	TNAU, Coimbatore, India Nov. 5- 25
N Sivaraj	Hands on training workshop on ecological niche modelling	KSCSTE Malabar Botanical Garden Nov. 22-24
V Celia Chalam	General management programme for women scientists	Administrative Staff College of India, Hyderabad, December 2-13
Pratibha Brahmi Sunil Archak	MDP on leadership development	ICAR-NAARM, Hyderabad Dec. 12-13
Prasanna Holajjer	*e*-office	ICAR-NAARM, Hyderabad Dec. 5-6
Technical staff and administrative staff		
Sh. Dayal Singh	Training on ToT on "Biodiversity governance"	HIPA, Fiarlawn Shimla Mar. 11
Kushaldeep Kaur Sodhi	LQMS & Internal audit as per IS/ISO/IEC17025:2017	Bureau of Indian Standards, Noida June 25-28
Mangat Ram	*e*-Office	ICAR-CPRI, Shimla Sept. 11-12
Bhatta Ram	Farm management	ICAR-IIFSR Modipuram, Meerut Sept. 17-23

Name of employee	Title of training programme	Place and Period
Radha Rani, P Suleman	*e*-office	ICAR-NAARM, Hyderabad Dec. 5-6
Bharat Lal Meena	Farm management	ICAR-IIFSR Modipuram, Meerut Sept. 17-23
Ranjit Singh Brahma Prakash	Auto mobile maintenance & road safety	ICAR-CIAE Bhopal Sept. 24-30
Balwant Singh Ravinder Kumar	Auto mobile maintenance & road safety	ICAR-CIAE Bhopal July 26-Aug. 1
Khushvinder Kumar	Auto mobile maintenance & road safety	ICAR-CIAE Bhopal Nov. 27-Dec. 3
Sangeeta Gambhir Yashoda Rani	Administrative and finance management	ICAR- NAARM, Hyderabad (Off-campus at ICAR-CIFT, Cochin) June 13-17
UC Sati	Capacity building programme towards a secure and resilient workplace	ICAR-CPRI, Shimla Nov. 25-27
Hemant Ankur	Public procurement	NIFM, Faridabad Nov. 18-23
Mahesh Kumar	Assets management	ICAR-IARI, New Delhi Nov. 6-8

19.3 Capacity building

19.3.1 Deputations abroad

- **Sunil Archak** attended the "Informal Consultation on the Enhancement of the Functioning of the Multilateral System of Access and Benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture" held at San José, Costa Rica, on Jan. 14-15, 2019.

- **Sunil Archak** attended the "Informal Consultation on the Enhancement of the Functioning of the Multilateral System of Access and Benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture" on Mar. 25-27, 2019 at Ethiopia.

- **Pratibha Brahmi** attended the community of practice workshop on the Nagoya Protocol for European, CIS, Arab and Asian countries organized by the UNDP-GEF Global ABS Project "Strengthening human resources, legal frameworks, and institutional capacities to implement the Nagoya Protocol" from 9-12 April, 2019 at Istanbul, Turkey.

- **B Sarath Babu** participated in the CGIAR Germplasm Health Workshop – 2019 organised at ICARDA, Morocco from April 29 to May 3 2019. He also made a brief presentation on Issues related to safe exchange of germplasm with CGIAR centres at National and Global platforms.

- **Kuldeep Tripathi** received travel grant award and attended Third Jack R Harlan International Symposium at SupAgro, Montpellier, France and presented a paper on "Harnessing genetic diversity of Indian lentil collections for discovery of trait specific germplasm" during June 3-7, 2019.

- **Sunil Archak** participated in the 9th Meeting of the Ad Hoc open-ended working group to enhance the functioning of the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture at FAO, Rome from June 17-21, 2019.

- **SC Dubey** and **Kavita Gupta** participated in the 5th APSA Expert Consultation on Phytosanitary Issues from Aug. 28-29, 2019 at Bangkok, Thailand.

- **SP Ahlawat** visited Tashkent State Agricultural University (TSAU), Tashkent, Uzbekistan during Sept. 25-26 2019 for 'International scientific and practical conference on 'Innovation in use of agrobiodiversity for sustainable agriculture development'. Institutes visited were Uzbek Research Institute of Horticulture, Viticulture & Winemaking (URIHVW) at Samarkand and Institute of Horticulture, Viticulture & Winemaking.

- **Gurinderjit Randhawa** and **Monika Singh** visited Brussels (Belgium) from 30 Sep – 13 Oct 2019 under DST-BELSPO Indo-Belgium Collaborative Project - "Belgian-Indian Networking in the field of the GMO research and analysis". The visit comprised of:

  (i) Exchange visit for Bench-learning to Sciensano (Belgium collaborating partner) on application of Next Generation Sequencing/ Nanopore Sequencing for detection of unauthorized GMOs in a collaborative research mode.

  (ii) Participation in the workshop organized at Sciensano on 10 Oct 2019 with focus on the development and validation of new cost-efficient methods from GMO detection. Dr. GJ Randhawa delivered two invited talks on "Regulation and approvals of genetically modified (GM) crops in India and Asia" and "GMO detection activities in India", and Dr. M Singh on "Development of cost- and time-efficient GMO detection tools".

  (iii) Participation in the Scientific Session of the Open Science Day of the 30th European Network of the GMO Laboratories (ENGL) Meeting held on Oct. 2, 2019. Dr. GJ Randhawa participated as invited speaker and Dr. M Singh as technical expert.

- **Sherry Rachel Jacob** attended an Expert Consultation meeting on Global Conservation Strategies, held at the Crop Trust office in Bonn, Germany during Oct. 14-15, 2019.

- **Rashmi Yadav** participated in 3rd Tropical Agriculture Conference (TropAg 2019) at Brisbane, Australia from Nov. 11-13, 2019.

- **Kuldeep Singh** and **Sunil Archak** participated in 8th session of governing body meeting of ITPGRFA, Rome from Nov. 11-16, 2019.

- **Rashmi Yadav** attended Brassica Group Meet at University of Western Australia, Perth, Australia from Nov. 15-16, 2019.

- **Vartika Srivastava** received visiting scholar grant to undertook training on 'Cryopreservation of tropical crop species' at Laboratory of Tropical Crop Improvement, KU Leuven, Belgium, Nov. 25 to Dec. 23, 2019.

- **Sandhya Gupta** participated and presented oral paper in the first International Symposium on Botanical Gardens & Landscapes (BGL 2019)', Bangkok, Thailand, Dec. 2-4, 2019.

- **Chitra Devi Pandey** attended the expert consultation workshop on "Global Conservation Strategy for crops in the *Cucurbitaceae* family" at World Vegetable Center for East and Southeast Asia, Research & Training Station, Kasetsart University, Kamphaeng Saen Campus,Nakhon Pathom, Thailand during Dec. 11-13, 2019.

19.3.2 Participation in seminars / conferences / symposia / workshops / meetings

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Anitha Kodaru	Academic council meeting of NIPHM	Krishi Bhavan, New Delhi, Jan. 3
B Sarath Babu, K Anitha, Kamala Venkateswaran, N Sivaraj, SR Pandravada, K Rameash	Sorghum field day	ICAR-IIMR, Hyderabad, Jan. 7
N Sivaraj	Meeting of local ICAR institutes, officials of agricultural universities and other institutes to formulate action plan for *Rythu Sadbhavana Yatra* in Andhra Pradesh.	ICAR-IIRR, Hyderabad, Jan. 12
Sunil Archak	First informal meeting by the Co-chairs of the ad hoc open-ended working group on the 'Enhancement of the Multilateral System of Access and Benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture'.	San José, Costa Rica, Jan. 14-15
Anitha Kodaru, VC Chalam, Kavita Gupta, Z Khan, BH Gawade	Inception workshop of network project on genetic enhancement of minor pulses organized by ICAR-NBPGR, New Delhi	ICAR-NBPGR, New Delhi, Jan. 15
N Sivaraj	National level multidisciplinary conference.	Chennai, Tamil Nadu, Jan. 19-20
M Latha	Biodiversity congress	Thalassery, Kannur, Kerala, Jan. 26-28
Sushil Pandey	National seminar on 'Strengthening of seed systems in North Eastern & Unreached regions – problems, prospects and policies'	Imphal, Manipur, Feb. 3-5
A Suma	XVIIth Scientific Advisory Committee meeting of KVK Thrissur	KVK Thrissur, Feb. 5
Vandana Tyagi	Indo-German seed project planning workshop under the project Indo-German cooperation on seed sector development	Hyderabad, Feb. 6-7
Ruchira Pandey	International symposium on edible *Alliums*: Challenges and opportunities	Pune, Maharashtra, Feb. 9-12
Pratibha Brahmi, S Nivedhitha, S. Rajkumar, Rashmi Yadav, M Latha	International symposium on 'Development of drylands- Converting dryland areas from grey into green'	ICAR-CAZRI, Jodhpur, Rajasthan, Feb. 11-14
Mamta Arya	Monitoring of *Rabi* crop trials under AICRNPC	Pasighat (Arunachal Pradesh), Feb. 12-15
Anuradha Agrawal	Satellite symposium on 'Dryland agrobiodiversity for adaptation to climate change'	Jodhpur, Rajasthan, Feb. 13
Pratibha Brahmi	7th workshop of the project evaluation of stress tolerant orphan legumes for dryland farming system across Sub-Saharan Africa and India"	CAZRI Jodhpur, Feb. 14
Veena Gupta	Institutional Variety Release Committee of CSIR-NBRI as Chairperson	CSIR-NBRI, Feb.14, and Dec. 6

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Anitha Kodaru	Brainstorming session, 'Certificate course in plant biosecurity (Massive open online course)'	NIPHM, Hyderabad, Feb. 13
B Sarath Babu	National convention on 'Revitalising rainfed agriculture'	New Delhi, Feb. 14-15
Gowthami R	International conference on 'Medicinal, aromatic and nutraceutical plants from mountainous areas' 9th Annual conference of the American Council for Medicinally Active Plants	Dehradun, Uttarakhand, Feb. 14-16
Archana P Raina, BH Gawade, KC Bhatt, Pardeep Kumar, Sandhya Gupta, Sangita Bansal, Vartika Srivastava Era Vaidya Malhotra	14th Agricultural science congress on 'Innovations for agricultural transformation'	NAS Complex, New Delhi February 20-24
V Celia Chalam	National symposium on 'Recent challenges and opportunities in sustainable plant health management'	Banaras Hindu University, Varanasi, Feb. 26-28
KM Rai	Annual progress meeting of NASF project as CCPI of project	NASC complex, Pusa Campus, New Delhi, March 6
Sushil Pandey	30th Annual group meeting of AICRP on small millets	Birsa Agricultural University, Ranchi, March 7-8
Joseph John K, K Pradheep, A Suma	Wayanad Seed Fest and National Seminar	Kalpetta, Wayanad, March 7-9
Mamta Arya	Interaction meeting with young scientists of small research stations/regional stations of ICAR for developing institutionalized system of mentoring'	KAB-II, New Delhi, March 8
Rashmi Yadav	Indian Seed Congress 2019: Seeds for sustainability	Hyderabad, March 11-12
B Sarath Babu	Workshop on ZBNF seed systems with all stakeholders and technical advisers at RySS (Rythu Sadhikara Sanstha),	Guntur, AP, March 14
Sushil Pandey	54th Annual group meeting of ICAR-AICRP on pearl millet	ICAR-IARI, New Delhi, March 15-17
Veena Gupta	DPC of Assistant Director (Botany), as subject matter expert	CCRUM, Ministry of Ayush, March 18
Vartika Srivastava	Workshop on KRISHI PORTAL	IASRI, New Delhi, March 18-19
Sunil Archak	Second informal meeting by the Co-chairs of the Ad Hoc open-ended working group on the 'Enhancement of the Multilateral System of Access and Benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture'.	Addis Ababa, Ethiopia, March 25-27
N Sivaraj	Meeting on 'North East Region Banana Project'.	ICAR-NRCB, Tiruchirapalli, March 22
Mamta Arya	Monitoring of *Rabi* crop trials under AICRNPC	Ranichauri (Uttarakhand), March 28
B Sarath Babu	RAC meeting of APSSRDI	Hindupur, April, 3
Anuradha Agrawal	Peer review meeting on 'Biotechnology (for input in agricultural policies and action-plans for a secure and sustainable agriculture)'	NIPGR, New Delhi, April 4

