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वार्षिक प्रतिवेदन
Annual Report
2012-2013

राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो
(भारतीय कृषि अनुसंधान परिषद)
पूसा परिसर, नई दिल्ली–110 012

NATIONAL BUREAU OF PLANT GENETIC RESOURCES
(Indian Council of Agricultural Research)
Pusa Campus, New Delhi - 110 012

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NBPGR

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This report includes unprocessed or semi-processed data, which would form the basis of scientific papers in due course. The material contained in the report therefore may not be made use of without the written permission of the Director, National Bureau of Plant Genetic Resources, New Delhi except for quoting it for scientific reference.

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CONTENTS

Preface

Executive Summary 1

Introduction 9

NBPGR Headquarters, New Delhi

1. Plant Exploration and Germplasm Collection 13
2. Germplasm Evaluation 19
3. Germplasm Conservation 40
4. Plant Quarantine 45
5. Germplasm Exchange 53
6. Tissue Culture and Cryopreservation 60
7. PGR Policy Planning 65
8. Agricultural Knowledge Management 67
9. Genomic Resources 70

NBPGR Regional Stations/ Base Centers

10. Regional Station, Akola 86
11. Regional Station, Bhowali 91
12. Base Center, Cuttack 96
13. Regional Station, Hyderabad 102
14. Regional Station, Jodhpur 111
15. Regional Station, Ranchi 117
16. Regional Station, Shillong 121
17. Regional Station, Shimla 125
18. Regional Station, Srinagar 129
19. Regional Station, Thrissur 131
20. General Information
    - 20.1 Institute Management Committee 141
    - 20.2 Research Advisory Committee 141
    - 20.3 Institute Research Council 142
    - 20.4 Institute Joint Staff Council 142
    - 20.5 Personnel 142
    - 20.6 Staff Reservations 149
    - 20.7 Staff Transferred/ Retired/ New Appointments/ Promotions 149
    - 20.8 Awards/ Honours/ Prizes 151
    - 20.9 Deputations Abroad 153
    - 20.10 Exchange Visit 154
    - 20.11 Library and Documentation Services 154
    - 20.12 Germplasm Advisory Committee (GAC) Meeting 154
    - 20.13 Field Days & Biodiversity Fairs organized 154
    - 20.14 Workshops/ Group Meetings/ Trainings organized 161
    - 20.15 Participation of Staff in Seminars/ Symposia Workshops/ Trainings etc. 161
    - 20.16 Publications 167
    - 20.17 Patents Granted 182
    - 20.18 Distinguished Visitors 182

Annexure I : Meteorological Data of Regional Stations 185

PREFACE

It gives me immense pleasure to place before you the Annual Report (2012-13) of the National Bureau of Plant Genetic Resources (NBPGR), a nodal organization mandated with planning, execution and coordination of all activities concerned with plant germplasm collection, introduction, quarantine, evaluation, conservation and documentation at national level. Since its establishment in 1976 by the Indian Council of Agricultural Research (ICAR), NBPGR has played a pivotal role in the management and sustainable utilization of plant genetic resources for crop improvement.

Taking into account the suggestions of the Germplasm Advisory Committees and Group Meetings of All India Coordinated Projects on various crop groups, plant explorations were undertaken to collect trait-specific germplasm and wild relatives of crop plants, which constituted >50% of the total collections made during the year 2012. Similarly, trait specific germplasm for improving nutritional quality, resistance to biotic and abiotic stresses, and transgenic material for research was introduced from abroad and made available to researchers after quarantine clearance.

During the year, under the National Initiative for Climate Resilient Agriculture (NICRA) 21,822 accessions of wheat and 18,775 accessions of chickpea germplasm were characterized at CCSHAU, Hisar and MPKV, Rahuri, respectively for the development of core sets. In addition, 21,445 accessions of wheat were evaluated at Issapur Farm under two sowing dates for screening against terminal heat tolerance. Further, 20,660 accessions of wheat were evaluated against rusts and foliar diseases at IARI RS, Wellington. On similar lines, >18,000 chickpea germplasm was evaluated during *Rabi* 2011-12 at MPKV, Rahuri for agro-morphological, biotic and abiotic stresses and quality parameters.

A total of 12,970 accessions of germplasm including varieties to be notified and released and trait-specific registered germplasm of various crops were received for long-term conservation in the National Genebank. In addition, 2,086 accessions belonging to fruit crops, bulb and tuber crops, medicinal, aromatic and rare/endangered plants, spices, plantation and industrial crops, and others were conserved as *in vitro* cultures. Significant progress was made in the development of protocols for cultivar identification in crops of national importance using molecular techniques like STMS, AFLP and ISSR markers. Varieties of different crops were fingerprinted and included in the database on DNA fingerprinting. Three M. Sc. students were awarded degrees in PGR from Post Graduate School, IARI, New Delhi during the year.

I take this opportunity to place on record my sincere thanks and gratitude to Dr S Ayyappan, Hon'ble Director General, ICAR and Secretary, DARE, Govt. of India, Prof. S K Datta, DDG (Crop Sciences), Dr Arvind Kumar, DDG (Education), Dr J S Sandhu, Former ADG (Seed), ICAR and Dr B B Singh ADG (OP & Seed), ICAR for their continued guidance, encouragement and support in executing the mandate of NBPGR.

I thank the HoDs, Officers-in-charge, all the scientists, technical, administrative and audit, and supporting staff of NBPGR for their teamwork, efficiency and dedication. Sincere efforts of Drs Arjun Lal, Kavita Gupta, Vandana Tyagi and Sangita Yadav in compilation and editing the report are appreciated.

27 May 2013
New Delhi

K C Bansal
Director

EXECUTIVE SUMMARY

National Bureau of Plant Genetic Resources (NBPGR) continued its role of leadership for the management of plant genetic resources in the country. Several significant achievements were made during the year 2012 in plant exploration and collection of germplasm; germplasm introduction, plant quarantine inspection, treatment and release of germplasm; characterization, evaluation, identification of promising accessions and maintenance; *ex situ* conservation of accessions in National Genebank and DNA Fingerprinting of crop cultivars and are summarized hereunder.

PLANT EXPLORATION AND COLLECTION OF GERMPLASM

A total of 37 explorations were undertaken across the country and 1,970 accessions of various agri-horticultural crops, their wild relatives and other economic plants were collected. Of these, 458 accessions were collected by NBPGR headquarters, New Delhi through nine explorations. A total of 288 herbarium specimens, 73 seed samples and 29 economic products were processed and added to the National Herbarium of Cultivated Plants (NHCP). Major emphasis was given for collection of wild species including wild relatives of crops. Germplasm collected by NBPGR regional stations during various explorations is summarized hereunder.

Akola: Two exploration and collection missions were undertaken, out of which one from the Melghat regions of Maharashtra for collection of millets, small millets and their wild relatives and another from Eastern Ghats of Andhra Pradesh for *Cucumis* and *Abelmoschus* species. A total of 111 accessions of germplasm belonging to ten genera and 17 species were assembled.

Bhowali: Three crop-specific explorations and one plant specific tour were undertaken and 124 accessions were collected which include landraces and primitive cultivars of cereals (33), fruits (26), wild relative of crops (51) and *Swertia* spp. (14) from remote areas of Uttarakhand hills and four districts of Sikkim including subdivision of Darjeeling, West Bengal under National Exploration Programme.

Cuttack: Three explorations were undertaken and a total of 174 accessions comprising cultivated rice (submergence tolerant-124); wild *Oryza* species (34); cotton (14); *Ocimum citriodorum* (1) and *Coix-lacryma-jubi* (1) were collected from 95 collection sites covering Odisha, Jharkhand and Tripura. The significant collections among rice germplasm include submergence tolerant land races (*Baliadadha*, *Khoda, Kakudimanji, Khadara, Champeisali, Putia, Bhutia*), *Oryza rufipogon* and *O. nivara* from higher altitude region (360m) of Jharkhand, coloured cotton (*Gossypium arboreum*) and perennial cotton (*Gossypium barbadense*) from Tripura.

Hyderabad: Three explorations were undertaken for collection of diversity in sorghum, small millets, vegetable cowpeas and leafy vegetables from different parts of Andhra Pradesh and the NEH region. In addition, under NAIP-Biodiversity project two explorations were undertaken in Adilabad district of Andhra Pradesh surveying 64 villages of 21 mandals covering 79 farmers resulting in the collection of 158 accessions of agri-horticultural crops.

Jodhpur: Two explorations were conducted, in one 65 accessions of wheat (*Triticum aestivum* L.) were collected from the interior villages of Jodhpur, Pali, Sirohi, Jalore and Barmer districts of Rajasthan to collect drought and terminal heat tolerant germplasm of wheat from the areas where irrigation water scarcity prevails and temperature goes higher (35-43^{o}C) at the time of reproductive period of wheat. In another exploration trip, the genetic variability of minor millets namely, finger millet (*Eleusine coracana* L.) (40) and little millet (*Panicum sumatrense* Roth.) (30) were collected.

Ranchi: Two explorations were undertaken, the first was undertaken to tap the genetic diversity in the *Cajanus cajan* (pigeonpea) in the eastern Jharkhand. The districts explored included Kodarma, Giridih, Deoghar, Godda, Sahibganj, Pakur, Dumka, Jamtara, Dhanbad and Bokaro. A total of 100 accessions of the pigeonpea representing high amount of diversity were collected. The second exploration to collect the diversity of upland rice (drought tolerant) and minor millets was undertaken in Ramgarh, Hazaribagh, Giridih and Ranchi districts of Jharkhand and a total of 60 accessions *viz.* rice (22), ragi (31), sorghum (5) and gundali (2) were collected.

Shillong: Three explorations were conducted in West Bengal, Arunachal Pradesh and Tripura, and a total of 185 accessions were collected. The Jalpaiguri and Cooch Behar districts of West Bengal were explored for collection of landraces of *Kharif* crops and 85 accessions comprising cereals and pseudocereals (27), pulses/ grain legumes (6), vegetables (33), oil seeds (8), rhizomatous crops (8), fibre crop (1) and other (2) were collected. Collection of hill rice germplasm (67 accessions) was made from East Kameng, Kurung Kumey and Papum Pare districts of Arunachal Pradesh. Notable diversity was found for two distinct categories of rice: late maturing and bold grained type called *Umte,* and early maturing small grained type called *Tening*. All four districts of Tripura were explored for collecting pigeonpea diversity in the state. In addition to *Cajanas cajan,* the wild pigeonpea (*C. scaraboedes*) germplasm was collected from Lembucherra and Jumpui hills area.

Shimla: Two explorations were undertaken to collect germplasm of wild and minor temperate fruits, common bean and rice landraces from different parts of Himachal Pradesh and Uttrakhand. A total of 86 accessions comprising common bean (43), rice (18), *Malus baccata* (2), *Prunus mira* (3), *P. armenica* (4), *P. cornuta* (2), *Rubus* sp. (3), *Sorbus lanata* (2), *Hippopahe rhamnoides* (3) and *Cotoneaster rotundifolius* (2) were collected. Significant collections include landraces of rice, kidney bean, amaranth and some wild relatives of temperate fruits.