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Anuradha Agrawal	3rd meeting of 'Agricultural policies and action-plans for a secure and sustainable agriculture'	Vigyan Bhavan Annexe, New Delhi, April 5
V Celia Chalam	Italian research day with the theme 'Sustainability of Italian agriculture: a bridge between tradition and innovation	Italian Cultural Institute, New Delhi, April 15
Rashmi Yadav, Kuldeep Tripathi	Workshop on 'ABD index and ecosystem services - overview of methodologies and indicators'	NASC Complex, April 15-16
DR Pani	73rd Foundation day celebration" of ICAR-NRRI Cuttack	ICAR-NRRI Cuttack, April 29
Joseph John K	Mango On-farm diversity appreciation day	Kannapuram, Kannur, Kerala, May 1
Anuradha Agrawal	Review meeting of 'Technical Expert Committee on Agriculture Biotechnology and Allied Sciences for NER'	DBT NER, New Delhi, May 2
Pardeep Kumar, MK Rana, VC Chalam	Launching of National Genomics and Genotyping Facility (NGGF) and Symposium on "Genomics in plant breeding and varietal identification"	NIPGR, New Delhi, May 4
V Celia Chalam	14th IPVE International plant virus epidemiology symposium	Seoul, Republic of Korea, May 13-17
Joseph John K	TOLIC meeting	Hotel Asoka Inn, Thrissur, May 15
Suma A	Expert committee meeting of KSBB	Thycaud, Thiruvananthapuram, May 15
B Sarath Babu, N Sivaraj	Workshop on 'Re-framing seed systems in Andhra Pradesh'	Agriculture Commissionerate, Chuttugunta, Guntur, May 21
S R Pandravada, B SarathBabu, N Sivaraj	International Day for Biodiversity	Bhavanipuram, Vijayawada, May 22
B Sarath Babu, N Sivaraj	Second cross-sectoral workshop (Focus Group Discussions) by mainstreaming biodiversity concerns into AP State Biodiversity Strategic Action Plan (SBSAP)	Vijayawada, May 22
Jyoti Kumari, Gayacharan, Kuldeep Tripathi, KK Gangopadhyay, Ruchi Bansal, Ashok Kumar	Consortium Research Platform on Agrobiodiversity Workshop	ICAR-NBPGR, New Delhi, May 23
VK Sharma	Intentional conference on 'Innovative horticulture and value chain management'	GBPUAT, Pantnagar, Uttarakhand, May 28-31
Joseph John K	KSBB meeting for evaluation of documents for KSBB awards	Thiruvananthapuram, May 29
DR Pani, Ruchi Bansal	54th Annual AICRIP meeting and rice workshop	ICAR-NRRI, Cuttack, May 30 -June 2

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
B Sarath Babu, SK Chakrabarty, Anitha Kodaru, SR Pandravada, Pratibha Brahmi, N Sivaraj, Kamala Venkateswaran, Kavita Gupta, Prasanna Holajjer, Pranusha P, Babu Abraham	Access and Benefit Sharing (ABS) implementation for R & D organizations in India	NBPGR, RS, Hyderabad, June 15
Sunil Archak	Ninth meeting of the Ad Hoc Open-ended working group to enhance the functioning of the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture.	Rome, June 16-21
Veena Gupta	World Day to combat desertification organized by Ministry of Environment, Forests and Climate Change	Vigyan Bhawan, June 17
Anuradha Agrawal	Peer review meeting on horticulture (for input in Agricultural policies and action-plans for a secure and sustainable agriculture)	TAAS, New Delhi, June 17
BH Gawade, Kartar Singh, Mamta Arya, Mohar Singh, MC Singh, SK Kaushik, SK Yadav, MC Singh, SP Singh, Sandeep Kumar, HL Raiger, Kuldeep Singh, Rahul Chandora	Brain storming meeting on "Improvement of potential crops and development of value chain" organised by AICRN on Potential Crops, ICAR-NBPGR, New Delhi	NAS Complex, New Delhi, June 20
Kuldeep Singh, SP Singh, Mohar Singh, Mool Chand Singh, SK Kaushik, SK Yadav, Sandeep Kumar, Raiger HL, Rahul Chandora	XXIX Group meet of All India Coordinated Research Network on Potential Crops	NASC Complex, New Delhi, June 21
Chitra Devi Pandey, KM Rai	X^{th} annual group meeting of All India Network Research Project on Onion and Garlic	ICAR-IARI, New Delhi, May 31-June 2
B Sarath Babu	32^{nd} International Seed Testing Association Congress	Hyderabad, Jun. 26 - July 3
Anuradha Agrawal	Refresher Course in Life Sciences	CPDHE, UGC-HRDC, University of Delhi, July 2
Kavita Gupta	Brainstorming session on "Trait discovery in wheat using genomics approaches"	ICAR-NBPGR, New Delhi, July 6,

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Archana P Raina	Meeting on 'Expert Consultation on Metabolomics: Exploring the System Biology approach in Agricultural Sciences' organized by ICAR-NRC Grapes, Pune and ICAR-CIFT, Cochin	NASC Complex, New Delhi, July 8
SK Raina	State level committee meeting on 'Agriculture and allied sectors in Jammu & Kashmir'	SKUAST, Jammu, July 12
N Sivaraj	ICFRE-Regional Research Conference for Identification of Research Needs	Telangana State Forest Academy, Dulapally, Hyderabad, Jul. 17
T Boopathi	International Conference on 'Plant Protection in Horticulture (ICPPH2019)' organized by Association for Advancement of Pest Management in Horticultural Ecosystems	ICAR-IIHR, Bengaluru, Karnataka July 24-27
Sunil Archak	Consultation meeting on 'Digital Sequence Information' organized by MoEFCC.	New Delhi, July 30
B Sarath Babu, N Sivaraj	Workshop on 'Interfacing Farmer's Science with Formal Science' (Seeds, Soil and Culture)	Deccan Development Society and CESS, Hyderabad, July 31
DP Semwal, S Nivedhitha, Lalit Arya, Manjusha Verma, Monika Singh	1st National Conference on 'Neglected and underutilized crop species for food, nutrition, energy and environment'	NIPGR, New Delhi, Aug 2
Dinesh Chand	XXVth Regional Committee No. VII Meeting	ICAR-NBSSLUP, Nagpur, Aug. 9– 10
KC Bhatt, RS Rathi	Workshop of UN Environment implemented GEF Project on 'Mainstreaming agro-biodiversity conservation and utilization in the agricultural sector to endure ecosystem services and reduce vulnerability'	ICAR-NBPGR, New Delhi, Aug. 19-21
Jyoti Kumari, Sherry Rachel	58th 'All India wheat & barley research workers' meet	IARI-RS, Indore, Aug. 24-26
B Sarath Babu	Interface meeting on 'Protection of plant varieties and farmers' rights authority with seed sector'	PJTSAU, Hyderabad, Aug. 26
DP Semwal	ESRI India user conference on 'GIS-Creating Vision for a New India'	Gurugram, Haryana, Aug. 28-29
B Sarath Babu	Research Advisory Committee meeting of the CSGRC	Hosur, Karnataka, Aug. 29
Anjali Kak Koul	National Group meet on 'Forage Crops Rabi -2019-20'	CAU, Imphal, Manipur Aug. 30-31
Mamta Arya, KM Rai	Training workshop on 'Value Chain Development for Heirloom Crops and Varieties'	ICAR-NBPGR, New Delhi, August 19-21
B Sarath Babu	5th Foundation day of Professor Jaya Shankar Telangana State Agriculture University	PJTSAU, Hyderabad, Sept. 3
SP Ahlawat, GD, Subarna Hajong, Mohar Singh, Rahul Chandora	14th International symposium on 'Buckwheat (Diversifying food systems for health and nutritional security)'	NEHU, Shillong, Sept. 3-6 Harish
Joseph John K	26th ICAR Regional Committee Zone VIII meeting	ICAR-IIHR, Bengaluru, Sept. 6-7
Vandana Tyagi	Water management and governance: Innovation for a secure future	Ambedkar Bhawan, New Delhi, Sept. 10

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Kuldeep Tripathi	Annual group meet on rabi pulses of AICRP on MULLaRP crops	CAU, Imphal Sept. 12-13
Prasanna Holajjer	Expert member for conducting skill test for the post of Lab Attendant.	NIPHM, Hyderabad, Sept. 16
Anitha Kodaru	Scrutiny committee meeting to scrutinize the applications received for the post of Assistant Director (Plant Protection).	NIPHM, Hyderabad, Sept. 23
B Sarath Babu, Anitha Kodaru	Brainstorming Session –Pest Free Areas	NIPHM, Hyderabad, Sept. 26
Gurinderjit Randhawa, Monika Singh	Open Science Day, 30th European Network of the GMO Laboratories (ENGL) Plenary meeting	Joint Research Centre (JRC), Ispra, Italy, Oct. 2
Sunil Archak	Asia regional preparatory meeting for the eighth session of the governing body of the International Treaty on Plant Genetic Resources for Food and Agriculture	New Delhi, Oct. 8-10
Gurinderjit Randhawa, Monika Singh	Workshop on 'GMO regulation and detection in European and Asian context', supported by BELSPO programme "Support for Networking Activities with India"	Sciensano, Brussels, Belgium, Oct. 10
Sunil Gomashe	Monitoring of sorghum germplasm under CRP on Agro-Biodiversity	Sorghum Research Unit, Dr. PDKV, Akola, Oct. 10
K Pradheep	Regional workshop on "Enriching custodian farmers with PPV& FRA Act to safeguard valued genetic resources towards green prosperity	ICAR-CTCRI, Thiruvanathapuram, Oct. 10-11
Chitra Devi Pandey, VC Chalam, Sushil Pandey, SK Yadav	10th National Seed Congress on "Quality seeds for farmers' prosperity"	ICAR-IARI, Pusa, New Delhi Oct. 14 -16
Monika Singh, Sandhya Gupta, Sangita Bansal, Vartika Srivastava, Era Vaidya Malhotra	5th International conference on 'Plant Genetics & Genomics: Germplasm to Genome Engineering'	NASC, New Delhi, Oct. 17-18
N Sivaraj	DBT-NER banana project review meeting.	New Delhi, Oct. 18-19
Meena Shekhar	International conference on "Global research initiatives for sustainable agriculture and allied sciences" organized by Astha Foundation, Meerut, Uttar Pradesh, India	ICAR-NAARM, Hyderabad, Oct. 20-22
B Sarath Babu	Youth as Torch Bearers of Business oriented Agriculture in South India	PJTSAU, Hyderabad, Oct. 21-22
Jameel Akhtar, BH Gawade, Chitra Devi Pandey, Anjali Kak Koul	Field day on 'Cowpea' organized by Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi	ICAR-NBPGR Research Farm, Issapur, Oct. 22
Mukesh Kumar Rana	Meeting of Indo-German cooperation on seed sector development	NASC, New Delhi, Oct. 24
Sunil Archak	Resumed ninth meeting of the Ad Hoc open-ended working group to enhance the functioning of the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture.	Rome, Oct. 24-26
B Sarath Babu, K Anitha, Kamala Venkateswaran	Blackgram germplasm field day	AVRDC farm, ICRISAT campus, Oct. 25

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
K Pradheep	Thematic consultation on 'Biodiversity, Agriculture and Nutritional Security'	Royal Orchid Resort & Convention Centre, Bengaluru, Oct. 29
Veena Gupta	Monitoring Committee meeting of Maharashtra Genebank	Indian institute of Science Education and Research at Pashan, Pune, Nov. 5
SC Dubey, V Celia Chalam, Kavita Gupta, B Sarath Babu, Anitha Kodaru, Prasanna Holajjer	XIX International Plant Protection Congress (IPPC2019)	Hyderabad International Convention Centre, Hyderabad, Nov. 10-14
K Pradheep	Modern trends in biosystematics of angiosperms and 29th Annual Conference of Indian Association for Angiosperm Taxonomy	Jawaharlal Nehru Tropical Botanical Garden and Research Institute, Palode, Kerala, Nov. 11-13
Sunil Archak	Eighth session of the governing body of the International Treaty on Plant Genetic Resources for Food and Agriculture	Rome, Nov. 11-16
B Sarath Babu, Anitha Kodaru, SK Chakrabarty, Kamala Venkateswaran, Prasanna Holajjer	Interactive meeting on the development of a project on millets	ICAR-IIMR, Hyderabad, Nov. 21
Ruchi Bansal	India-Australia International Education and Research Workshop	Dr Ambedker International Centre, New Delhi, Nov. 22
Sunil S Gomashe	International conference on 'Modern agriculture approaches in 21st Century'	Department of Social Work, University of Lucknow, Nov. 22-23.
Anitha Kodaru	Scrutiny committee for scrutiny of the applications received for the post of Asst. Scientific Officer (Entomology) on Direct/ Deputation Basis	NIPHM, Hyderabad, Nov. 29
Zakaullah Khan, Jameel Akhtar, Pardeep Kumar	International conference on 'Global perspective in agricultural and applied sciences for food and environmental security (GAAFES-2019)'	Kumaun University, Nainital, UK, Dec. 01-02
Era Vaidya Malhotra, Sangita Bansal, SK Yadav	International conference and global meet on science and technology (GMST 2019) for ensuring food and nutritional security	ICAR- NRC Seed Spices Ajmer, Dec. 01–03
Sandhya Gupta	First International symposium on 'Botanical gardens and landscapes (BGL 2019)'	Bangkok, Thailand, Dec. 2-4
Suma A	National Seminar on 'Forestry, plant genetics and improvement'	Kerala Forest Research Institute, Thrissur, Kerala, Dec. 3-4
DR Pani	INSPIRE 2.0 on 'Confluences of Rice Ecosystem Stakeholders for popularizing ICAR/ SAU Technologies in Odisha'	ICAR-NRRI, Cuttack, Dec. 6
Sandhya Gupta	Progressive horticulture conclave (PHC-2019) on 'Futuristic Technologies in Horticulture'	ICAR-IISR, Lucknow, Dec. 8-10
Mamta Arya, Rahul Chandora	II NPSC meeting of UNEP-GEF project 'Mainstreaming agricultural biodiversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability'	NASC Complex, New Delhi, Dec. 11-12th Dec'

Name	Title of seminars / conferences / symposia / workshops / meetings	Place and Period
Kuldeep Singh, B Sarath Babu	Programme of 'Audit visit of EU Experts for European Union Seed Equivalence in India	GMO, Lam Farm, Guntur, Dec. 16-17
Dinesh Chand, Smita Karale	Town Official Language Implementation Committee (TOLIC), Akola half yearly meeting	Hotel Central Plaza, Akola, Dec. 18
Meena Shekhar	National Conference on 'Climate change and agriculture: Impacts, resilience & adaptations for sustainable food security' organized by International Development Centre Foundation, Vasundahara, Ghaziabad	India International Centre, New Delhi Dec. 20-21
SC Dubey, V Celia Chalam, Jameel Akhtar, Pardeep Kumar	Annual zonal meeting and national symposium on 'Bio-intensive approaches for crop diseases management' organized by Indian Phytopathological Society (Delhi Zone)	ICAR-IARI, New Delhi, Dec. 21
SC Dubey, Jameel Akhtar, BH Gawade, Anjali Kak Koul, Neeta Singh	Brainstorming on 'Enhancing the productivity and quality of dual-purpose legumes in dryland areas using integrated genetic and genomic approaches' jointly organized by ICAR-NBPGR, New Delhi and ICAR-IGFRI, Jhansi	ICAR-NBPGR, New Delhi, Dec. 24
Mohar Singh	Annual review meeting of DST funded project "Mainstreaming of farmer varieties in Uttarakhand & Himachal Pradesh"	Wildlife Institute of India, Dehradun, Dec. 27
B Sarath Babu	4th Foundation day of ICAR- IIRR	ICAR-IIRR, Hyderabad, Dec. 27
Sheikh M Sultan	13th Institute Management Committee Meeting of ICAR-CITH Srinagar as member of IMC of ICAR-CITH	ICAR-CITH Srinagar, Dec. 28 -29

GENERAL INFORMATION 20

Summary: In total, 119 scientific, 72 technical, 43 administrative/finance and 53 supporting staff personnel were in position at ICAR- NBPGR including regional stations, as on December 31. During the year, 4 promotions, 01 transfers and 11 retirements were effected across all staff categories. The scientific staff were bestowed with 17 awards. Dissemination of research outputs in the form of peer-reviewed research articles (121), books (08), book chapters/ manual chapters (84), popular articles (14), TV talks (07), reports (03), training manuals (07), and e- publications (04). As a part of outreach activities, the institute organized 05 field days and 10 PGR awareness-cum- biodiversity fair programmes.

20.1 Institute management committee (IMC)

The Director, ICAR-NBPGR, Pusa Campus, New Delhi-110012	Chairman
The Director (Agri.), Delhi Government, 5/9 Under Hill Road, Delhi-54	Member
The Director (Agri.), Dte. of Agriculture, Haryana Krishi Bhawan, Sector-21, Panchkula, Haryana-134112	Member
The Head, Plant Pathology Division, ICAR-IARI, New Delhi-12	Member
Dr. R C. Bhattacharya, Principal Scientist, ICAR- NIPB, New Delhi-110012	Member
Dr. B. S. Dwivedi, Head, Division of Soil Sciences and Agril. Chemistry, ICAR-IARI, New Delhi-110012	Member
Dr. Ratan Tiwari, Principal Scientist, ICAR-IIWBR, Karnal Haryana	Member
Dr. P. K. Singh, Principal Scientist, NBAGR, Karnal	Member
Sh. Mukesh Maan, Village Alipur, Narela, Delhi	Member
Sh. Sanjay Maruti Patil, BAIF Office, Amrai Campus, Jauhar, District Palghar, Maharashtra	Member
The ADG (Seed), ICAR, Krishi Bhawan, New Delhi-110001	Member
The Comptroller, ICAR-IARI, New Delhi-110012	Member
The Sr. Admn. Officer ICAR-NBPGR, New Delhi-110012	Member Secretary

20.2 Research advisory committee (RAC)

Dr SK Sharma, Ex-Vice-Chancellor, CSK-HPKV, Palampur, Himachal Pradesh	Chairman
Dr. Sujata Arora, Advisor, Ministry of Environment, Forest & Climate Change, New Delhi	Member
Dr Pritam Kalia, Emeritus Scientist, ICAR-IARI, New Delhi	Member
Dr DK Yadava, ADG (Seed) acting, ICAR, New Delhi	Member
Dr SR Yadav, Emeritus Scientist, Professor, Dept of Botany, Shivaji Univ. Kolhapur, Kolhapur, Maharastra	Member
Dr SR Bhat, Emeritus Scientist, NRCPB, ICAR-IARI, New Delhi	Member
Dr VV Ramamurthy, Emeritus Scientist, ICAR-IARI, New Delhi	Member
Dr Kuldeep Singh, Director, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr SC Dubey, Principal Scientist & Head DPQ, ICAR-NBPGR, New Delhi	Member Secretary

The XXI meeting of the RAC of ICAR-NBPGR was held on 15-16th July, 2019 at New Delhi under the Chairmanship of Dr SK Sharma, EX-Vice-Chancellor, CSK-HPKV, Palampur. The members of RAC provided general and division specific recommendations.

20.3 Institute research council (IRC)

The 30th Institute Research Council (IRC) meeting from 17th-19th July, 2019 was held under the Chairmanship of Dr Kuldeep Singh, Director, ICAR-NBPGR with Dr. Sushil Pandey as Member secretary. The Principal Investigators / OICs / scientists of the respective regional stations presented the progress report of the institute projects operational at headquarters and various regional stations / base centres. HoDs and OICs of units / RS / BC made the presentations followed by the PIs of the respective projects.

20.4 Institute joint staff council (IJSC)

Elected members of IJSC for different categories: Technical Staff: Sh Satya Prakash (Secretary, Staff Side) and Sh Braham Prakash (TO); Administrative staff: Mr Yogesh Kumar (Assistant); Skilled Supporting Staff: Sh Yatish Chandra and Sh Braham Dev Paswan. Office side members were: Dr. Rakesh Bhardwaj, Dr. S.P. Ahlawat, Dr. Anuradha Aggarwal, Dr. Amit Kumar Singh and Sr.AO.

20.5 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 Sushil Pandey	IRC member secretary
Dr Rakesh Bhardwaj	Nodal officer Krishi Portal

PME cell coordinated all scientific activities such as project proposals (8), manuscripts (48)/ abstracts (95); training/ fellowship proposals (38) etc. as per the ICAR guidelines. It also 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 (target and achievements), half-yearly (progress report of scientists), other agenda items and ATRs for Director's conference and the regional committee meetings. Also, inputs for various documents/issues/reports of CGIAR projects/foreign-aided projects/parliament questions/audit paras, or any such information as and when required for the council/ any other agencies.

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 2019-20 was prepared based on the training needs assessment and submitted to the Council. During the reporting period, fourteen scientists and three technical staff have attended different training programmes and the same is being updated regularly in the ICAR-ERP System as per Council's guidelines. The information on HRD activities was compiled in the form of six-monthly report, annual report, impact assessment proformae etc. and submitted to the ADG (HRM).

KRISHI Portal

Knowledge based Resource Information Systems Hub for Innovations in agriculture (KRISHI) is an initiative of ICAR to gather its knowledge resources at one place for all stakeholders. The portal has been developed as a centralized data repository system of ICAR consisting of technology, data generated through experiments/surveys/observational studies, geo-spatial data, publications, learning resources, etc. Safe transfer of raw experimental data in electronic form was ensured on transfer and superannuation of scientists working at ICAR-NBPGR.

20.6 Personnel

The list of staff at NBPGR is provided herewith. It is not a documentary proof of seniority.