Srinagar: Two explorations were undertaken and a total of 66 accessions comprising rice landraces (32), linseed (12) and wild safflower (22) were collected from different areas of Kashmir.

Thrissur: A total of 115 accessions of germplasm were collected in two exploration and collection missions carried out in one district of Arunachal Pradesh and nine districts of Assam. Besides, fifteen collections were added to the germplasm holdings through personal efforts.

EXCHANGE OF GERMPLASM

Introduction of germplasm: A total of 1,18,659 samples were imported which included 37,018 accessions (38,776 samples) of germplasm and 8,140 entries (79,883 samples) of CGIAR nurseries for trials.

Promising trait specific germplasm introduced:

***Triticum aestivum* (Wheat)** : Nullisomic/ tetrasomic/ monosomic Chinese spring wheat lines (EC731579 to 731636); winter variety Anton with enhanced end use quality and low levels of polyphenol oxidase (PPO) EC732856; substitution/ deletion/ aneuploid lines EC736143-736162; wheat genetic stock with ph 1b mutant allele into an adapted Kansas winter wheat, GS -170 , PI663870, which would accelerate the evaluation and utilization of wheat alien recombinants in cultivar improvement (EC755279); Alien disomic substitution 1E(1A) line DGE-2 in wheat (Reg. No. GS-171, PI 663216), a unique chromosomal constitution and a unique allele Glu-E1b, DGE-2 useful in basic research (EC758755); good yield potential, grain protein levels similar to other hard red spring wheat cultivars and acceptable milling and baking characteristics (EC758756) all from USA; drought tolerant higher yielding and early maturing variety' Waagan' (EC759227) from Australia; registered lines to provide spring wheat and winter wheat breeding programs with access to genes from elite cultivars possessing the alternate growth habit (EC762316-17) from USA; registered cultivar 'Fieldstar'- combination of high yield, resistance to wheat midge, leaf rust and stem rust (EC753236) from Canada.

***Oryza sativa* (Paddy):** Salinity tolerant lines (EC733828 to 733846, EC736365 to 736471); heat tolerant (EC733948 to 733954); submergence tolerant lines (EC734714 to 734788, EC739648 to 739657) all from IRRI, Philippines; drought tolerant lines (EC752621 to 752830) from USA; lines tolerant to iron toxicity and phosphorus deficiency, resistant to brown plant hopper and bacterial blight (EC750230 to EC750257) from IRRI, Philippines; maintainer and restorer lines in paddy (EC751605 to EC751645) from IRRI, Philippines; resistance to sheath blight and blast diseases (EC758366 to EC758368) from USA.

***Sorghum bicolor* (Sorghum):** Core set (EC750258 to EC750459) from Japan.

***Ricinus communis* (Castor):** Low toxin ricin variety (EC736481) from USA.

***Carthamus* spp. (Safflower):** Breeding lines with high oleic acid content (EC755659 to EC755688) from Mexico.

***Vigna unguiculata* subsp. *unguiculata* (Cowpea)** Core collections (EC738076 to EC738278) from Italy.

Cucumber: Recombinant lines (EC738814 to EC739038) from Netherlands.

Lycopersicon esculentum: Resistant to gray leaf spot, race 1 of *Fusarium* wilt, *Tobacco Mosaic Virus,* susceptible to late blight, FW race 2, TyLCV type 1, 2, 3. (EC737661 to 737662) from Taiwan; resistant to Tomato yellow leaf curl disease, late blight, race 2 of the *Fusarium* wilt, gray leaf spot round blocky, semi determinate Type (EC753215 to 32) from Taiwan; lines resistant to Tomato yellow leaf curl disease, late blight, *Fusarium* wilt race 2, gray leaf spot, fruit shape round blocky (EC751801 to EC751813) from Taiwan.

Export of Germplasm: Requirements for germplasm from abroad were met by arranging material from different Indian sources and 1,773 samples of different crops were exported to ten countries under Standard Material Transfer Agreement (SMTA)/ Material Transfer Agreement (MTA) after the approval of DARE/ NBA. Also, 7,579 samples of ICRISAT mandate crops (FAO designated) were exported to other countries.

National Supply: A total of 6,922 samples of different crops were supplied to national users for utilization in various crop improvement programmes in the country based on requests received from research workers under MTA.

QUARANTINE OF GERMPLASM

At New Delhi, A total of 1,18,659 samples (1,01,738 processed at New Delhi and 16,921 at Hyderabad) of imported germplasm accessions as well as trial material 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 (1,511) - comprised insects (485), nematodes (127), fungi/ bacteria (805), viruses (20) and weeds (74). Of the 1,511 infested/ infected/ contaminated samples, 1,378 were salvaged through physico-chemical methods *viz*., fumigation, hot water treatment (HWT), X-ray radiography, pesticidal dip, mechanical cleaning and growing-on test. One hundred and thirty three (93 mango stones from Israel due to rotting/ decay, 39 samples of paddy from USA due to *Neovossia horrida*, one sample of *Brassica napus* from Australia due to *Phoma lingam* and one sample of *Vigna unguiculata* from Italy, heavy *Callosobruchus maculatus* infestation) were rejected. A total of 1,773 samples were processed for export of which 40 infested/ infected samples were salvaged and eight Phytosanitary Certificates were issued. Four hundred and twenty one 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 viral symptoms only was released to the indenters. Quarantine processing of 946 samples of imported transgenic planting material revealed, fungi and insect infestation in maize and rice; absence of terminator gene was ensured and all samples were salvaged prior to release. A total of 9,644 samples were received from Germplasm Conservation Division for seed health testing of which 604 samples were subjected to X-ray radiography and a total of 183 samples were rejected as they could not be salvaged.

At Hyderabad, A total of 24,500 samples consisting of 16,921 import samples and 7,579 export samples were processed for quarantine clearance and a total of 59 phytosanitary certificates were issued. Several pathogens of quarantine importance were intercepted, of these, downy mildew (*Peronospora manshurica*) of soybean from USA, *Peanut stripe virus* and bacterial wilt of groundnut (*Ralstonia solanacearum*) from Senegal are quarantine pests for India. The import samples (5,253) that were found infested/ infected with pests/ pathogens could be salvaged and released to the consignees except 43 detained/rejected samples (groundnut-38; soybean-3 and chickpea-2). In exports, 89 samples were rejected due to the association of pests/ pathogens. Quarantine service was extended to 44 organizations in South India. Post-entry quarantine inspection was conducted on 2,480 samples of different crops grown at PEQIA of ICRISAT (2,080), private industry (139 including one transgenic sample), and NBPGR greenhouse (261).

GERMPLASM CHARACTERIZATION, EVALUATION AND MULTIPLICATION

A total of 5,975 accessions of various agri-horticultural crops comprising cereals (2,341), millets (110), pulses (1,086), oilseeds (1,211), vegetables (629), underutilized crops (543), and medicinal and aromatic plants (55) were

grown at New Delhi for characterization, evaluation, regeneration and multiplication. In addition, 4,763 accessions of international nurseries comprising wheat, barley and *Triticale* were also evaluated under post-entry quarantine nursery (PEQN). A total of 1,359 accessions of various crops namely, okra (72), *Brassica* (460), black gram (197), brinjal (373), tomato (191) and cucumber (66) were raised for preliminary evaluation against important biotic stresses while in advanced screening, a total of 175 accessions comprising okra (39), *Brassica* (16), brinjal (62), pearl millet (32) and tomato (26) were screened for major diseases and insect pests. Under abiotic stresses, 145 wheat accessions were screened for terminal heat tolerance and maize (570), pearl millet (80), black gram (266) and rice bean (63) were screened for drought and heat. Under quality evaluation a total of 2,183 accessions of different crops namely rapeseed-mustard (1,084), linseed (150), amaranth (100), buckwheat (100), wheat (13), walnut (11), maize (130), faba bean (181), lentil (180) brinjal corset (168), and kodomillet (66) were analyzed for oil content and fatty acid profile, protein, sugar, minerals, amino acids, antioxidant potential and anti-nutritional factors. Under phyto-chemical evaluation, 509 samples of different medicinal and aromatic plants were analyzed for their active compounds. In the multi-location evaluation (MLE), 3,790 accessions of various crops viz., wheat (1,100), rice (915), maize (175), mustard (240), brinjal (200), okra (200), chickpea (205), pigeonpea (305) and lentil (450) were evaluated for agronomic traits, biotic and abiotic stresses and quality parameters in collaboration with AICRPs and SAUs. In pre-breeding, seven wild annual *Cicer* species were characterized for nine important morphological parameters. Hybridity of nine lentil F_1 crosses was confirmed by morphological as well as ISSR markers. Four inter-specific chickpea crosses (F_1) were confirmed using RAPD and SSR markers. Under National Initiative for Climate Resilient Agriculture (NICRA) 21,822 accessions of wheat and 18,775 accessions of chickpea germplasm were characterized at CCSHAU, Hisar and MPKV, Rahuri respectively for the development of core sets. In addition, 21,445 accessions of wheat were evaluated at Issapur Farm under two sowing dates for screening against terminal heat tolerance. Further, 20,660 accessions of wheat were evaluated against rusts and foliar diseases at IARI RS, Wellington. The details of germplasm characterized and evaluated at the various regional stations are as follows:

Akola: A total of 3,615 accessions of germplasm were characterized during 2012, out of which 388 accessions during *Kharif* 2011, 1,041 accessions during *Rabi* 2011-12 and 2,186 accessions during *Kharif* 2012. Regenerated and multiplied 2,366 accessions of germplasm for LTS/ MTS during *Kharif* 2012. These include sesame(1,175) and horse gram (1,191) accessions.

Bhowali: A total of 61 accessions were received for regeneration, characterization and maintenance. Some of the elite seed samples and live rooted plant material *viz.* horticultural crops: kiwi (2,516), kagazi nimbu (304), hill lemon (105), malta (203), M & AP and WEUPS (Wild Economically Useful Plant Species): rosemary (50,462), sweet basil (25,465), geranium (2,884), lavender (203) were supplied to different farmers/ indentors.

Cuttack: Out of 3,197 accessions of various crops grown for characterization a set of 2,123 accessions comprising cultivated rice (1,832), green gram (21), black gram (23), *Ocimum* species (47), *Mucuna pruriens* (12), wild *Oryza* species (168) and other wild relatives of crops (20) were characterized for various agro-morphological traits.

Under germplasm evaluation activity a set of 20 accessions of cultivated rice viz. IC46918, 53724, 49673, 46852, 51976, 5911, 49676, 67764, 49419, 46935, 9996, 46502, 62496, 75428, 49724, 46793, 49776, 46696, 46510, 46488 were identified as highly tolerant against leaf blast. Another set of 14 accessions of rice germplasm was identified as tolerant both for survival elongation percentage in deep water condition as compared with best check genotypes (Swarna *sub*-1 and Jalamagna)

Hyderabad: A total of 2,118 accessions of sorghum, horsegram, linseed, dolichos bean, tomato, French bean, finger millet, little millet, green gram, cowpea, chilli and brinjal were grown in the field along with appropriate checks for characterization/ evaluation/ multiplication. In addition, wild legumes including *Canavalia ensiformis, Mucuna pruriens* and *Vigna trilobata* were also raised for seed multiplication and initial characterization. Further, 559 accessions of diverse crops were characterized, evaluated and multiplied under the NAIP Biodiversity Project. A total of 47 accessions including paddy and amaranth germplasm were multiplied at the station and sent for long term conservation in the

National Genebank (NGB).