(i). Scientific staff in position as on 31st December 2019

S. No.	Name	Designation	Discipline
1	Dr. Kuldeep Singh	Director	Genetics & Plant Breeding
	PLANT EXPLORATION & GERMPLASM COLLECTION DIVISION		
2	Dr. Sudhir Pal Ahlawat	Head	Plant Breeding
3	Dr. Anjula Pandey	Principal Scientist	Economic Botany
4	Dr. K.C. Bhatt	Principal Scientist	Economic Botany
5	Dr. Dinesh Prasad Semwal	Principal Scientist	Economic Botany
6	Dr. Ranbir Singh Rathi	Principal Scientist	Economic Botany
7	Sh. Soyimchiten	Scientist	Horticulture (Fruit Science)
8	Nivedhitha	Scientist	Economic Botany & PGR
9	Sh. Pavan Kumar Malav	Scientist	Economic Botany & PGR
10	Sh. Ravi Kishore Pamarthi	Scientist	Economic Botany & PGR
	AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT		
11	Dr. Sunil Archak	National Fellow & Incharge, Principal Scientist	Biotechnology
12	Madhu Bala Priyadrashi	Senior Scientist (SS)	Computer Application
	UU & UEP		
13	Dr. S.K. Kaushik	Principal Scientist	Genetics & Plant Breeding
14	Dr. Vinay Mahajan	Principal Scientist	Genetics & Plant Breeding
15	Dr. Hanuman Lal Raiger	Principal Scientist	Agril. Statistics
	GERMPLASM EXCHANGE AND POLICY UNIT		
16	Dr. Pratibha Brahmi	Incharge	Economic Botany
17	Dr. Vandana Tyagi	Principal Scientist	Economic Botany
18	Dr. S.K. Yadav	Principal Scientist	Horticulture
19	Dr. Pragya	Principal Scientist	Horticulture
	GERMPLASM EVALUATION DIVISION		
20	Dr. Ashok Kumar	Principal Scientist & Head (Act.)	Plant Breeding
21	Dr. K.K. Gangopadhyay	Principal Scientist	Horticulture
22	Dr. Archana P. Raina	Principal Scientist	Biochemistry (Plant Science)
23	Dr. Rakesh Bhardwaj	Principal Scientist	Biochemistry
24	Dr. Sandeep Kumar	Principal Scientist	Biochemistry
25	Dr. Jyoti Kumari	Principal Scientist	Plant Breeding
26	Dr. Rashmi Yadav	Principal Scientist	Agronomy
27	Dr. Ishwar Singh	Principal Scientist	Agronomy

S. No.	Name	Designation	Discipline
28	Dr. Vinod Kumar Sharma	Principal Scientist	Plant Breeding
29	Dr. Raj Kumar Gautam	Principal Scientist	Plant Breeding
30	Dr. K.S. Hooda	Principal Scientist	Plant Pathology
31	Dr. Vikender Kaur	Scientist	Economic Botany
32	Dr. Gayacharan	Scientist	Agril. Biotechnology
33	Dr. Ruchi Bansal	Scientist	Plant Physiology
34	Dr. Kuldeep Tripathi	Scientist	Economic Botany & PGR
35	Dr. Vijay Singh Meena	Scientist	Horticulture-Fruit Science
36	Dr. Mamta Singh	Scientist	Genetics & Plant Breeding
37	Sh. Nand Lal Meena	Scientist	Biochemistry
38	Dr. Sapna	Scientist	Biochemistry
39	Sh. Rakesh Srivastava	Sr. Scientist	Horticulture
	GERMPLASM CONSERVATION DIVISION		
40	Dr. Veena Gupta	Principal Scientist & Head (Act.)	Economic Botany
41	Dr. Neeta Singh	Principal Scientist	Plant Physiology
42	Dr. J. Radhamani	Principal Scientist	Plant Physiology
43	Dr. Anjali Kak Koul	Principal Scientist	Economic Botany
44	Dr. Chithra Devi Pandey	Principal Scientist	Seed Science & Technology
45	Dr. Sushil Pandey	Principal Scientist	Seed Science & Technology
46	Dr. Sherry Rachel Jacob	Senior Scientist	Seed Science & Technology
47	Dr. Vimla Devi	Senior Scientist	Genetics & Plant Breeding
48	Sh. J. Aravind	Scientist	Plant Genetics
49	Dr. Padmavati G. Gore	Scientist	Economic Botany & PGR
	PLANT QUARANTINE DIVISION		
50	Dr. S.C. Dubey	Head	Plant Pathology
51	Dr. V. Celia Chalam	Principal Scientist	Plant Pathology
52	Dr. Kavita Gupta	Principal Scientist	Agril. Entomology
53	Dr. Moolchand Singh	Principal Scientist	Agronomy
54	Dr. Zakaullah Khan	Principal Scientist	Nematology
55	Dr. Jameel Akhtar	Principal Scientist	Plant Pathology
56	Dr. Surendra Pal Singh	Principal Scientist	Agril. Entomology
57	Dr. Boopathi T.	Senior Scientist	Agricultural Entomology
58	Dr. Gawade Bharat Hanamant	Scientist	Plant Nematology
59	Dr. Pardeep Kumar	Scientist	Agril. Biotechnology
60	Raj Kiran	Scientist	Plant Pathology
61	Pooja Kumari	Scientist	Plant Pathology

S. No.	Name	Designation	Discipline
	TISSUE CULTURE AND CRYPRESERVATION UNIT		
62	Dr. Anuradha Agrawal	Principal Scientist & Incharge	Economic Botany
63	Dr. Rekha Chaudhury	Principal Scientist	Economic Botany
64	Dr. Sangita Bansal	Principal Scientist	Agricultural Biotechnology
65	Dr. Ruchira Pandey	Principal Scientist	Economic Botany
66	Dr. Neelam Sharma	Principal Scientist	Economic Botany
67	Dr. Sandhya Gupta	Principal Scientist	Economic Botany
68	Dr. Vartika Srivastava	Scientist	Fruit Sciences
69	Dr. Gowthami R.	Scientist	Genetics & Plant Breeding
70	Dr. Era Vaidya Malhotra	Scientist	Agricultural Biotechnology
	DIVISION OF GENOMIC RESOURCES		
71	Dr. Gurinderjit Randhawa	Principal Scientist & Incharge	Plant Physiology
72	Dr. Soma Sunder Marla	Principal Scientist	Biotechnology
73	Dr. M.C. Yadav	Principal Scientist	Genetics / Cytogenetics
74	Dr. Mukesh Kumar Rana	Principal Scientist	Plant Breeding
75	Dr. Rakesh Singh	Principal Scientist	Biotechnology
76	Dr. Ambika Baldev Gaikwad	Principal Scientist	Biotechnology
77	Dr. Lalit Arya	Principal Scientist	Plant Biochemistry
78	Dr. Manjusha Verma	Principal Scientist	Plant Biochemistry
79	Dr. Sundeep Kumar	Principal Scientist	Biotechnology
80	Dr. Rajesh Kumar	Principal Scientist	Plant Biotechnology
81	Dr. Amit Kumar Singh	Senior Scientist	Biotechnology
82	Dr. R. Parimalan	Senior Scientist	Biotechnology
83	Dr. Yasin Jeshima K.	Scientist	Genetics
84	Dr. S. Rajkumar	Senior Scientist	Genetics / Cytogenetics
85	Sheel Yadav	Scientist	Biotechnology – Plant Science
86	Dr. Monika Singh	Scientist	Agril. Biotechnology
87	Dr. Wankhede Dhammaprakash Pandhari	Scientist	Plant Genetics
	NBPGR, Regional Station, Hyderabad		
88	Dr. Anitha Kodaru	Principal Scientist	Plant Pathology
89	Dr. S.R. Pandrawada	Principal Scientist	Economic Botany
90	Dr. Kamla Venkateswaran	Principal Scientist	Economic Botany
91	Dr. Natarajan Sivaraj	Principal Scientist	Economic Botany
92	Dr. P. Pranusha	Scientist	Plant Genetics
93	Dr. Prasanna Holajjer	Scientist	Nematology
94	Dr. Bhaskar Bajaru	Scientist	Plant Pathology

S. No.	Name	Designation	Discipline
		NBPGR, Regional Station, Akola	
95	Dr. Dinesh Chand	Principal Scientist	Economic Botany & PGR
96	Dr. Sunil Sriram Gomashe	Senior Scientist	Genetics & Plant Breeding
		NBPGR, Regional Station, Bhowali	
97	Dr. Mamta Arya	Scientist & OIC	Plant Genetics
98	Dr. Krishna Madhav Rai	Scientist	Fruit Science
		NBPGR, Regional Station, Cuttack	
99	Dr. Diptiranjan Pani	Principal Scientist	Economic Botany
100	Dr. R.C. Mishra	Principal Scientist	Economic Botany
		NBPGR, Regional Station, Shimla	
101	Dr. Mohar Singh	Principal Scientist	Plant Breeding
102	Mr. Badal Singh	Scientist	Economic Botany & PGR
103	Mr. Rahul Chandora	Scientist	Economic Botany & PGR
104	Dr. Narender Negi	Scientist	Fruit Sciences
		NBPGR, Regional Station, Thrissur	
105	Dr. Joseph John K.	Principal Scientist	Economic Botany
106	Dr. M. Latha	Principal Scientist	Plant Breeding
107	Dr. K. Pradheep	Principal Scientist	Economic Botany
108	Suma A.	Scientist	Economic Botany
		NBPGR, Regional Station, Srinagar	
109	Dr. Sheikh Mohd. Sultan	Principal Scientist	Economic Botany
110	Dr. Susheel Kumar Raina	Senior Scientist	Genetics & Plant Breeding
		NBPGR, Regional Station, Jodhpur	
111	Dr. Kartar Singh	Scientist	Plant Pathology
112	Dr. Neelam Shekhawat	Scientist	Genetics & Plant Breeding
		NBPGR, Regional Station, Ranchi	
113	Dr. Shashi Bhushan Choudhury	Scientist	Genetics & Plant Breeding
114	Dr. Shephalika Amrapali	Scientist	Economic Botany & PGR
115	Reshmi Raj K. R.	Scientist	Genetics & Plant Breeding
		NBPGR, Regional Station, Shillong	
116	Dr. Harish G.D.	Scientist	Genetics & Plant Breeding
117	Dr. Julius Uchoi	Scientist	Horticulture-Fruit science
118	Dr. Subarana Hajong	Scientist	Economic Botany & PGR
On deputation			
119	Dr. R.K. Tyagi	Principal Scientist	Ecomomy Botany
120	Dr . J.C. Rana	Principal Scientist	Genetic & Plant Breeding

(ii). Technical staff in position as on 31st December 2019.

S. No.	Name	Designation
	Division of Plant Exploration and Germplasm Collection	
1	Dr. NS Panwar	Chief Technical Officer
2	Smt Rita Gupta	Senior Technical Officer
3	Sh Om Prakash Dhariwal	Technical Officer
4	Sh SK Sharma	Technical Officer
	Germplasm Exchange and Policy Unit	
5	Sh SP Singh	Chief Technical Officer
6	Sh Surender Singh	Chief Technical Officer
7	Sh PC Binda	Technical Officer
8	Sh SK Ojha	Senior Technician
	Division of Plant Quarantine	
9	Sh AK Maurya	Chief Technical Officer
10	Sh DS Meena	Chief Technical Officer
11	Sh Naresh Kumar	Technical Assistant
12	Dr Sadhna	Technical Assistant
	Division of Germplasm Evaluation	
13	Dr BL Meena	Chief Technical Officer
14	Sh Babu Ram	Assistant Chief Technical Officer
15	Dr BS Panwar	Assistant Chief Technical Officer
16	Sh YS Rathi	Assistant Chief Technical Officer
17	Sh OS Ahlawat	Senior Technical Officer
18	Sh RK Sharma	Senior Technical Officer
19	Sh Narendra Pal	Technical Officer
20	Sh SS Bhoj	Technical Officer
21	Sh Sunil Kumar	Senior Technical Assistant
	Division of Genomic Resources	
22	Dr Sanjeev Kumar Singh	Assistant Chief Technical Officer
23	Sh D Gautam	Assistant Chief Technical Officer
24	Sh Rohtash Singh	Technical Assistant
25	Kushaldeep Kaur Sodhi	Technical Assistant
26	Akankshha Bajpai	Technical Assistant
	Division of Germplasm Conservation	
27	Dr AD Sharma	Chief Technical Officer
28	Dr Rajvir Singh	Assistant Chief Technical Officer
29	Smt Smita Lenka Jain	Assistant Chief Technical Officer