Jodhpur: A total of 195 accessions of wheat were evaluated to identify the terminal heat tolerance genotype(s) of wheat. A few genotypes exhibited encouraging results on the basis of 1000- seed weight and they are being further tested during *Rabi* 2012-13. To generate genetic variability in wheat the crosses of *Triticum aestivum x Triticum sphaerococcum*, and *Triticum durum x Triticum polonicum* were attempted. The *Summer* trials of guar, mung, moth and cowpea were introduced first time and it was found that yield of *Summer* guar was higher than customary *Kharif* gaur. During *Kharif* the 3,033 accessions of guar (1,044), pearl millet (860), mungbean (122), mothbean (192), cowpea (419), sesame (146), and castor (44) were evaluated and characterized.

Ranchi: A total of 514 accessions comprising kulthi (362), *Mucuna* (31) and *Cajanus cajan* (113) were multiplied and evaluated. A total of 669 accessions of mandate crops, namely, jack fruit, tamarind, jamun, bael, barhal, aonla, mango, *Lawsonia indica*, moringa and several medicinal and aromatic plant species were maintained in the field genebank. Accessions of *Jatropha* spp. were maintained in National Jatropha Germplasm Garden.

Shillong: During *Kharif* 2012, a total of 1,134 accessions of different agri-horticultural crops comprising paddy (350), maize (132), rice bean (106), buckwheat (55), ginger (150), turmeric (185), chilli (105) and *Perilla* (51) were characterized and 137 accessions of under-utilized crops were evaluated under replicated trials. The germplasm of rhizomatous crops, such as *Dioscorea* (46), and fruit crops *viz*. banana (60), citrus (29), guava (8), other fruits (9) and M&APs (100) have been maintained in the field genebank.

Shimla: A total of 2,979 germplasm accessions were grown during the year for characterization, evaluation and multiplication. Genetic variability for seed and pod colour, shape and size was recorded in pea, kidney bean, cowpea germplasm and also for other traits in different crops. Also screened 65 accessions of common bean against four races 3,515,598 and 529 of bean anthracnose (*Colletotrichum lindemutianum*) and IC288280, IC296478, IC448888, IC313194, IC278723, IC319423, IC398487, EC169813, EC398530 and EC500226 showed resistance to all the races. Among fruits, 137 accessions of apple (25), pear (23), peach (24), plum (31), apricot (23) and walnut (34) were characterized and evaluated for different qualitative and quantitative characters. Wide range of variability was recorded for traits like fruit colour, shape and size.

Srinagar: A total of 672 accessions comprising wheat (310), barley (264) and mustard (98) were evaluated for their morpho-agronomic characters as per the minimal descriptors during *Rabi* 2011-12 under rainfed conditions of the Himalayas. Strawberry (03), *Allium cepa* var. *proliferum* (pran) (5), mint (1), *Iris* (1), garlic (12) and *Dioscorea deltoidea* (23) are being maintained in the experimental field.

Thrissur: During *Rabi* 2011-12, 160 accessions of rice (*Oryza sativa*), 100 of horse gram (*Macrotyloma uniflorum*), 34 of cucumber, seven of *Alpinia galanga*, five of *Alpinia calcarata*, 17 of *Kaempferia galanga* and 31 of kokum were characterised/ evaluated. During *Kharif* 2012, 11 accessions of upland rice landraces, 126 of lowland rice and 30 of deepwater rice, 24 of sesame, 11 of bittergourd, 50 of teasel gourd, 27 of ashgourd and 34 of Malabar tamarind (*Garcinia cambogia*) were characterised/ evaluated. A new species of wild okra, *Abelmoschus enbeepeegearense* was described. Out of the collected germplasm, one accession of unique landrace of chilli, 59 of landraces of deep-water rice and 21 of *Oryza rufipogon* from Assam and 131 multiplied accessions mostly of forage crops and wild *Vigna* were sent for long-term storage at NGB, NBPGR, New Delhi.

GERMPLASM CONSERVATION

A total of 12,970 accessions of germplasm including varieties to be notified and released and trait-specific registered germplasm of various crops were received for long-term conservation in the National Genebank. These were processed following the international genebank standards, adding another 6,767 accessions to the base collection, raising the total germplasm holding to 3,95,753. Monitoring of seed germination and quantity in stored germplasm (8,390) and distribution (14,678) for evaluation/regeneration/research/restoration of active collections were the other priority activities. Dormancy breaking methods were standardized for *Vigna* spp. and *Solanum lasiocarpum.* Three new species of barley (*Hordeum brevisubulatum, H. brevisubulatum* subsp. *violaceum* and *H. jubatum*) and one species of wild

wheat (*Triticum fungicidum*) were procured for conservation in the National Genebank. Taxonomic validation and seed multiplication of thirty species of wild wheat accessions conserved in the National Genebank was done. Storability of seeds of 19 crops belonging to different crop groups was assessed at Chang-La (naturally cold low energy conservation conditions) and two other controlled environments *viz.* Leh and National Genebank (-18^{0}C). A total of 19 accessions with unique traits were approved for registration.

Supportive research directed towards understanding and manipulation of factors that prolong the storage life of seeds in a cost-effective manner and overcoming seed germination problems continued. Seeds of 19 crops belonging to different crop groups (cereals, grain legumes, pseudocereals, millets and forages, fibre crops, oilseeds, vegetables, fruits, medicinal and aromatic plants & narcotics, spices and condiments and agro-forestry) and conditioned to 7% moisture were monitored after one year of storage at four locations *viz.* LTS module (at -18^{0}C), inside the storage facility at Chang La, outside the chamber and at Defence Institute for High Altitude Research (DIHAR), Leh.

***In vitro/* Tissue Culture Conservation:** During the year, a total of 2,086 accessions belonging to fruit crops, bulb and tuber crops, medicinal, aromatic and rare/ endangered plants, spices, plantation and industrial crops, and others were conserved as *in vitro* cultures, under culture room conditions (25±2^{0}C; 16/8h) and/ or at low temperature (4^{0}C). The average subculture duration ranged from 3 to 24 months, depending on the species. Plantlet regeneration was achieved in new species *viz*., *Allium albidum* and *A. clarkei*. In *Picrorrhiza scrophuliflora,* cultures were conserved for 20 weeks at low temperature (5^{0}C and 10^{0}C). In *Kaempferia galanga,* encapsulated shoot bases were stored in cryovials without nutrient medium, up to 60 days at 20^{0}C and 25^{0}C (16/8h photoperiod). Cryopreservation experiments using vitrification or droplet vitrification technique, led to varying degree of pre- and post-freezing re-growth in *Allium* spp., *Gladiolus cv., Musa* sp. *and Rauvolfia serpentina.* The genetic stability assessment was carried out in post-thaw regenerated plantlets of *A. chinense* and *A. hookeri* using SSR markers. There were no significant differences between the post-thaw regenerated plants and their controls.

Cryopreservation: A total of 21 accessions comprising *Allium sativum* (10), *Dioscorea deltoidea* (4) and *Musa* sp. (7) were cryostored as shoot tips or meristems. A total of 105 accessions comprising temperate fruits and nuts, medicinal and aromatic plants, industrial crops and spices were cryostored as seeds, embryonic axes and dormant buds during the year, totalling 9,946 accessions in the cryogenebank. Periodic testing for viability of 200 accessions of orthodox and non-orthodox seeds, and 20 accessions of dormant buds of *Morus* species revealed retention of original viability in most of the accessions after 3-8 years of cryostorage.

DNA FINGERPRINTING

Microsatellite based markers were used for genetic diversity analysis of pearl millet (27 accs.), finger millet (35 varieties), maize (143 varieties), flax (94 accs.) pomegranate (45 accs.) and *Luffa* (37 accs.). Twenty one species of *Allium* and two of *Morinda* (31 genotypes) were characterized using RAPD and RAPD, ISSR, SCOT markers respectively. New microsatellite markers were developed through genomic library construction and enrichment in bitter gourd (56 loci) and finger millet (15 loci); through cross species transferability in *Crambe* and bottle gourd and from transcript sequences in *Giloe*. SSR markers were also used for molecular profiling of finger millet minicore (110), wheat (186) and rice (62). DNA fingerprinting services were rendered to various public and private organizations for fingerprinting of forty six samples of various crops.

Trait specific markers were generated for specific traits (from the identified germplasm) i.e. for *Tomato leaf curl virus* (from resistant sponge gourd), flowering characteristics (from gynoecious bittergourd lines), alkaline condition responsive genes (from wheat KRL-99), high erucic acid (from *Crambe*), oxidative stress management and zinc transporter genes in cowpea and maize and for various biotic (UG99) and abiotic (drought, salt and heat stress) in wheat. To facilitate allele mining for stress tolerance, core collections of *Cucumis*, mothbean and *Lathyrus* were designated and validated using molecular markers. Over 150 candidate genes for moisture stress tolerance were analyzed in reference sets of *Cucumis*, mothbean and *Lathyrus* and so far 394 SNPs each have been shortlisted for SNP genotyping. Transcriptome profiling for generation of genomic resources for moisture stress tolerance and allele mining from the tolerant and susceptible genotypes has resulted

in the identification of curated transcripts: 12,859 and 13,448 transcripts in *Cucumis*; 5,047 and 5,016 transcripts in mothbean and 20,992 and 19,553 transcripts in *Lathyrus.* Expression analysis in mothbean using heat tolerant genotypes indicated that mannose-o phosphate isomerase, global transcription factor, *prlli*-interacting factor G, and ribulose bis-phosphate were over expressed after 30 min treatment in tolerant genotypes. Genotyping of mothbean core collection of 250 accessions was completed using 15 SSR and 250 anonymous DNA markers. Analysis indicated presence of moderate sub-structure in the collection and will be used for association analysis along with the phenotype and SNP data. The *Lathyrus* core set of 295 accessions was genotyped with 255 polymorphic markers and estimation of population sub-structure was completed for use in association analysis. Towards QTL localization for improvement of oil quality and yield in sesame, two sesame accessions with high sesamin contents were identified along with associated SNPs and InDels. Thirty of these were used for genotyping the RILs for mapping. Analyses of SNP variation and corresponding differences in fatty acid profiles led to identification of three single nucleotide polymorphisms in desaturase genes which appear to be responsible for changes in secondary structure of the desaturase proteins. These are being further validated. Sesame recombinants with more than 2 per cent higher linoleic acid (18:2) contents were identified.

Relationships among six species of the genus *Luffa* were studied based on nuclear internal transcribed spacer (ITS) sequences and chloroplast maturase K sequences and studies on ntragenomic variation and Haplotypes of Internal Transcribed Spacer region (ITS) in *L. acutangula* L. (Roxb.) Cucurbitaceae were carried out. Studies on Biosystematics and molecular phylogeny of *Vigna, Cucumis* and *Abelmoschus* were continued. Seed micro-morphology of *Vigna* genus was observed to be helpful in establishing identities of species, and consequently a new species was described, *viz. Vigna indica*. Based on molecular phylogeny, the identity and taxonomic status of some taxa like *Vigna trilobata, V. stipulacea, V. hainiana, V. dalzelliana, V. minima; Cucumis callosus, C. melo* var. *agrestis, C. hystrix, C. muriculatus,* and *Abelmoschus manihot* and their subspecies have been assessed and taxonomic confusions have been removed. In *Abelmoschus*, analysis of 16 genomic regions indicated role of at least three species, *A. moschatus, A. tetraphyllus* and *A. tuberculatus* in the origin of okra. The work accomplished included analyses of 101 samples of 10 *Abelmoschus* species for the loci, *ITS-1, ITS-2, trnL-F, trnL exon, rbcL, rpoC1, psbA-trnH, nad B, rps14 –cobr,* trnC-D, atp F-H, trn E-T, matK, rbcL, rpl intron and nad1. *A. enbeepeegearense* J John, Scariah, Nissar, KV Bhat *et* Yadav, a new species from the low elevation Western Ghats of India comprising Kerala, Karnataka and Tamil Nadu was described.

In bioinformatics, an in house designed search algorithm was applied and an efficient Degenerate PCR Primer design tool was developed for amplification of orthologs from even distantly related species. The tool is available for free public use at: http://192.168.1.5/Dgen/DGEN_tool/index.html.

Qualitative and quantitative PCR/ real-time PCR assays have been developed for detection of *Bt* Brinjal event EE1 and 10 GM maize events. Molecular testing of 1,149 imported transgenic accessions of GM maize, rice, cotton, cabbage and *Arabidopsis* has been completed. Monitoring for adventitious presence of transgenes in *ex situ* cotton collection conserved in National Genebank using PCR based diagnostics was conducted. Under ISO/IEC 17043:2010, GM detection laboratory has successfully executed three proficiency testing for testing the unknown GM contents of different GM maize events in the test samples. NBPGR also successfully participated in the ring trial to validate two real-time PCR methods to check contamination in GM rice.

OTHER ACTIVITIES

- Meetings of the Institute Management Committee, Research Advisory Committee and Institute Research Council were held timely to review the progress of work related to PGR management and planning strategies for strengthening various activities and infrastructure/facilities to achieve the targets.
- The scientists, research associates, technical and administrative staff from the headquarters and its regional stations/ centres participated in a number of seminars, symposia, conferences, workshops, trainings and summer institutes to exchange ideas and upgrade their skills. Eleven scientists were sent abroad to participate in foreign meetings. Details of these participations are given in Chapter 20 on General Information.

- Several distinguished scientists, administrators, policy makers, farmers and students visited the National Genebank, DNA Fingerprinting labs, plant quarantine glasshouses, National Containment facility (CL-4 level) and tissue culture labs at the headquarters and field genebanks at Issapur, Akola, Bhowali, Cuttack, Hyderabad, Jodhpur, Ranchi, Shillong, Shimla and Thrissur.
- **Symposia/ Workshops/ Trainings/ Brain-storming sessions Organized by NBPGR**:
- A two days training programme on "Vegetable Seed Production" under UPASK at NBPGR from January 23- 24, 2012 at Regional Station, Bhowali
- A two day's training programme on "Herbal Plants – M&AP" under UPASK from January 27- 28, 2012 at NBPGR, R/S Bhowali
- Workshop and Training on "Gene Expression Data Analysis and Structural Bioinformatics" from March 1- 11, 2012 at NBPGR, New Delhi
- A Model Training Course on "Role of Underutilized and Neglected Plant Genetic Resources in Health and Nutritional Security" from March 12- 19, 2012 at NBPGR, New Delhi
- Training on "Conservation of Plant Genomic Resources" from March 12- 25, 2012 at NBPGR, New Delhi
- "All India Plant Breeders Meet" on May 3- 4, 2012 at NBPGR, New Delhi
- National Workshop cum training on "Computational Genome Analysis Techniques in Discovery of Agronomically Important Crop Genes" from September 24- 29, 2012 at NBPGR, New Delhi
- "Bioinformatics Software Training & Sensitization Workshop" from October 19- 25, 2012 at NBPGR, New Delhi
- **Field Days Organized**: At Issapur Experimental Farm and IARI, New Delhi, Five Germplasm Field Days on *Rabi* oilseeds, *Rabi* pulses, maize and okra were organized to promote germplasm utilization by the plant breeders/ research workers. Wheat Germplasm Week from March 22- 28, 2012 was organized at four locations comprising NBPGR Experimental Farm, Issapur, on March 22; NBPGR Post Entry Quarantine Nursery (PEQN), New Delhi on March 23; NBPGR New Area Farm (IARI), New Delhi on March 24 and at CCS HAU, Hisar on March 26- 28, 2012. Field days on various crops were also conducted at Regional Stations *viz.,* Akola, Hyderabad, Jodhpur and Thrissur for the benefit of breeders. Germplasm Advisory Committee meetings of various crop groups were organized under the expert guidance of crop specialists.
- **Germplasm Registered:** Out of 99 proposals considered 19 were approved for registration by the Plant Germplasm Registration Committee.
- **Publications:** NBPGR Annual Report and quarterly Newsletter were published and distributed to all concerned with PGR management. Besides, research papers (138) on various subjects were published in national and international journals; book chapters/ review articles (48) in various edited books/ manuals/ annual review/ teaching aids (6); crop catalogues (1); and popular technical articles/ technical bulletins in Hindi/ English (47) were published by the scientists of the NBPGR (details are given in chapter 20).

INTRODUCTION

The National Bureau of Plant Genetic Resources, commonly known as NBPGR was established by the Indian Council of Agricultural Research (ICAR) in 1976 with its main campus at New Delhi. Being the nodal organization in India it has been given the national mandate to plan, conduct, promote and coordinate all activities concerning plant exploration and collection and also for safe conservation and distribution of both indigenous and introduced genetic variability in crop plants and their wild relatives. The Bureau is also vested with the authority to issue Import Permit and Phytosanitary Certificate and conduct quarantine checks on all seed materials and plant propagules (including transgenic material) introduced from abroad or exported for research purpose.

NBPGR: Mandate and Objectives

Mandate

To act as nodal institute at national level for acquisition and management of indigenous and exotic plant genetic resources (PGR) for food and agriculture, and to carry out related research and human resource development for sustainable growth of agriculture.

Objectives

1. To plan, organize, conduct and coordinate exploration and collection of desired indigenous and exotic PGR.
2. To undertake introduction, exchange and quarantine for augmenting PGR.
3. To characterize, evaluate, document and conserve crop genetic resources and promote their use in collaboration with other national organizations.
4. To develop genomic resources and tools, to discover and validate the function of genes of importance to agriculture and to develop bioinformatics tools for enhanced utilization of genomic resources.
5. To develop information network for effective utilization of PGR.
6. To conduct research, undertake teaching and training, develop policy guidelines and create public awareness on PGR.
7. To promote use of PGR for sustainable agriculture at international level.

Besides having a 40 ha experimental farm at Issapur village (about 45 km west of Delhi), the Bureau also has a network of 10 regional stations/ base centre's that provide access to representative agro-ecological situations in the country. It has strong linkages with leading crop-based Institutes, National Research Centers. All India Coordinated Crop Improvement Projects, State Agricultural Universities and other stakeholders. NBPGR also works in close collaboration with several international institutes/ organizations through memoranda/ work plans developed under bilateral/ multilateral agreements. The Bureau not only provides genetic resources to on-going crop improvement programmes to sustain continued advances in agricultural productivity and stabilize production, but also conserves them safely to meet needs of future generations.

Organizational Set-up

The Director, NBPGR is overall in-charge of administration, research management and coordination. The Institute Management Committee, Research Advisory Committee, Crop Advisory Committees and the Institute Research Council play important roles. 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) Geromic Resources. The Bureau has units of Germplasm Exchange, Tissue Culture and Cryopreservation (TCCU), PGR and Policy Planning (PPU) and Agricultural Knowledge Management (AKMU). A Principal Scientist/ Senior Scientist Heads each Division/ Unit.

Other centralized services include units of Administration and Management, Purchase, Stores, Maintenance, Audit and Accounts, Security and Library. Regional Stations/ Base Centres, headed by a Principal Scientist/ Senior Scientist, are located at Akola, Shimla, Bhowali, Shillong, Jodhpur, Hyderabad, Thrissur, Srinagar, Ranchi and Cuttack. It also houses an All India Coordinated Network Research Project on Under-utilized Crops. The total sanctioned staff strength is 354 comprising 117 scientific, 94 technical, 57 administrative and 86 supporting staff.