S. No.	Name	Designation
30	Sh Satya Prakash Sharma	Technical Officer
31	Smt Nirmala Dabral	Technical Officer
32	Sh Lal Singh	Technical Assistant
33	Anjali	Senior Technical Assistant
	Tissue Culture and Cryopreservation Unit	
34	Sh Devender Kumar Nerwal	Assistant Chief Technical Officer
35	Sh. Anangpal Singh	Assistant Chief Technical Officer
36	Sh. Dharam Pal Singh Meena	Senior Technical Officer
37	Sh. Ramesh Chandra	Technical Officer
38	Sh Suresh Chandra Mali	Technical Assistant
	Agricultural Knowledge Management Unit	
39	Sh Rajiv Gambhir	Chief Technical Officer
40	Sh VK Mandal	Technical Assistant
41	Shivangi Mathur	Technical Assistant
	Library	
42	Smt Sangita Tanwar	Assistant Chief Technical Officer
43	Sh Om Prakash	Technical Officer
	Director Technical Cell	
44	Sh Abhay Sharma	Technical Officer
45	Sh AK Sharma	Senior Technical Assistant
	Vehicle Cell	
46	Sh Brahm Prakash	Technical Officer (Driver)
47	Sh Wazir Singh	Senior Technical Assistant (Driver)
48	Sh Balwant Singh	Technical Officer (Driver)
49	Sh Khusvinder Kumar	Senior Technician (Driver)
50	Sh Ram Balak Rai	Technical Assistant (Driver)
51	Sh Ravinder Kumar	Technical Assistant (Driver)
52	Sh Ranjit Singh	Senior Technical Assistant (Driver)
	Regional Station, Akola	
53	Sh Rakesh Lathar	Technical Assistant
	Regional Station, Bhowali	
54	Sh PS Mehta	Assistant Chief Technical Officer
55	Sh Mohan Ram	Senior Technical Assistant (Driver)
56	Sh Gopal Singh	Technical Assistant (Driver)
57	Sh. Anuj kumar Sharma	Technician

S. No.	Name	Designation
	Regional Station, Hyderabad	
58	Sh Babu Abraham	Assistant Chief Technical Officer
59	Sh R Gunashekharan	Technical Officer
60	Sh MAA Khan	Senior Technical Assistant (Driver)
61	Sh MV Reddy	Technical Assistant (Driver)
	Regional Station, Jodhpur	
62	Sh Bhatta Ram	Technical Officer
63	Mr. Dharam Raj Meena	Technical Assistant
64	Mrs. Chanchal Gaina	Technical Assistant
	Base Centre, Ranchi	
65	Sh AK Gupta	Senior Technical Officer
66	Ashwini Kumar	Technical Assistant
67	Sh Narendra Ram	Technical Officer (Driver)
	Regional Station, Shimla	
68	Sh Joginder Singh	Senior Technical Assistant
69	Sh Dayal Singh	Senior Technical Assistant
70	Sh Ram Chander	Technical Assistant
	Regional Station, Thrissur	
71	Sh S Mani	Assistant Chief Technical Officer
72	Sh R Ashokan Nair	Assistant Chief Technical Officer
73	Smt A Indra Devi	Assistant Chief Technical Officer

(iii). Administrative staff in position as on 31st December 2019.

S. No.	Name	Designation
	Establishment Section	
1	Sh Abhishek Srivastava	Senior Administrative Officer
2	Sh UC Sharma	Administrative Officer
3	Smt Poonam Batra	Personal Assistant
4	Smt Sangeeta Gambhir	Assistant Administrative Officer
5	Smt Savitri Devi	Assistant
6	Sh Yogesh Kumar Gupta	Assistant
7	Sh KC Kundu	Assistant
8	Sh Arvind Kumar	Assistant
9	Sh Sandeep Gaur	Assistant (on Lien)
10	Ms Sanjoo Verma	Assistant
11	Sh Hemant Ankur	Assistant

S. No.	Name	Designation
12	Sh Dev Kumar	UDC
13	Sh. Umesh Kumar	LDC
	Accounts Section	
14	Smt Yashoda Rani	Assistant Administrative Officer
15	Sh Mahabir Singh Yadav	Assistant
16	Smt Madhu Chawla	Assistant
	Stores	
17	Smt Poonam Singh	Administrative Officer
18	Sh Dinesh Sharma	Assistant
	Purchase	
19	Sh Avdesh Kumar	Assistant Administrative Officer
20	Sh Sanjay Dangwal	Assistant
	Audit Section	
21	Sh KK Sharma	Senior Finance & Accounts Officer
22	Sh Mahesh Kumar	Finance & Accounts Officer
23	Sh Surender Kumar	Assistant Administrative Officer
24	Smt Bharti Sharma	Assistant
25	Sh Prabal Dasgupta	Assistant
	Pension & Records	
26	Smt Amrita Negi	Assistant Administrative Officer
	Director's Cell	
27	Smt Kanchan Khurana	Personal Secretary
	Prof. PGR & GCD	
28	Sh Ganga Nand	Personal Secretary
	Division of Plant Exploration and Germplasm Collection	
29	Smt Urmila Singh	Personal Assistant
	Division of Germplasm Evaluation	
30	Smt Neelam Khatri	Personal Assistant
	Hindi Unit	
31	Sh. Ashutosh Kumar Tiwari	Assistant Director (Official Languages)
	Security	
32	Sh UC Sati	Security Officer
	Regional Station, Akola	
33	Sh Purushottam Dhoke	Assistant
34	Smt Smita D Karale	UDC

S. No.	Name	Designation
	Regional Station, Bhowali	
35	Sh NS Patwal	Assistant Administrative Officer
	Base Centre, Cuttack	
36	Sh SK Lal	Assistant
	Regional Station, Hyderabad	
37	Smt Radha Rani	Assistant
38	Sh M Srinivasa Rao	Assistant Administrative Officer
39	Sh P Suleiman	UDC
	Regional Station, Jodhpur	
40	Smt Leela Sharma	Assistant
	Regional Station, Shimla	
41	Smt Pratibha Bhatt	Assistant Administrative Officer
	Regional Station, Shillong	
42	Smt Lakshmilian Kharnary	Assistant
	Regional Station, Thrissur	
43	Sh S Bhadra Kumar	Assistant Administrative Officer

(iv). Skilled supporting staff in position as on 31st December 2019.

S. No.	Name
	Director's Cell
1	Sh Surender Kumar
2	Sh Hari Chand Paswan
	Division of Plant Exploration and Germplasm Collection
3	Smt Manju Devi
4	Smt Sharda Devi
	Germplasm Exchange and Policy Unit
5	Sh Arun Kumar
	Division of Plant Quarantine
6	Sh Suresh Chand Rai
7	Sh Sat Narayan Thakur
	Division of Germplasm Evaluation
8	Sh Mahesh Ram
9	Sh Kush Kumar
10	Sh Braham Dev Paswan
11	Sh Ram Kalit Rai

S. No.	Name
12	Sh Yatish Chandra
13	Smt Rukmani
14	Sh Suresh Ram
15	Sh Om Prakash
	Division of Genomic Resources
16	Smt Agya Devi
17	Sh Ramesh Chand
	Tissue Culture and Cryopreservation Unit
18	Sh. Chandeshwar Rai
19	Sh. Nand Kishore
20	Smt. Geeta Devi
	Agricultural Knowledge Management Unit
	AICRN-PC
22	Sh Mahadev Maurya
	Library
23	Sh Umesh Kumar

S. No.	Name
	Dispatch Section
24	Sh Anant Swaroop
	Accounts Section
25	Sh Sanjeev Paswan
	Audit Section
26	Sh Sunil Kumar
27	Sh Yogesh Kumar
	Establishment
28	Sh Roshan Lal
	Experimental Farm, Issapur
29	Sh Dhir Singh
30	Sh Mahabir Singh
	Regional Station, Akola
31	Sh SR Pacherwal
32	Sh RC More
33	Sh RP Barsse
34	Sh AD Godlinga
35	Sh MB Nikose
	Regional Station, Bhowali
36	Sh Anand Kumar
37	Sh GC Arya
38	Smt Tulsi Devi

S. No.	Name
	Base Centre, Cuttack
39	Sh Sarangdhar Barik
	Regional Station, Hyderabad
40	Mohd. Mazhar Pasha
41	Sh M Shankar
42	Sh E Satyanarayan
43	Sh MB Keshwa Raju
44	Sh M Srinivas
	Regional Station, Jodhpur
45	Sh DS Rajpurohit
	Base Centre, Ranchi
46	Sh Vijay Kumar
	Regional Station, Shimla
47	Sh Paras Ram
48	Sh Rohit
49	Sh Sukhdev
50	Sh Dalip Singh
51	Sh Inder Singh
	Regional Station, Shillong
52	Sh AK Deka
	Regional Station, Thrissur
53	Sh MK Prakassen

20.7 Staff transferred / superannuated / new appointments / promotions

20.7.1 Transfers

Dr. Om Vir Singh, PS & OIC, Jodhpur was transferred from ICAR-NBPGR to ICAR-VPKAS, Almora on 20th December 2019.

20.7.2 Appointments

Dr. K. S. Hooda, PS joined ICAR-NBPGR on 28th Nov, 2019.

Dr. Shefalika Amrapali, Scientist joined ICAR-NBPGR on 29th Nov 2019.

Sh. Ravi Kishore Pamarthi, Scientist joined ICAR-NBPGR on 4th Dec, 2019.

Dr. R.K. Gautam, PS joined ICAR-NBPGR on 12th Dec, 2019.

Dr. Julius Uchoi, Scientist,joined the station on 11th January, 2020 upon his transfer from Regional Research Station, Jaisalmer, Central Arid Zone Research Institute, Jodhpur.

Mrs. Reshmi Raj K. R., Scientist joined RS Ranchi from 11th Feb, 2019.

Mr. Rakesh Lathar, joined as Technician (T-1) at ICAR-NBPGR, RS Akola on 16th July, 2019.

Mr. Anuj Kumar Sharma joined as Technician (T-1) at ICAR-NBPGR, RS Bhowali on 5th Aug, 2019.

Mrs. Chanchal Gena, joined at ICAR-NBPGR Regional Station Jodhpur as Technician on 31st July, 2019.

Mr. Dharam Raj Meena, joined at ICAR-NBPGR Regional Station Jodhpur as Technical Assistant on 1st Nov., 2019.

Mr. Ashwini Kumar joined at ICAR-NBPGR Regional Station Ranchi as Technical Assistant on 6th Aug, 2019.

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

Dr. Sadhna, joined at Division of Plant Quarantine as Technical Assistan

20.7.3 Retirements

Mrs. Pratibha, AAO at RS Shimla retired on 31st Mar., 2019.

Sh. Suresh Chad Rai, SSS at New Delhi retired on 31st Mar., 2019.

Mrs. Poonam Suneja, Chief Technical Officer at New Delhi retired on 30th Apr., 2019.

Sh. Roshan Lal, SSS at New Delhi retired on 30th Apr., 2019.

Dr B S Phogat, Principal Scientist at New Delhi retired on 30th Apr., 2019.

Sh. R. Ashokan Nayar, Assistant Chief Technical Officer at RS Thrissur retired on 31st May, 2019.

Sh. Lalu Rai, SSS at New Delhi retired on 31st May, 2019.

Mrs. Vijay Laxmi Sharma, Assistant at New Delhi retired on 31st Oct., 2019.

Sh. Ramit Joshi, Sr. Technical Assistant at RS Bhowali retired on 31st Dec., 2019.

Sh. Om Prakash, Technical Officer at New Delhi retired on 31st Dec., 2019.

Dr. SK Chakroborty, Principal Scientist at RS Hyderabad retired on 31st Dec., 2019.

20.7.4 Promotions

Drs. Amit Kumar Singh, **S.S. Gomashe** and **R. Parimalan** were promoted to Sr. Scientist.

Drs. Yasin Jeshima K, Vartika Srivastava, Era Vaidya Malhotra, Gayacharan, Vikender Kaur, Pardeep Kumar, Bharat Gawade, D.P. Wankhede, Sh J. Aravind and **Smt. Sheel Yadav** were promoted to Scientist (SS).

Sh. Umesh Kumar was promoted to the grade of LDC.

Sh. Sh. G N Chary, Sh. P Gandhi, Smt D Kalamma, Smt G Rajamani, Sh N Srinivas, Sh G Narsimha, Md SaleemUddin Sh Mangat Ram, Sh Shankar Das were promoted to the grade of SSS.

20.7.5 Obituaries

(Late) Sh. Dhir Singh, Supporting staff, left for heavenly abode on 22.04.2019

20.8 Award/ honours/ prizes during 2019

- **Anitha Kodaru** conferred with '*Award for Excellence in Research*' at 8th Science and Technology Awards-19 instituted by EET CRS on 9th June, 2019 at Bengaluru.
- **Anuradha Agrawal** nominated as Member of committee constituted for developing a report on 'Agricultural Policies and Action-Plans for Secure and Sustainable Agriculture', via OM dated 12 Feb. 2019, received from the office of the Principal Scientific Adviser (PSA) to the Government of India. Final report submitted in Sept 2019. (http://psa.gov.in/sites/default/files/pdf/Report%20of%20Policies%20and%20 Action_4-9-2019.pdf).
- **Chanchal Gena** won 1 Gold (Jevlin throw), 1 Silver (High Jump) and 3 Bronze (Long jump, 100 m race and Shot put during ICAR sports meet held at ICAR-NBSS & LUP Nagpur from November 8-9, 2019.
- **Gurinderjit Randhawa** has been elected as *Fellow* of National Aacademy of Agricultural Sciences, New Delhi.
- **Jameel Akhtar** awarded with *Reviewer Excellence Award'* on September 16, 2019 by Agricultural Research Communication, Karnal.
- **Jameel Akhtar** received '*Scientist of the Year Award-2019'* by Agricultural & Environmental Technology Development Society (AETDS), U.S. Nagar, Uttarakhand, India during International Conference 'GAAFES-2019' organized at UGC-HRD Centre, Kumaun University, Nanital, on Dec 1-2, 2019.
- **Meena Shekhar** received '*Lifetime Achievement Award'* during International Conference on 'Global Research Initiatives for sustainable agriculture and Allied Sciences' organized at ICAR-NAARM, Hyderabad on October 20-22, 2019.
- **Pardeep Kumar** received *Young Scientist Award'* by Agricultural & Environmental Technology Development Society (AETDS), U.S. Nagar, Uttarakhand, India during International Conference 'GAAFES-2019'organized at UGC-HRD Centre, Kumaun University, Nanital on Dec 1-2, 2019.
- **Prasanna Holajjer** received '*Young Scientist Award*' at 8th Science and Technology Awards-19 instituted by EET CRS on June 9, 2019 at Bengaluru, Karnataka.
- **RC Misra** has been conferred with '*Environmentalist of the Year Award- 2019'* with citation from Orissa Environmental Society, Bhubaneswar on June 5, 2019 during World Environment Day celebration at Hotel Suryansh, Bhubaneswar.
- **Sangita Bansal** received '*Distinguished Scientist Award 2019*' from Hi-Tech Horticulture Society, Dec. 1, 2019.
- **SC Dubey** awarded *Fellow of National Academy of Biological Sciences*, Chennai, India.
- **SC Dubey** delivered the *Dr. H. K. Saxsena Memorial Lead Lecture* on 'Diversity analysis, diagnostics, epidemiology and management of *Rhizoctonia solani* associated with pulse crops in different agro-ecological regions of India' during the National conference on plant health

management for eco-friendly and sustainable agriculture during November 25-26, 2019 at CSAUAT, Kanpur.

- **SK Yadav** conferred with '*Distinguished Scientist Award 2019*' during International conference and global meet on Science and technology (GMST 2019) for ensuring food and nutritional security held on December 01 –03, 2019 at NRC Seed Spices Ajmer.
- **SR Pandravada** was conferred with '*Best Scientist Award*' at 4th South Asian Education Awards-19 instituted by EET CRS on March10, 2019 at Hyderabad, Telangana.
- **V Celia Chalam** received '*Certificate of Appreciation'* for organizing a symposium on "Emerging pathogens and their management: phytoplasmas, viruses and viroids in XIX International Plant Protection Congress (IPPC2019) held on November 10-14, 2019 at Hyderabad
- **V Celia Chalam** received '*Certificate of Appreciation'* presenting a paper entitled "Role of diagnostics and quarantine regulations in biosecurity against plant viral diseases in South and East Asia: Challenges" during 14th IPVE International Plant Virus Epidemiology Symposium held on 13th to 17th May 2019 at Seoul, Republic of Korea.

Best paper/poster/oral presentations

- **Era V Malhotra** awarded 'Best Oral Presentation Award' for paper entitled 'Characterization of MicroRNAs and their target genes in *Cajanus scarabaeoides* (L.) Thouars – a crop wild relative of pigeonpea' during the *3rd Global Meet on Science and Technology,* Dec. 1-3, 2019 at ICAR–NRCSS, Ajmer, Rajasthan.
- **T Boopathi** received a '*Best Oral Presentation Award'* for research paper on '*Impact of temperature and host plants on an invasive spiralling whitefly, Aleurodicus dispersus (Hemiptera: Aleyrodidae)*' by Association for Advancement of Pest Management in Horticultural Ecosystems, Bengaluru, Karnataka during 2019.

20.9 Publications

20.9.1 Research Papers

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20.9.7 Popular articles

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20.9.9 Registration Notices

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20.9.10 Participation in Radio/ TV programmes

MC Singh participated as an expert in *Hello Kisan*- a live TV programme on DD-Kisan channel, two times during 2019.

MC Singh participated as an expert in *Kisan Ki Baat* programme on All India Radio four times during 2019.

VS Meena delivered a TV talk on DD Kisan on "*Susk and ardsusk phalotpadan*" which live telecasted on April 3, 2019.

Rashmi Yadav delivered radio talk on "*Cultivation of sesame crop*" broadcasted by FM Gold, New Delhi on July 18, 2019

VS Meena delivered radio talk on "*Navropit baagon ki dekhbhal*" which broadcasted on August 29, 2019 from indraprasth channel, Delhi.

VS Meena delivered a TV talk on DD Kisan on 'नए बागों की देखभाल' on September 10, 2019.

Kartar Singh delivered a TV talk on DD Rajasthan on "*Conservation and utilization of Agro-biodiversity*" on October 31, 2019.

20.10 Organization of Germplasm Field Days

20.10.1 Germplasm Field Day on Wheat and Barley: Germplasm field day on wheat and barley was organized at NBPGR Farm, Issapur, New Delhi on March 28, 2019. It was attended by participants from 15 different national and international organizations (Fig. 20.1). Total of 3,279 accessions of wheat comprising 1780 indigenous landrace accessions, 460 exotic germplasm, 224 minicore acc., were grown for characterization, multiplication, evaluation and validation. Similarly, 969 accessions of barley comprising 685 core set acc. and 284 exotic germplasm are grown for characterization, multiplication and evaluation.

20.10.2 Germplasm field day for lentil and linseed: Germplasm field day was organized at ICAR-NBPGR, New Delhi on March 14, 2019 (Fig. 20.2). It was attended by forty participants. Dr. DK Yadava, ADG (Seeds), ICAR, Dr. PK Chakrabarty, ADG (PP & OP), Dr Ashutosh Sarker, Coordinator, ICARDA and Dr. SK Sharma, Former Director, NBPGR & Chairman RAC visited farm during field day.

20.10.3 Germplasm field day on moth bean, mung bean, cow pea and cluster bean: The Germplasm Field Day on these crops was organized at RS-NBPGR, Jodhpur on September 21, 2019. The field day was attended by a number of participants including scientists from different organizations namely ICAR-CAZRI, Jodhpur; ICAR-IIPR, Agricultural University Jodhpur, ICAR-NBPGR Headquarters, New Delhi and the farmers from arid legumes growing areas of Rajasthan.

20.10.4 Germplasm field day on stone fruits: Germplasm field day on stone fruits (Peach, Plum & Apricot) was organized at RS ICAR-NBPGR, Shimla on June 7, 2019. The field day was attended by 19 participants from different organization (ICAR institutes, SAUs and State Horticulture of Himachal Pradesh) All the participants assessed on spot variability/traits for their ongoing crop improvement programme as well as direct use to the farmers after evaluation at their respective centers (Fig. 20.3).

20.10.5 Germplasm field day on cowpea: Germplasm field day on cowpea was organized at two places NBPGR, New Delhi and UAS, Bengaluru to display the diversity available in cowpea germplasm (3,720 acc.) in two different environments (Fig. 20.4). This event was organized under DBT funded minor pulses project.

20.11 PGR awareness and TSP

20.11.1 Awareness programmes cum workshop on conservation of PGR: Two programmes were organized under Tribal Sub Plan at Ratanpuriya village of Peepalkhoont tehsil in Pratapgarh District, Rajasthan on Nov. 16, 2019 (Fig. 20.5) and at KVK, Banswara district, Rajasthan on Nov. 30, 2019 (Fig. 20.5) to educate the tribals about the importance of conservation of landraces/ local cultivars and protection of endangered species of crops of that area.

20.11.2 Workshop cum awareness programme on conservation of PGR: A Workshop cum awareness programme under Tribal Sub-Plan on "Conservation of plant genetic resources for health and nutritional security" was organized at tribal village, Badnapur, Tal: Chikhaldara, Dist: Amravati, Maharashtra, on December 13, 2019 (Fig. 20.6). A total of 223 participants comprising tribal farmers attended the programme. Tribal women farmers also

Fig. 20.1. Germplasm field day on wheat and barley

Fig. 20.2. Germplasm field day for lentil and linseed

Fig. 20.3. Field day on stone fruits

Fig. 20.4. Germplasm field day on cowpea at ICAR-NBPGR, Issapur Farm and UAS, Bengaluru

participated proactively in the event. The tribal farmers were appraised on importance of conserving the valuable plant genetic resources in their region. Farmers exhibited the seeds and live samples at the event. NBPGR also displayed the diversity collected in millets, oilseeds, pulses and potential crops live samples. A kit consisting of small farm implements (Spade, Pick-axe and Ghamela), seeds of grain amaranth and one year old plantlets of *Simarouba glauca* were distributed to 150 beneficiary tribal

Fig. 20.5. Organization of TSP at Pratapgarh and Banswara


Fig. 20.6. Workshop cum awareness programme on conservation of PGR

farmers from Badnapur, Solamahu, Kalapani, Dobanbarda, Malkapur, Ramtek villages.

20.11.3 Grassroot Level Awareness Programmes cum Biodiversity Fairs on Crop Genetic Resources Conservation: Two grassroot level awareness programmes cum biodiversity fairs on crop genetic resources conservation were organised one each at Paderu, Visakhapatnam and Santhinagar, Araku, Visakhapatnam on July 26 and 27, 2019, respectively under TSP to bring in awareness to the tribal farmers regarding the need and necessity of conservation of Agri-biodiversity. The programmes were organised by the RS-NBPGR Hyderabad in association with NGO-SANJEEVINI Rural Development Society (Fig. 20.7-20.11). The

Fig. 20.7. Inauguration of Agri-biodiversity Exhibition at Paderu

Fig. 20.8. Visit to the Biodiversity Block of Community Gene Bank, Killoguda

Fig. 20.9. Directors address to the Tribal Farmers at Paderu

Fig. 20.10. Tribal Farmers viewing Agri-biodiversity Exhibition

Fig. 20.11. Distribution of Kits to tribal farmers at Araku and Paderu

Programmes were envisaged keeping in view the erosion of agri-biodiversity especially in the tribal areas of Visakhapatnam District. More than 400 farmers from four mandals *viz*., Paderu, Hukumpeta, Arakuvalley and Dumbriguda participated in the programmes. During tribal farmers' interactive session, they shared their experiences on the importance of traditional varieties. Dr. Kuldeep Singh, Director, ICAR-NBPGR, addressed farmers and briefly sketched role of NBPGR in safeguarding the valuable germplasm of traditional crops.