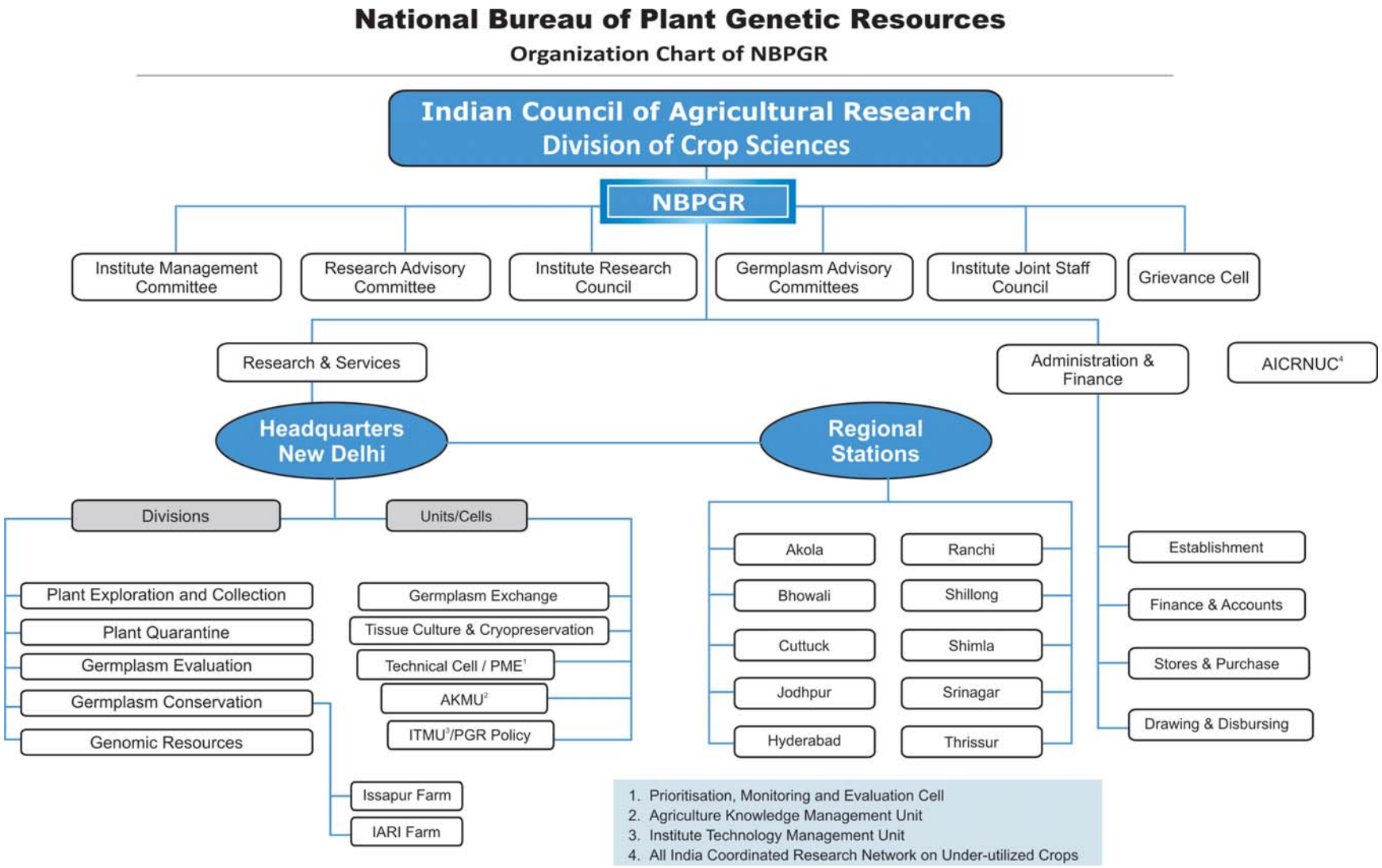


Fig 1. Organizational setup of NBPGR

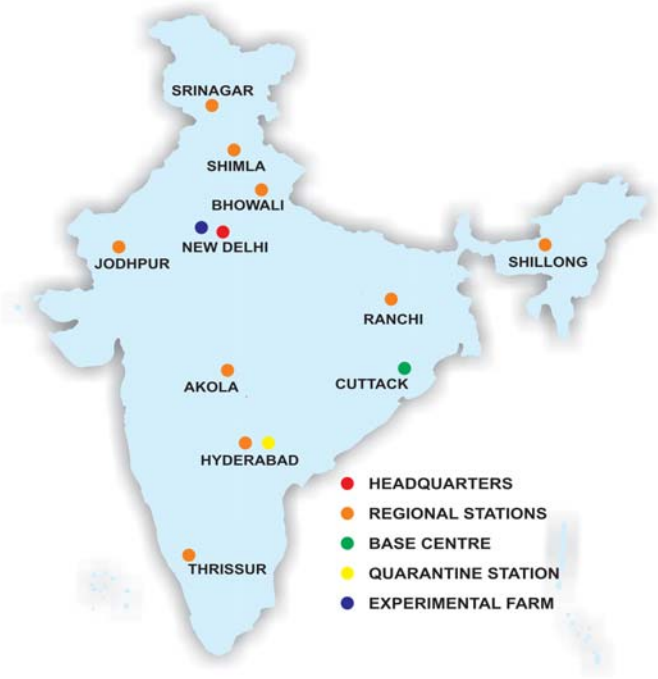


Figure-2: NBPGR Network in India

National Genebank

The National Genebank was established by the Council at NBPGR to conserve national heritage of germplasm collections in the form of seeds, vegetative propagules, tissue/ cell cultures, embryos, gametes etc. Based on experiences gained from working with a built-in cold storage vault obtained from UK in 1983, four modules (two units of 100 m^3 and two of 176 m^3 capacity) were installed for long-term storage of seeds of orthodox species kept in laminated aluminium foils at -18^{0}C after drying them to 5-7% moisture content. Stand-by diesel generator backs up the electricity supply. Vegetatively propagated clonal materials and recalcitrant seeds species are being maintained under field conditions backed up by tissue culture repositories. The Bureau has a strong programme on *in vitro* conservation and cryopreservation.

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 base collections for long-term storage. Its cryopreservation facility contains six liquid nitrogen tanks (cryo-tanks), each containing 1000 litres of liquid nitrogen. These six cryo-tanks have a total capacity to store 0.25 million samples. Thus, the National Genebank has a total capacity to store 0.85 to 1.25 million samples. This is one of the most modern Genebanks in the world.

Indian National Plant Genetic Resources System (INPGRS)

NBPGR is gradually developing and strengthening the national plant genetic resources system by linking up the National Base Collection (kept under long-term storage at NBPGR) with 57 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.

International Collaboration

NBPGR implements work plans developed under MoU between ICAR and Bioversity International. FAO and Biodiversity International also sponsor regional training courses on conservation and utilization of genetic resources of local crops of agricultural importance in South Asia and adjoining regions to be conducted by NBPGR.

Besides working closely with Bioversity International, NBPGR also collaborates actively with the International Agricultural Research Centers (IARCs) like ICRISAT, IRRI, ICARDA and CIMMYT. It exchanges 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 advanced training programmes focusing on scientific procedures for collection, exchange, quarantine/ biosecurity, biosafety, bioinformatics, DNA Fingerprinting, evaluation, documentation and conservation linked to use of plant genetic resources. Major accomplishments of its staff are published in Annual Reports. NBPGR Newsletter is brought out quarterly. Crop Catalogues based on computerized data are also developed and published. Bureau's library at Headquarters specialized in information dealing with plant genetic resources and also subscribes to foreign and national journals.

Post-graduate Teaching Programme

Since academic session 1997, Bureau is undertaking teaching in plant genetic resources leading to M.Sc.

degree linked with Post Graduate School, IARI, New Delhi. From the academic session 2004-2005, a Ph.D. degree programme in plant genetic resources has also started in collaboration with the Post Graduate School, IARI, New Delhi.

Extension Services for PGR Awareness

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 grass root level workers, tribal people, and farmers (particularly women) by organizing biodiversity fairs in villages. Students on educational tours from State Agricultural Universities are invited to visit the National Genebank, DNA Fingerprinting, tissue culture and quarantine labs, plant quarantine glass houses/containment facility at New Delhi.

Funds allocated and expenditure incurred during the financial year 2012-13

(Rs. In Lakh)

Non-Plan 2012-13			
A. Recurring	**Budget Estimate**	**Revised Estimate**	**Expenditure**
Pay & Allowance	2978.00	3413.00	3282.92
OTA	0.00	0.00	0.00
TA	7.00	8.00	8.00
HRD	2.00	2.00	2.00
Contingency	229.00	440.73	425.43
Total (A)	**3216.00**	**3863.73**	**3718.35**
B. Non Recurring			
Equipment	16.00	33.00	24.53
Works	175.00	235.00	235.00
Library	2.00	2.00	1.97
Total (B)	**193.00**	**270.00**	**261.50**
Grand Total	**3409.00**	**4133.73**	**3979.85**
Plan 2012-13			
A. Recurring	**Budget Estimate**	**Revised Estimate**	**Expenditure**
Pay & Allowance	0.00	0.00	0.00
OTA	0.00	0.00	0.00
TA	24.01	25.00	25.00
HRD	2.00	3.00	3.00
Contingency	890.00	947.00	946.98
Total (A)	**916.01**	**975.00**	**974.98**
B. Non-Recurring			
Equipment	250.00	16.96	16.96
Works	200.00	43.04	43.04
Library	20.00	20.00	19.99
Land	0.00	0.00	0.00
Vehicles	0.00	0.00	0.00
Livestock	0.00	0.00	0.00
Others (Specify)	0.00	0.00	0.00
Total (B)	**470.00**	**80.00**	**79.99**
Total (a+b)	**1386.01**	**1055.00**	**1054.97**
NEH	80.00	10.00	9.90
TSP	66.39	35.00	34.76
Grand Total	1532.40	1100.00	1099.63

AICNP 2012-13			
	Budget Estimate	**Revised Estimate**	**Expenditure**
TA			1.79
Contingency			1.28
Funds Released to Centres	256.17	330.00	326.07
Total	**256.17**	**330.00**	**329.14**

1. PLANT EXPLORATION AND GERMPLASM COLLECTION

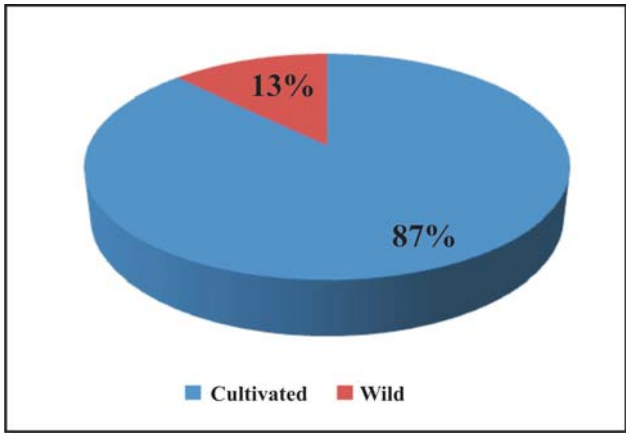
Summary: A total of 37 explorations were undertaken across the country and 1,970 accessions of various agri-horticultural crops, their wild relatives and other economic plants were collected. Of these, 458 accessions were collected by NBPGR headquarters, New Delhi through nine explorations. A total of 288 herbarium specimens, 73 seed samples and 29 economic products were processed and added to the National Herbarium of Cultivated Plants (NHCP).

1.1. Plant Exploration and Germplasm Collection

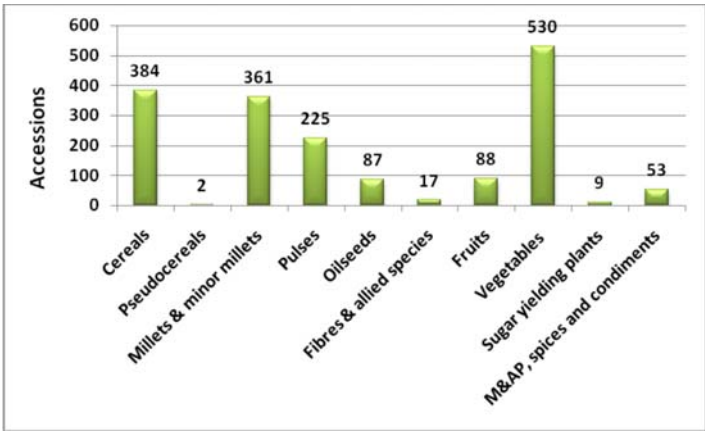
During the year 2012, a total of 37 explorations were undertaken and 1,970 accessions of different agri-horticultural crops comprising 1,714 accessions of cultivated and 256 of wild species including wild relatives of crop plants were collected from parts of Andhra Pradesh, Arunachal Pradesh, Assam, Gujarat, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh and West Bengal in collaborative mode involving crop-based institutes/ State Agriculture Universities (SAUs)/ Krishi Vigyan Kendras (KVKs), etc. across the country. Details of explorations undertaken and germplasm collected are given below (Table 1).