The interactive session was followed by agri-biodiversity exhibition on seed diversity in paddy and other cereals, sorghum and other millets, pulses, oilseeds, underutilized legumes and medicinal plants. Kit consisting of pickaxe, axe, spade, shovel and iron basket along with literature in vernacular language were distributed to 200 tribal farmers. Dr Kuldeep Singh visited the Community Seed Bank at Killoguda, being maintained by SANJEEVINI where over 200 different traditional varieties of cereals, millets, pulses and oilseeds collected from the region were conserved in earthen pots in traditional style.

20.11.4 PGR awareness programme cum-Biodiversity fair: Base centre, Cuttack organized PGR awareness programme cum-Biodiversity fair tribal areas at Jabagada village of Nandapur block, Koraput, Odisha under "Tribal Sub Project" on November 28, 2019 (Fig. 20.12). About 150 tribal farmers were attended and witnessed the diversity on of plant genetic resources displayed during the programme. They have also received seeds, planting materials of different vegetable crops and small farm implements under TSP.

20.11.5 PGR Awareness Programme at Shimla: One day PGR awareness camp on promotion and conservation of traditional crops was organized on November 5, 2019 at Tabo District Lahual & Spiti of Himachal Pradesh in collaboration with Krishi Vigyan Kendra (KVK) Taboo-II, Lahual & Spiti Himachal Pradesh (Fig. 20.13). A total of 250 tribal farmers of valley attended this awareness camp. The prime aim of this programme was to bring awareness among farming community on the benefits of plant genetic resources including crop landraces which are being maintained by them and facilitating registration of Farmers' Varieties with PPV&FRA.

20.11.6 Biodiversity fair cum PGR awareness camp by RS-NBPGR, Shilllong: It was organized under TSP at Mawpun village of Ri-Bhoi District, Meghalaya on March 26, 2019 by ICAR NBPGR Regional Station- Shillong, Umiam in collaboration KVK, Ri-bhoi. The program was attended by 104 farmers (24 Male & 80 Female) of Khasi tribal community. During the programme an exhibition and display of local farmer's varieties/ germplasm was also organized. Hand tools, adjustable row marker and spade with handle were distributed to 100 farmers (Fig. 20.14-20.19).

20.11.7 Training Cum Awareness Programme on PPV & FRA act, 2001: It was organized under UNEP- GEF Project jointly by ICAR-NBPGR Regional Station, Shillong, Meghalaya and Foundation for Development Integration (FDI), Guwahati, Assam at Dangdhora, Jorhat, Assam on March 5, 2019. The programme was attended by 182 participants belonging to ThengalKachari tribal farming community (Fig. 20.18-20.21).

Fig. 20.12. Organizing PGR awareness programme at a) Jabagada, Koraput under TSP; b) Maripalem, Koraput under TSP

Fig. 20.13. PGR awareness camp at Tabo under TSP component

Fig. 20.14. Speech by OIC, ICAR-NBPGR RS Shillong

Fig. 20.15. Organizers and farmers

Fig. 20.16. Release of booklet on Protection of Plant Varieties & Farmers' Rights

Fig. 20.17. Distribution of hand tools

Fig. 20.18. Dr. S. Hajong giving a talk on Conservation of germplasm through "community seed bank"

Fig. 20.19. Exhibition of local germplasm

Fig. 20.18. Organizers and farmers

Fig. 20.19. Participants of the programme

Fig. 20.20. Handing over of rice germplasm to ICAR-NBPGR RS Umiam

Fig. 20.21. Participants of the programme

20.11.8 Popularization of grain amaranth among farmers: The seeds of grain amaranth variety **Suvarna** were provided to the farmer of Village- Chincholi (Shingane), Amaravati district, Maharashtra. This was the first time farmer raised the amaranth crop for testing it on farm. A very small quantity (30g) of seeds were given to farmer gave yield of almost 18kg of grain amaranth seeds. Farmers from the adjoining villages expressed their willingness to take up grain amaranth crop in next *Rabi* season at least for home consumption purpose.

Fig. 20.22. Grain Amaranth variety Suvarna on farmer's field

Fig. 20.23. Suvarna -Grain Amaranth variety performance at farmer's field

Re-introduction of this potential crop will greatly help the farmers for diversifying the cropping systems. (Fig. 20.22–20.23).

20.11.9 Progress on TSP activities: "Agro-biodiversity fair-cum-seminar on conservation of local crop genetic resources" was organized on November 14, 2019 in Village Darkot, Block Munsyari of district Pithoragarh, Uttarakhand under TSP. A total of 148 participants (66 male farmers and 82 female farmers) from eight villages Darkot, Dummar, Mapwalwada, Darati, Talla Ghorpatta, Bunga, Sarmoli and Khasiwada participated in the event including state officials and resource persons. Unique landrace diversity in native crops *viz.,* paddy, millets, rajmash, horsegram, barley, wheat *etc.* were displayed in a small exhibition and their potential role in nutritional and livelihood security of the residents emphasized. Diversity in fruits and other crops was also displayed with the help of display posters. Petty farm implements (VL-Hank fork, VL-Kutla, VL- Daranti and VL-Hand hoe) were distributed to farmers. Farmers were sensitized about the importance of biodiversity 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 (Fig. 20.24).

20.11.10 Promotion of local landraces and their re-introduction in the hills- A success saga: Earlier, many landraces of native cropswere sown in the mountainous regions of Uttarakhand, but at present many species have become extinct due to unavailability of seeds of these species. To create awareness about the importance of agro-biodiversity among farmers, a couple of interface meetings/ *goshthies* were organized at different villages and champion farmers were selected for the display of crop diversity in the area. A number of different landraces were grown in the field of these champion farmers and nearby villagers were invited at the field to showcase the native crop diversity. Small programs were organized in these villages at the site of diversity for display. Farmers were invited and were asked to identify the landraces in the form of a questionnaire. All the farmers were motivated to grow these landraces in their fields. There were farmers who mentioned that few of the showcased landraces used to be grow of in them earlier and have become extinct nowadays and have shown interest to grow them again if provided with seeds. Similarly, other farmers have also selected the landrace of their choice in order to get the seeds from ICAR-NBPGR, Bhowali for sowing in their respective fields next year (Fig. 20.25-20.28).

Local landraces of paddy (rainfed and irrigated), black seeded soybean, horsegram, wheat, barley, frenchbean, amaranth, buckwheat and fingermillet were distributed to farmers of village Suri (Almora), Gadsyari (Almora), Matila (Almora), Chanauli (Someshwar), Mawe (Someshwar), Malonj (Someshwar), Tolma (Chamoli), Malari (Chamoli), Doni (Tehri) and Munsyari (Pithoragarh). Continuous efforts are made to mainstream these

Fig. 20.24. Dr K.M. Rai addressing farmers during TSP program at Darkote (Pithoragarh) on 14.11.2019

Fig. 20.25. Training on preparing Peoples Biodiversity Register under 'Green Skill Development'


Fig. 20.26. Interaction with farmers during training-cum-awareness programs on PPVFR Act, 2001


Fig. 20.27. Farmer's Field Day organized at Bhowali on 12.09.2019


Fig. 20.28. Interaction with farmers and showcasing crop diversity

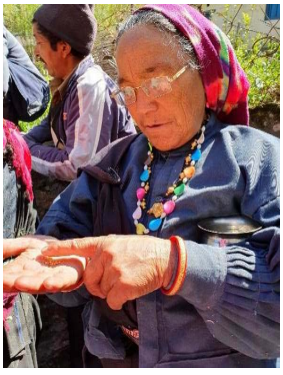

Fig. 20.29. Smt Sarasvati Devi on importance of prosomillet

landraces and as a result, landraces of paddy and wheat have been brought back to farmers field in these areas. In higher altitude area of district Chamoli, prosomillet diversity was showcased and farmers were very interested to grow it again. One farmer Mrs. Saraswati Devi mentioned that they used to grow and consume prosomillet earlier but as the food preference has changed, they have stopped growing it now (Fig. 20.29). She also talked about how their health is getting deteriorated due to non-consumption of coarse grain in their diets and have shown keen interest in growing prosomillet again in her field so that it can be brought back to the food habit of her family. Other farmers have also come forward to get the seeds of prosomillet to grow it again for domestic consumption.

20.12 Exhibitions/fairs organized/ participated

20.12.1 Participation in State level Agriculture Exhibition (AGROTECH- 2019): ICAR-NBPGR, Regional Station, Akola participated in Agriculture Exhibition organized by Dr. PDKV, Akola on occasion of 121st birth anniversary of late Dr. Panjabrao Deshmukh in collaboration with State Department of Agriculture and Agriculture Technology Management Agency (ATMA), Maharashtra during December 27-29, 2019 (Fig. 20.30). RS-Akola exhibited seed variability of oilseeds, pulses, millets, amaranth and specimens of vegetable crops and crop wild relatives (CWRs). Farmers were appraised on the need to conserve our traditional seeds and diversify the cropping system by inclusion of minor pulses, millets and potential crops to attain nutritional and health security. The farmers appreciated the efforts carried out by ICAR-NBPGR.

20.12.2 Germplasm exhibition at farmers fair: The RS-NBPGR, Jodhpur participated in the exhibition cum farmer fair held at ICAR-CAZRI on January 21, 2019 and Sept 16, 2019 (Fig. 20.31). Germplasm accessions were placed with photographs and posters depicting the various activities and mandates of the station. Farmers visited the stall and showed interest on the exhibits.

Fig. 20.30. Participation of ICAR-NBPGR, RS-Akola in AGROTECH-2019

Fig. 20.31. Exhibition at CAZRI kisan mela

Fig. 20.32. Exhibition at district level kisan mela, Cuttack

20.12.3 Exhibition and display of PGR: Base centre Cuttack exhibited and displayed PGR of Odisha at Kisan Mela and Public Amenities held at ICAR-NRRI, Cuttack on February 26, 2019 (Fig. 20.32). It also co-organized one day rice germplasm field day with ICAR-NRRI, Cuttack on November 11, 2019.

20.12.4 Tree plantation week / Van Mahotsava: During first week of July 2019 tree plantation week celebrated at NBPGR, Experimental station, Issapur. This plantation drive was actively participated by NBPGR staff, farmers of village Issapur and Manjri. Dr. Vijay Singh Meena, Incharge, Issapur Farm encouraged local farmers for planting more saplings in monsoon season in their villages for maintaining ecological balance and reduces carbon footprints for sustainable environment (Fig. 20.33-20.34).

20.12.5 Mera Gaon Mera Gaurav (MGMG) activities: Base centre Cuttack imparted hands on training to twenty-five farmers of village Itipur and Jaipur Patana on seed treatment of groundnut and pulses with organic bio-formulation of *Trichoderma* on Jan 11, 2019 (Fig. 20.35).

The scientists at ICAR-NBPGR, Bhowali are closely working with the farming community of MGMG villages and helping the community to strengthen their on-going efforts to promote traditional hill farming in overall framework of indigenous food sovereignty. Conservation of local landraces is being done and efforts are being made for broadening the existing crop diversity by introducing new/ obsolete/rare crop landraces collected throughout the state. Apart from that, sensitizing

Fig. 20.33.

Fig. 20.34.

Fig. 20.35. Distributing organic bio-formulation of *Trichoderma* for seed treatment under MGMG programme

Fig. 20.36. Distribution of saplings under MGMG

farming community towards conservation of agro biodiversity has been done regularly through *goshthies* as well as creating awareness towards proper sanitation and cleanliness has been done on a regular basis. Seeds of different landraces were distributed for promoting conservation as well as quality planting material of *Citrus* were provided to farmers of these villages (Fig. 20.36).

20.12.6 Facilitation of farmer's visit: Arrangements were made for visit of 40 farmers from five villages of Radhakrushnapur cluster to ICAR-NRRI and ICAR-NBPGR to attend "Kisan Mela" organized at ICAR-NRRI on February 26,, 2019. The farmers have interacted with scientists of NRRI and NBPGR in the Kisan gosthi and discussed about various problems they are facing during cultivation

20.12.7 Farmers visit to RS-NBPGR, Srinagar: Two groups of farmers including women from Himachal Pradesh visited RS-NBPGR, Srinagar on June 29 and July, 25, 2019 and interacted with the scientists of the station about local plant genetic resources and traditional crops, their importance, advantages, need for their on-farm conservation and their relevance to the livelihood and nutritional security of hill people especially under prevailing climatic conditions (Fig. 20.37). The farmers were on a visit to ICAR-CITH, Srinagar.

20.12.8 Farmers visit to RS-NBPGR, Hyerabad: In farmers visits, 90 farmers from Bihar and Madhya Pradesh and 30 participants of the Inter-State Training Programme in Telangana being conducted by the Agricultural Technology Management Agency

Fig. 20.37. Farmer visit to the RS-NBPGR, Srinagar

Fig. 20.38. National Resource Persons from Bihar and Madhya Pradesh visited the RS-Hyderabad Station's Facilities in June 2019

Fig. 20.39. Visit of participants of the Inter-State Training Programme in Telangana conducted by Agricultural Technology Management Agency (ATMA) to RS Hyderabad

Fig. 20.40. Visit of scientists from ICAR-NBPGR at ICARNA, Amlaha

(ATMA) visited RS-NBPGR, Hyderabad in the month of June and August, 2019, respectively (Fig. 20.38-20.39).

20.12.9 Visit to ICARDA Food Legume Research Platform: Scientists of ICAR-NBPGR visited ICARDA, Amlaha on March 5, 2019 and focussed on collaboration on grain legumes for accelerating utilization of genetic resources (Fig. 20.40).

20.13 Students visiting NBPGR for exposure

20.13.1 Visit of students to Base centre, Cuttack: Several students of B.Sc. (Ag.) Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (Chhattisgarh) visited the centre and were imparted orientation training on 'Germplasm collection, introduction, conservation in FGB and maintenance of medicinal and aromatic plants' on July 6, 2019 (Fig. 20.41). A group of 10 students of UG (+3 Sc.-Botany Hons.) from Ravenshaw College, Cuttack visited NBPGR Base Centre for orientation on plant genetic resources management and herbarium preservation techniques, on November 8, 2019 (Fig. 20.42).

20.13.2 PGR Awareness generation among student community at Kerala: A total of 466 students along with faculty members visited the station from College of Forestry (KAU), Thrissur, Kerala, B.Sc. (Botany) students from St. Joseph's College, Irinjalakuda, Kerala, B.Sc. (Botany) students St. Thomas College, Thrissur, Kerala, M. Sc. (Botany) students from Sri Krishna College, Guruvayur, B.Sc. (Agri) students from College of Hort. (KAU), Thrissur, Kerala, B. Sc. (Botany) students from St. Mary's College, Thrissur, Kerala, PG (Agri.) Scholars from Hort. College & Research Institute,(TNAU), Coimbatore, Tamil Nadu. The students were briefed about the various objectives and PGR activities of the Bureau in general and the specific mandates of Thrissur Station in particular, with the aid of multimedia presentations and visit to Field/ MTS Facility/ Laboratory.

20.13.3 Students visit to RS-NBPGR, Hyderabad: The students of various universities, schools visited the RS-NBPGR, Hyderabad. These includes, students of MGM Agribiotech College, Aurangabad, Maharashtra Agricultural College and SV Agricultural College, Tirupati (Fig. 20.43 & 20.44).

20.13.4 Students visit to ICAR-NBPGR Regional Station, Jodhpur: A group of 90 students from Mahila PG Maha Vidyalaya Jodhpur, Faculty of Biotechnology visited ICAR-NBPGR Regional Station, Jodhpur on October 18, 2019 (Fig. 20.45). The scientist of the Station interacted with the students regarding mandate and activities of ICAR-NBPGR in general and ICAR-NBPGR RS Jodhpur in particular. The students were made aware of the concept and approaches in plant genetic resources collection, conservation and

Fig. 20.41. Orientation training to B.SC Ag. students of IGKV, Raipur

Fig. 20.42. Orientation training to B.SC Ag. students of IGKV, Raipur

Fig. 20.43. Students of B.Sc. III yr (Agriculture) PJTSAU visited RS Hyderabad on August 31, 2019

Fig. 20.44. Students of B.Sc. III yr (Agriculture) PJTSAU visited RS Hyderabad on August 31, 2019

Fig. 20.45. Students visit to Jodhpur station's field

utilization. The students showed keen interest in the various agri-horticultural species, their wild relatives and medicinal and aromatic plants being conserved effectively in the MTS unit of Jodhpur Station.

20.13.5 Exposure/ education Visit at RS NBPGR-Shillong: A group of 23 students from Handique Girls' College, Guwahati, Assam, two students (Ph.D) from ICAR-NBPGR, Delhi and IARI, Delhi, 45 students of B.Sc (Botany) Ist and IIIrd semester visited Shillong Regional Station. Besides, two students (Ph.D) from ICAR-NBPGR, Delhi and IARI, Delhi and 26 students of BSc (Agri) IIIrd year from College of Agriculture, Tripura visited Shillong Regional Station during 2019.

20.14 Distinguished Visitors

Shri Kailash Choudhary Ji, Hon'ble Minister of State for Agriculture and Farmers Welfare, Govt. of India visited ICAR-CITH Srinagar on Sept. 26, 2019 (Fig. 20.46). On the occasion scientists of ICAR-NBPGR RS Srinagar interacted with the visiting dignitary regarding mandate and activities of ICAR-NBPGR in general and ICAR-NBPGR RS Srinagar in particular.

20.14.1 Visit of Chairman, RAC, ICAR-NBPGR to RS-NBPGR, Srinagar: Dr. SK Sharma, Chairman RAC and ex-Director ICAR-NBPGR New Delhi visited ICAR-NBPGR RS Srinagar on July 29, 2019 and along with Dr. DB Singh, Director ICAR-CITH Srinagar inaugurated new office of the station (Fig. 20.47).

20.14.2 Rythu Sadassu at Hyderabad: RS-NBPGR Hyderabad staff attended the "**Rythu Sadassu**" program at Chilkuru village, Kodad mandal, Suryapet district of Telangana on November 16, 2019 to interact and educate the farmers on improved cultivation practices of rice and pest management practices. About 80 farmers attended the programme and interacted with the scientists and gained knowledge on the latest technological interventions.

20.15 Vigilance awareness week, Parthenium Day, Indian Constitution Day and International Women's Day celebrations

A meeting of all staff members was organized and pledge was taken on the occasion of Vigilance awareness week which was observed from Oct. 28

Fig. 20.46. Shri Kailash Choudhary Ji, Hon'ble Minister of State for Agriculture and Farmers Welfare, Govt. of India visited ICAR-CITH Srinagar

Fig. 20.47. New Office of ICAR-NBPGR RS Srinagar

to Nov. 2, 2019 at NBPGR, New Delhi and different regional stations. Parthenium day was conducted on November 1, 2019 and all the staff members participated and removed parthenium seedlings from crop fields and field bunds across all NBPGR stations. International Women's day was celebrated on March 8, 2019 and all women staff and employees were felicitated individually by the Director and station incharges (Fig. 20.48). All staff members of headquarters and regional stations participated on the occasion of the Indian Constitution Day on Nov. 26, 2019 and the Director and Officer-In-Charges read the preamble and elucidated the significance to all the staff members.

Fig. 20.48. Celebration of International Women's Day at RS Hyderabad

Meteorological data (temperature in degrees Celsius and rainfall in mm) for the year 2019.

Station	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Akola	Max temp	28.5	32.2	36.7	42.1	43.1	40.1	32.1	29.2	29.9	30.5	30.5	27.9
	Min temp	10.5	15.6	17	22.2	26.4	24.7	20.9	20	19.9	17.9	14.7	15.2
	Rainfall	0	1.9	0	13.5	0	89.6	285.7	179.5	263.1	85.1	11.8	14.2
Bhowali	Max temp	13.64	14.08	17.78	25.13	29.08	28	25.38	24.6	24.95	24	19.5	15.33
	Min temp	0.68	3.47	6.3	12.08	14.24	16.82	18.38	18.43	18.13	9	8.29	1.62
	Rainfall	75.9	168.9	52.5	50.5	15	145.6	366.8	277.8	158.2	3.5	55.1	102
Cuttack	Max temp	28.15	31.04	33.19	36.48	37.41	34.39	32.34	31.94	31.69	31.55	29.61	27.01
	Min temp	12.87	17.23	22.43	25.05	25.9	26.32	25.56	25.51	25.09	24.07	20.52	16.7
	Rainfall												
Hyderabad	Max temp												
	Min temp	0	21.2	16	40	190	197	488.26	522	529	746.8	6.4	0
	Rainfall												
Jodhpur	Max temp	24.7	26.1	31.9	40.6	40.6	41.6	37.6	33.6	34.7	34.4	32.5	24.4
	Min temp	10.4	12.3	18	25	27.4	30.5	28.4	26.2	26.4	21	15.8	11.5
	Rainfall	0.9	0	0	2	21.4	54.4	183.1	277.5	70.7	9	1.4	0.3
Ranchi	Max temp	17.22	23.39	32.16	35.39	37.02	36.08	33.84	28.98	28.89	29.78	25.83	18.39
	Min temp	11.07	9.04	13.97	20.17	23.01	25.06	24.69	23.22	23	22.83	16.3	9.15
	Rainfall	0	21	18	22	22	187	199	424	213	167	0	9
Shillong	Max temp	21.2	22.6	25.1	26.6	28.1	28.1	27.9	29.6	27.1	25.1	24.2	20.5
	Min temp	6.6	8.9	11.9	15.2	18	19.9	20.4	20.6	19.3	16.1	12.8	6.9
	Rainfall	22.8	13.6	19.9	180.9	203.3	380.9	396.7	290.6	429.7	259.1	33.2	24.8
Shimla	Max temp	11.74	13.34	16.66	23.84	25.62	27.97	23.96	23.65	23.78	21.48	18.4	14.28
	Min temp	2.71	3.63	6.43	12.72	14.26	16.81	16.82	16.6	15.39	11.38	8.36	3.85
	Rainfall	3.37	5.49	2.46	2.08	2.3	3.31	11.53	16.29	3.56	1.23	1.16	0.77
Srinagar	Max temp	7	8.6	14	20.7	25.3	29.8	31	29.8	27.7	23.2	15	8.6
	Min temp	-2.5	0	3.7	8.4	11.6	15	18.3	17.5	12.3	6.4	1.9	-2
	Rainfall	54	69	122	86	68	45	62	68	32	27	39	55
Thrissur	Max temp	32.9	35.3	36.8	36.1	34.6	32.2	30.4	29.5	31.2	32.4	32.9	32.3
	Min temp	20.4	23.4	24.8	25.5	24.9	23.5	22.8	21.9	22	21.4	21.7	22.1
	Rainfall	0	0	0	76.4	48.8	324.4	654.4	977.5	419	418.4	205	4.4
New Delhi	Max temp	21.95	21.5	27.7	36	39.25	39.75	37.3	32.6	33.5	31.25	26.05	16.6
	Min temp	7.5	10.6	12.9	21	25.35	26.85	26.65	26.4	25.2	18.35	13.6	6.75
	Rainfall	52	72.2	10	5.7	45.4	31.2	283.9	227	17.6	41	7.4	66

भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संस्थान ब्यूरो

पूसा कैम्पस, नई दिल्ली – 110012

ICAR-National Bureau of Plant Genetic Resources

Pusa Campus, New Delhi - 110012