Table 1: Total explorations undertaken and germplasm collected

Headquarters/ Regional Stations/ Base Centres	Explorations undertaken	Accessions collected
Jodhpur (Arid region)	2	135
Thrissur (Southwest coastal region)	2	115
Cuttack (Humid/ moist tropical east coastal region)	3	174
Shillong (Northeast Hill region)	3	185
Bhowali (Central Himalayan region)	4	124
Shimla (Northwest Himalaya and high altitude region)	2	86
Srinagar (Northwest Himalaya and high altitude region)	2	66
New Delhi (Northwest plains)	9	458
Ranchi (Sub-tropical humid region)	2	160
Akola (Central Indian region)	2	111
Hyderabad (Southeast coastal region)	6	356
Total	**37**	**1,970**



Germplasm collected (%) in cultivated and wild



Germplasm collected in different crop groups species

1.2 Explorations undertaken by Headquarters

Nine explorations were undertaken in parts of North East region (Arunachal Pradesh, Assam, Manipur and Sikkim), Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal and a total of 458 accessions (cultivated: 389 accessions and wild: 69 accessions) of different agri-horticultural crops were assembled (Table 2). The details of areas explored and germplasm collected during explorations are given below:

Table 2: Explorations undertaken by the Headquarters

Areas explored/ diversity collected	Collaborator(s)/ Facilitator(s)	Duration	No. of accessions		
			Cult.	Wild	Total
Leafy *Brassica* from parts of Arunachal Pradesh	ICAR Research Complex, Basar, DRMR, Bharatpur	Febraury 14 to 28	85	-	85
Minor fruits from parts of Madhya Pradesh and Uttar Pradesh	-	April 23 to 30	-	31	31
Cucurbitaceous vegetables (cult. & wild) from parts of Manipur	Central Agricultural University (CAU), Imphal	September 27 to October 7	48	06	54
Vegetables (chilli, brinjal and cucurbits) from parts of West Bengal	Bidhan Chandra Krishi Vishwavidhyalaya, Kalyani	October 1 to 10	87	-	87
Cucurbitaceous vegetables (cult. & wild) from parts of Sikkim and West Bengal	Indian Institute of Vegetable Research (IIVR), Seed Production Centre, Kushinagar	October 11 to 22	50	14	64
Paddy landraces from parts of West Bengal	-	October 26 to November 6	39	03	42
Crop landraces and wild relatives from parts of Assam	-	November 16 to 25	28	07	35
Crop landraces and wild relatives from parts of Tamil Nadu	Tamil Nadu Agriculture University (TNAU), Coimbatore	November 24 to 21 December 12	08	29	
Citrus from parts of Manipur	-	December 10 to 21	31	-	31
Total	**389**	**69**	**458**		

1.2.1 Leafy mustard collection from parts of Arunachal Pradesh: A total of 85 accessions comprising of *Brassica juncea* subsp. *rugosa* (71), *B. rapa* var. *toria* (13) and *B. rapa* subsp. *chinensis* (1) were collected from parts of West Siang, East Siang, Lower Subansiri and Papum Pare districts of Arunachal Pradesh in collaboration with ICAR Research Complex, Basar and DRMR, Bharatpur. Variability was observed in leafy mustard for leaf colour (pale green, dark green, purplish green), size (10-80 cm in length) and maturity period (medium to very late). Besides, cut-leaf mustard (*B. juncea* subsp. *integrifolia*) was an interesting collection made from East Siang district.

1.2.2 Tropical minor fruits from parts of Madhya Pradesh and Uttar Pradesh: Thirty one accessions in different tropical minor fruits comprising *Aegle marmelos* (7), *Carissa carandas* (1), *Diospyros melanoxylon* (1), *Manilkara hexandra* (21) and *Pithecellobium dulce* (1) were collected from parts of Chitrakoot, Lalitpur and Banda districts of Uttar Pradesh and Ashok Nagar, Tikamgarh and Gwalior districts of Madhya Pradesh. Local types varying in fruit size and rind thickness in *A. marmelos* and fruit shape and taste in *M. hexandra* were among the collected germplasm.

Profuse bearing in *Aegle marmelos* from Tikamgarh, Madhya Pradesh

1.2.3 Vegetable germplasm collection from parts of West Bengal: An exploration was undertaken in collaboration with BCKV, Kalyani, West Bengal for

collection of local diversity in chilli, brinjal and cucurbitaceous vegetables (87) from parts of Nadia, Murshidabad, 24-Parganas and Hoogly districts in West Bengal. The taxa collected were *Benincasa hispida* (10), *Capsicum annuum* (3), *Cucumis sativus* (11), *Cucurbita moschata* (9), *Lablab purpureus* (9), *Lagenaria siceraria* (15), *Luffa acutangula* (15), *L. aegyptiaca* (1), *Momordica charantia* (4), *Solanum melongena* (7) and *Trichosanthes anguina* (3). Variability was observed in fruit shape and size in ash gourd, bottle gourd, brinjal, chilli and cucumber.

1.2.4 Collection of paddy landraces from West Bengal: A total of 42 accessions comprising *Oryza sativa* (33), *O. rufipogon* (2), and *O. nivara* (1) and others such as *Vigna mungo* (4), *V. radiata* (1) and *Corchorus olitorius* (1) were collected from parts of Malda, Dakshin and Uttar Dinajpur districts of West Bengal. Variability was observed in paddy mainly for plant height, kernel colour, shape, size, presence/ absence of awns and aroma, which included some important local landraces *viz. Gujininia, Desi mansuri, Chini atap, Jeera shal, Gauchi, Kala mogha, Bini dhan* (awnless), *Kala nunia* (husk colour black), *Tulai panja, Gogal shal* and *Nagra dhan* (awned).

1.2.5 Collection of cucurbits germplasm from Manipur: Fifty four accessions comprising of *Benincasa hispida* (2), *Cucumis hystrix* (1), *C. melo* (1), *C. sativus* (13), *Cucurbita moschata* (10), *Lagenaria siceraria* (4), *Luffa aegyptiaca* (7), *Momordica charantia* (4), *M. subangulata* subsp. *renigera* (2), *Trichosanthes anguina* (4), *T. bracteata* (2), *T. cordata* (1), *T. dioica* (1) and *T. wallichiana* (2) were collected from parts of Imphal East, Imphal West, Bishnupur, Thoubal, Churachandpur, Ukhrul and Tamenglong districts of Manipur in collaboration with Central Agricultural University (CAU), Imphal, Manipur. Variability was observed in fruit size, shape (oblong, cylindrical, clavate), skin colour at ripening (greenish yellow, yellow, golden yellow, brown-netted) and flesh colour

Variability in cucumber collected from Manipur

***Trichosanthes wallichiana* from Sikkim**

Variability in cucumber from Hailakandi, Assam

(white, pale yellow, orange) in cucumber. Variability was also observed in other cucurbits (pumpkin, sponge gourd, bottle gourd) for fruit shape, size and colour. In ash gourd, germplasm having elongate fruits and small seeds was an interesting collection made from Tamenglong district.

1.2.6 Collection of cucurbits germplasm from Sikkim and West Bengal: A total of 64 accessions comprising of *Benincasa hispida* (2), *Cucumis sativus* (8), *Cucurbita maxima* (8), *C. moschata* (9), *Gymnopetalum chinense* (1), *Lagenaria siceraria* (6), *Luffa acutangula* (3), *L. aegyptiaca* (4), *Momordica charantia* (3), *M. subangulata* subsp. *renigera* (4), *Trichosanthes anguina* (3), *T. bracteata* (5), *T. himalensis* (1), *T. lepiniana* (2) and *T. wallichiana* (5) were collected from parts of East, West and South districts of Sikkim and Darjeeling district of West Bengal in collaboration with IIVR Seed Production Centre, Kushinagar, Uttar Pradesh. Variability was observed in fruit weight, shape (globose, oblong, elongate-drum shaped, oblate), skin colour (deep green, pink, reddish-orange, ashy green), flesh colour (yellow, deep yellow, orange) in *Cucurbita maxima* and for shape, size and fruit colour in *C. moschata*.

1.2.7 Collection of crop landraces and wild relatives from Assam: A total of 35 accessions comprising *Abelmoschus tetraphyllus* var. *pungens* (1), *Cajanus cajan* (6), *Cucumis sativus* (1), *Dioscorea esculenta* (1), *Luffa acutangula* (1), *L. aegyptiaca* (1), *Oryza sativa* (8), *Momordica dioica* (1), *Ocimum americanum* (2), *O. sanctum*

(5), *Sesamum indicum* (1), *Trichosanthes cordata* (1), *T. cucumerina* (2), *Vigna umbellata* (1) and *Zea mays* (2) were collected from parts of Cachar, Dema Hasao and Hailakandi districts of Assam. Variability was observed in pigeon pea for flower colour (yellow, orange), grain colour (white, brownish) and in paddy for husk colour, grain colour, shape, size and aroma which included some named local landraces *viz. Khoi beroin, Kalajiri*, *Pani beroin, Gandi beroin*, *Sembra, Kalasahi* and *Aizong*. In cucumber, an interesting collection having round fruit with reddish brown netted skin and yellowish flesh was made from Hailakandi district.

1.2.8 Collection of crop landraces and wild relatives from Tamil Nadu: A total of 29 accessions comprising *Abrus precatorius* (1), *Amaranthus tricolor* (1), *Cajanus cajan* (1), *Capsicum annuum* (1), *Citrullus colocynthis* (2), *Cucumis melo* var. *momordica* (2), *Echinochloa colona* (1), *Lagenaria siceraria* (1), *Luffa aegyptiaca* (1), *Momordica charantia* var. *muricata* (1), *Ocimum sanctum* (2), *Oryza sativa* (6), *Plectranthus caninus* (1), *Sesamum indicum* (1), *Sesbania grandiflora* (1), *Solanum melongena* (4), *Sorghum bicolor* (1) and *Vigna mungo* (1) were collected in areas adjacent to Kalakkad-Mundanthurai Tiger Reserve (KMTR), Tirunelveli district of Tamil Nadu in collaboration with Tamil Nadu Agricultural University (TNAU), Coimbatore. Variability was observed in shape, size and colour of grains in paddy.

1.2.9 Citrus germplasm collection from Manipur: Thirty one accessions comprising of *Citrus grandis* (2), *C. macroptera* (3), *C. medica* (7), *C. megaloxycarpa* (1), *C. reticulata* (6), *C. sinensis* (3) and *C. jambhiri* (9) were collected from parts of Bishnupur, Thoubal, Ukhrul, Chandel, Churachandpur districts of Manipur. Variability was observed in fruit shape, size, taste and TSS content.

Profuse bearing in *Citrus jambhiri* '*Kachai lemon*' from Ukhrul, Manipur

1.3 National Herbarium of Cultivated Plants

A total of 288 herbarium specimens,73 seed samples and 29 economic products were processed and added to the National Herbarium of Cultivated Plants (NHCP), taking the existing collection to 20,991 herbarium specimens (representative of 3,962 species belonging to 1,466 genera and 265 families), 3,007 seed samples and 633 economic products. During the period under report, digital images were made of 54 taxa added that were not earlier represented in the NHCP as herbarium specimens.

Herbarium specimens/ samples added through explorations included *Solanum lasiocarpum*, *Piper attenuatum*, *Albizia lucidior*, *Allium hookeri*, *Cucurbita ficifolia*, *Parkia timoriana*, *Camellia sinensis* var. *assamica*, *Trichosanthes* spp. and *Garcinia sopsopia* from north eastern region (Arunachal Pradesh, Assam, Manipur, Meghalaya and Nagaland), and *Cymbopogon caesius* from Maharashtra. Material received from regional stations included wild *Eruca sativa* from Bhowali, Uttarakhand; and 'type specimen' of *Abelmoschus enbeepeegearense* and *Momordica subangulata* subsp. *renigera* from Thrissur, Kerala. Specimens were added from material maintained in the field at CAZRI and NBPGR RS, Jodhpur, Rajasthan (64) of *Acacia* spp. (4), *Moringa concanensis* and cultivars of *Ziziphus mauritiana* (5). Specimens were made of material under study in experimental culture of *Aegilops* spp. (9), indigenous and exotic legumes (16) *viz. Vigna marina*, *Lablab purpureus, Cicer* spp. and *Sesbania grandiflora*, vegetables *Allium cepa* var. *aggregatum* (9) from peninsular region, NEH and north western Himalaya (11), *Abelmoschus* spp. (17), *Allium chinense* (2) from NEH, *Capsicum chinense* (1), *Cordia dichotoma* (1) and a local type 'Tikri ber' *Ziziphus mauritiana* (2). Voucher specimens of registered material of *Camellia sinensis* (HS20915), and collections made under collaborative programmes *viz. Rubus ellipticus* (HS20928) from Himachal Pradesh, *Solanum melongena* (HS20932) wild types from Tamil Nadu and *Podophyllum hexandrum* (HS20933) from Uttarakhand were added.

Authentication certificates (45) for a total of fifty six taxa were issued to students/ researchers. Seven groups

of students and researchers were provided technical know-how on herbarium processing, preparation and maintenance of specimens and samples.

1.3.1 Digitization of National Herbarium of Cultivated Plants: Digital scans/ close-up images of selected plant parts were added in fruit, vegetable and millet taxa; data on characters observed/ recorded by collectors in the field but lost on drying, and voucher details of materials collected along with the unique identity (collector's number, indigenous or exotic number, IC/EC, etc.) were also included. Some of the important material related to crop taxa (belonging to major crop categories) represented in the NHCP were identified; some rare introductions into India were represented *viz. Sorghum bicolor* (low grain yielding and sweet stemmed *ankolib* type); *Macadamia integrifolia* (Macadamia nut), *Malpighia emarginata* (Barbados/ West Indian cherry), *Malus manshurica* (Manchurian apple/ Siberian crabapple), *Passiflora gracilis* (Crinkled passion flower, only annual *Passiflora* species), *Prunus japonica* (Oriental bush cherry) and *Vitis rotundifolia* (Muscadine) among fruits; among indigenous species, less known wild relatives of crops such as *Vitis jacquemontii* (wild relative of wine grape) and *Morus australis* (Japanese mulberry), and threatened species *Diospyros condolleana* among fruits.

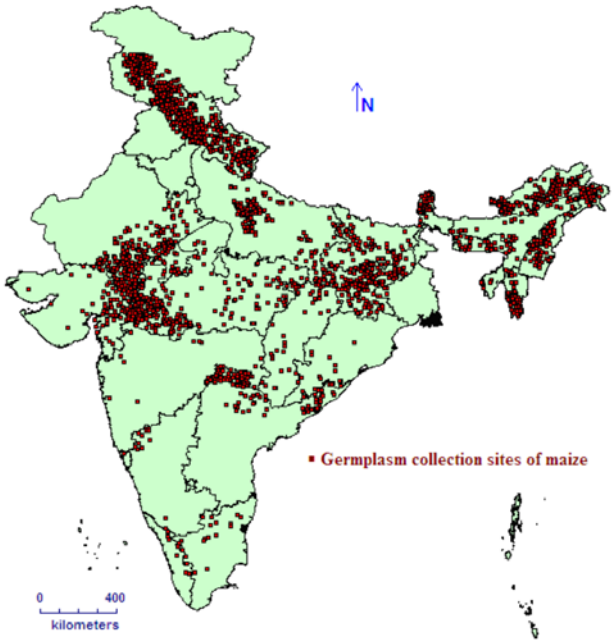
1.4 Biosystematic Studies

***Allium* spp.:** During the period under report a total of 31 accessions of different species of *Allium* were raised under experimental condition in Delhi and Bhowali. Recording of data on morphological characters was continued on newly collected germplasm of *Allium viz. A. ampeloprasum*, *A. cepa* var. *cepa*, *A. cepa* var. *aggregatum*, *A. chinense*, *A. hookeri*, *A. tuberosum* and *A. sativum* (Burma type) from Manipur. Variability was recorded in *A. chinense* (6) from north-eastern Himalaya and *A. cepa* var. *aggregatum* (12) from western, eastern Himalaya and south India. Bulbils and live plant of a cultivated species of *Allium* collected from district Solan, Himachal Pradesh were studied, grown and identified as *A. ampeloprasum* var. *ampeloprasum*.

***Trichosanthes* spp.**: Twenty seven accessions representing eight taxa, *viz*., *Trichosanthes cucumerina* var. *anguina*, *T. bracteata*, *T. lepiniana*, *T. wallichiana*, *T. dioica*, *Gymnopetalum chinense*, *T. cordata* and *T. himalensis* were collected from Manipur, Sikkim and Darjeeling areas, the last two being collected first time. Field study on a rare endemic species namely *T. nervifolia* (close to snake gourd) and *Gymnopetalum tubiflorum* was done at Kalakkad-Mundanthurai Tiger Reserve (KMTR), Tamil Nadu. Experimental study of characters of taxonomic significance in 10 taxa (36 accessions) was undertaken. Herbarium specimens (800) of *Trichosanthes* and *Gymnopetalum* (about 20 taxa) represented at the Central National Herbarium, Botanical Survey of India, Kolkata were studied. Diagnostic key characters for distinguishing three taxa in *T. cucumerina* complex namely *T. cucumerina* var. *cucumerina* (syn. *T. lobata*), *T. cucumerina* var. *anguina* and *T. villosula* (syn. *T. perrottetiana*) have been worked out.

1.5 Documentation of Diversity Collected in Different Agri-horticultural Crops of India

Mapping of collected diversity in maize (over 6,000 accessions) was done using passport data gathered, which indicates that maximum collections were assembled mainly from north-eastern, north-western Himalayan regions, western and eastern plains. All maize growing areas have been surveyed in the past and diversity augmented from different parts of the country. Based on gaps identified, trait specific germplasm including local types need to be assembled from western Himalayas and Peninsular India.



Collection sites of maize

1.6 Documentation of Information on Local Uses

During explorations information related to local use of plant genetic resources was recorded.

- *Homalomena aromatica* (Vern. *Pankhok kondolee*/ *Gandi-kachhu*): Young leaf stalks are cooked as vegetable after peeling; they have medicinal value for paralysis and arthritis/joint pain. Luke warm leaf stalk juice is dropped in ear to treat earache. This plant is being exploited through uprooting in large quantity (Rs 25/- per kg are paid to villagers for uprooting) in Cachar district of Assam.

- *Cajanus cajan* (Vern. *Mayong*): Crushed young leaf juice with warm water is given in treatment of jaundice and mouth sores in Cachar and Hailakandi districts of Assam.

- *Ocimum sanctum* (*Tulsi*): Leaf juice is applied on cuts and wounds to check bleeding. Leaf juice is also dropped in eyes to cure conjunctivitis and other eye infection. On occasion of Ekadashi (eleventh lunar day of the bright or dark fortnight of lunar month in the Hindu calendar), the plant is decorated as bride and worshipped for prosperity.

- *Urginea indica* (Vern. *Ban-pyaj*): The paste of corm is mixed with 8-10 chilies and ginger for flatulence in cattle (in severity it should be given within 1-2 hrs period) in Hailakandi district, Assam.

- *Ocimum americanum*: Grown in kitchen garden and its leaves are used for making chutney by Khasi people in Hailakandi district, Assam.

- *Cucumis sativus*: Ripe fruits are boiled and offered to weak person and those suffering from jaundice.

- *C. hystrix:* Boiled fruits are used in liver related problems in Churachandpur district, Manipur.

- *Trichosanthes* spp. (Vern. *Indrayani*): Fruit paste is applied over wounds, mumps and swellings in West Sikkim.

Research Programme (Programme Code: Title, Leader)

PGR/PGC-BUR-01.00: Exploration for collection of germplasm of agri-horticultural crops, maintenance of herbarium and biosystematic and ethno-botanical studies (**DC Bhandari**)

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

PGR/PGC-BUR-01.01: Exploration for collection of genetic resources of agricultural crops and their wild relatives (**DC Bhandari,** KC Bhatt, Anjula Pandey, DP Semwal and NS Panwar)

PGR/PGC-BU**R-01.02: Exploration for collection of genetic resources of horticultural crops and their wild relatives (**Rakesh Srivastava (up to April 30, 2012), **SK Malik,** E Roshini Nayar and Rakesh Singh).

PGR/PGC-BUR-01.03: Exploration for collection of medicinal and aromatic plants diversity from different phyto-geographical regions (**KC Bhatt,** RC Misra, DP Semwal, Rakesh Singh and NS Panwar).

PGR/PGC-BUR-01.04: National Herbarium of Cultivated Plants (NHCP), establishment, maintenance, build-up and taxonomic studies on crop plants (**E Roshini Nayar,** Anjula Pandey, K Pradheep and Rita Gupta).

PGR/PGC-BUR-01.05: Genetic resources and systematic studies of Alliaceae in India: *Allium* (**Anjula Pandey,** KS Negi, K Pradheep and Rita Gupta)

PGR/PGC-BUR-01.06: Genetic resources and systematic studies of Cucurbitaceae in India: *Trichosanthes* (**K Pradheep,** KC Bhatt, DR Pani and Rakesh Singh)

PGR/PGC-BUR-01.07: Geo-informatics for assessment of diversity distribution in agri-horticultural crops (**DP Semwal,** DC Bhandari, KC Bhatt and Rakesh Singh)

Externally funded projects

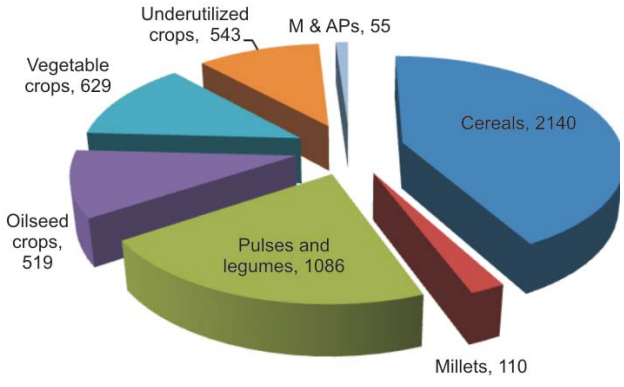
- New Millennium Indian Technology Leadership Initiative (NMITLI) Project on Genetic improvement of *Jatropha curcas* for adaptability and oil yield (Code: 014-CSIR-PECD-KCB-05: completed on 31.3.2012)
- Digitization of the National Herbarium of Cultivated Plants under DST funded project (076-DST-PECD-ERN-011)

2. GERMPLASM EVALUATION

Summary: During the year, a total of 5,975 accessions of various agri-horticultural crops comprising cereals (2,341), millets (110), pulses (1,086), oilseeds (1,211), vegetables (629), underutilized crops (543), and medicinal and aromatic plants (55) were grown at New Delhi for characterization, evaluation, regeneration and multiplication. In addition, 4,763 accessions of international nurseries comprising wheat, barley and *Triticale* were also evaluated under Post-entry Quarantine Nursery (PEQN). A total of 1,359 accessions of various crops namely, okra (72), *Brassica* (460), black gram (197), brinjal (373), tomato (191) and cucumber (66) were raised for preliminary evaluation against important biotic stresses while in advanced screening. A total of 175 accessions comprising okra (39), *Brassica* (16), brinjal (62), pearl millet (32) and tomato (26) were screened for major diseases and insect pests. Under abiotic stresses, 145 wheat accessions were screened for terminal heat tolerance and maize (570), pearl millet (80), black gram (266) and rice bean (63) were screened for drought and heat. Under quality evaluation a total of 2,183 accessions of different crops namely rapeseed-mustard (1,084), linseed (150), amaranth (100), buckwheat (100), wheat (13), walnut (11), maize (130), faba bean (181), lentil (180) brinjal core set (168), and kodomillet (66) were analyzed for oil content and fatty acid profile, protein, sugar, minerals, amino acids, antioxidant potential and anti-nutritional factors. Under phyto-chemical evaluation, 509 samples of different medicinal and aromatic plants were analyzed for their active compounds. In the multi-location evaluation (MLE), 3,790 accessions of various crops viz., wheat (1,100), rice (915), maize (175), mustard (240), brinjal (200), okra (200), chickpea (205), pigeonpea (305) and lentil (450) were evaluated for agronomic traits, biotic and abiotic stresses and quality parameters in collaboration with AICRPs and SAUs. In pre-breeding, seven wild annual *Cicer* species were characterized for nine important morphological parameters. Hybridity of nine lentil F_1 crosses was confirmed by morphological as well as ISSR markers. Four interspecific chickpea crosses (F_1) were confirmed using RAPD and SSR markers. Under National Initiative for Climate Resilient Agriculture (NICRA) 21,822 accessions of wheat and 18,775 of chickpea germplasm were characterized at CCSHAU, Hisar and MPKV, Rahuri respectively, for the development of core sets. In addition, 21,445 accessions of wheat were evaluated at Issapur Farm under two sowing dates for screening against terminal heat tolerance. Further, 20,660 accessions of wheat were evaluated against rusts and foliar diseases at IARI RS, Wellington. A total of 4,425 accessions were supplied to 88 indenters belonging to different ICAR institutes, SAUs and other national organizations to facilitate their use in crop improvement programmes. One Germplasm Advisory Committee meeting on maize, sorghum and pearl millet was organized under the expert guidance of crop specialists.

2.1 Germplasm Evaluation

2.1.1 Characterization and preliminary evaluation for agro-morphological traits: A total of 5,082 accessions of various agri-horticultural crops comprising cereals (2,140): wheat (1,214), barley (253) and maize (563) millets (110): pearl millet (110); pulses (1,086): black gram (396), lentil (490) and green gram (200); oilseeds (519): rapeseed-mustard (417) and crambe (102); vegetables (629): brinjal (200), tomato (200), cucumber (66), sponge gourd (90), bottle gourd (10) and faba bean (vegetable type) (63); underutilized crops (543): faba bean (393), grain amaranth (100) and rice bean (50); medicinal and aromatic plants (55): Aloe (30) and *Tinospora* (25) were characterized and evaluated for major agro-morphological traits. In addition, 893 accessions comprising wheat (106), pearl millet (95), rapeseed-mustard (460), *Crambe* (102), and linseed (130) were grown for regeneration and multiplication. A total of 323 accessions of medicinal and aromatic plants (M & APs) comprising vetiver (131), palmarosa (55), giloe (25), aloe (50), asparagus (22) and other M&APs (40) were also maintained in the field genebank. In addition, 4,763 entries received from CG centres were grown in the Post-entry Quarantine Nursery (PEQN) for screening against major diseases and pests, seed multiplication, on the spot assessment and seed supply to indenters. A brief detail of various activities undertaken along with the number of accessions included has been given in Table 1.



Accessions characterized and evaluated in various crop groups

Table 1: Status of characterization, preliminary evaluation and regeneration/ multiplication during 2012

Crop group	Characterization and evaluation	Regeneration/ multiplication	Total
Cereals	2,140	201	2,341
Millets	110	-	110
Pulses and legumes	1,086	-	1,086
Oilseed crops	519	692	1,211
Vegetable crops	629	-	629
Underutilized crops	543	-	543
M & APs	55	-	55
Total	**5,082**	**893**	**5,975**

Based on characterization and preliminary evaluation, promising accessions for various agro-morphological traits have been identified in different crops.

In maize, 75 accessions collected from North Eastern region and 276 accessions obtained from National Genebank were characterized, while 212 accessions were under second year of evaluation and 95 accessions were multiplied for LTS. Wide variability has been observed for different agro-morphological traits particularly for plant vigour, maturity, plant height, tassel traits and cob shape, size and colour.

Pearl millet genotypes for popping quality: Out of 110 pearl millet accessions, 26 were selected from different species and analyzed for popping characteristics. Based on the size of popped grains, eight germplasm namely, 283737, 283734, 283681, 283908, 312753, 284848, 283847, 283744 yielded in highest popped size of more than 7 mm. Popping yield of the lines varied from 48.23 to 83.82%.

2.1.1.1 Mega characterization and evaluation programme: Mega characterization and preliminary evaluation of wheat and chickpea germplasm conserved in the National Genebank was planned and executed in collaboration with SAUs. Under this programme 21,822 accessions of wheat and 18,775 accessions of chickpea germplasm were characterized at CCS HAU, Hisar and MPKV, Rahuri respectively, for development of core sets. In addition, 21,445 accessions of wheat were evaluated at NBPGR Issapur Farm under two sowing dates for screening against terminal heat tolerance. Further, 20,660 accessions of wheat were evaluated

Multicob accessions collected from NEH region

Accessions having high node number with seminal roots collected from NEH: Important traits for lodging and water logging tolerance


IC283734 and IC283744 having popping size >7 mm and popping yield of 80%


Pearl millet IC275995 and IC275069 having high biomass and green fodder potential


IC420405 IC420422

Two carotenoid rich cucumber accessions from NEH region


IC539701 IC567390

Bottle gourd with segmented leaf

Bottle gourd fruit with ridge and furrows

against rusts and foliar diseases at IARI RS, Wellington. The above activities have been undertaken under the National Initiative for Climate Resilient Agriculture (NICRA).

2.1.1.2 Evaluation of *Brassica* germplasm for nitrogen use efficiency (NUE): A total of 45 accessions of *Brassica* were evaluated for nitrogen use efficiency under three nitrogen fertility conditions (0 kg N/ha (Control), 40 kg N/ha, 80 Kg N/ha during *Rabi* 2011-12. Data on qualitative and quantitative traits related to NUE were recorded. Out of these, 10 accessions viz: IC267693, IC275106, IC277700, IC296501, IC3396605, IC339671, IC338494, IC571625, IC571654 and IC538719 were found promising for nitrogen use efficiency based on plant height, number of branches/

Characterization and Evaluation of Entire Set of Wheat Germplasm *for Heat Tolerance and Resistance to Rusts*

Chickpea characterization at MPKV, Rahuri

Recording of canopy temperature for terminal heat tolerance

plant, number of siliqua/plant, grain yield and oil content. The promising accessions have been further validated during *Rabi* 2012-13.

2.1.1.3 Augmentation of rapeseed-mustard germplasm: To augment rapeseed-mustard germplasm, an exploration was undertaken in NEH region during February 2012 in collaboration with DRMR, Bharatpur, NBPGR RS, Shillong, ICAR Research Complex for NEH Region, Barapani and KVKs of Arunachal Pradesh for collection of leafy mustard types from four districts of Arunachal Pradesh such as West Siang, East Siang, Lower Subansiri and Papum Pare. A total of 85 accessions of *Brassica* germplasm were collected which included a rare collection of cut-leaf mustard (*Brassica juncea* subsp. *japonica*) from East Siang of Arunachal Pradesh.

2.1.2 Evaluation for Biotic and Abiotic Stresses: Germplasm of major agri-horticultural crops were evaluated for their performance against different biotic stress and screened for identification of resistance sources to major diseases and insects pests. Under abiotic stress, wheat accessions were screened for terminal heat tolerance and maize, pearl millet, black gram and rice bean accessions were screened for drought and heat. The details of progress under various heads are given below:

2.1.2.1 Screening of germplasm of various crops for resistance against biotic stresses

2.1.2.1.1 Response of wild okra germplasm to yellow vein mosaic disease: A total of 76 germplasm accessions of eight wild *Abelmoschus* species including 14 checks of cultivated species were evaluated for their response to yellow vein mosaic disease (YVMD). Incidence and severity of yellow vein mosaic disease and infestation of whitefly, the vector of the disease were recorded. The disease reaction in the accessions was estimated based on co-efficient of infection (CI). The differential response of YVMD was observed in accessions of all the species. None of the species has complete resistance against the *Begomovirus* species at Delhi location. This constitutes the first report of occurrence of yellow vein mosaic disease in accessions of wild *Abelmoschus* species. Altogether 27 accessions showed resistant reaction, of which only 10 accessions were resistant (CI ranging from 4.5 to 8.3) that belong to *A. pungens, A. crinitus, A. moschatus, A. caillei, A. tetraphyllus* and *A. tuberculatus*; 17 accessions were moderately resistant (CI ranging from 10.0 to 18.3) while 49 accessions were susceptible to YVMD (Table 2). Out of 14 cultivated varieties used as checks, 11 were found susceptible having CI of 70.4 (Pusa Sawani). Promising accessions showing resistant reaction have been identified (Table 6).

2.1.2.1.2 Advanced screening of promising okra germplasm for resistance to YVMD: In okra, 39 accessions that had shown resistant reaction against YVMD during *Kharif* 2011 were again tested in a replicated trial during *Kharif* 2012. The disease reaction

Table 2: Response of wild okra germplasm to *Yellow vein mosaic disease*

Name of wild taxa	No. of accessions under different disease reaction			
	Total	HR	R	MR
Abelmoschus angulosus	2	0	0	0
A.manihot subsp. *tetraphyllus* var. *pungens*	4	0	1(4.5)	0
A. ficulneus	6	0	0	2 (10.1-12.7)
A. crinitus	1	0	0	1 (18.2)
A. moschatus subsp. *moschatus*	4	0	2 (5-8.3)	2 (10-15)
A. caillei	25	0	2(4.8-6.5)	5 (10.7-18.2)
A. manihot subsp. *tetraphyllus*	20	0	4 (4.5-8.3)	4 (10-18.3)
A. tuberculatus	10	0	1 (6.3)	0

Values in parentheses are CI range

was assessed on the basis of co-efficient of infection (CI) and area under disease progress curve (AUDPC). CI ranged from 2.0 (IC433718) to 52.3 (IC111482), while the CI of susceptible check Pusa Sawani was 70.4. AUDPC value of the resistant (323.5 to 567.9) and moderately resistant accessions (445.0 – 728.0) were observed to be lowered than those of susceptible accessions (496.9 – 1345.2) indicating lesser rate of spread of the disease in resistant and moderately resistant accessions (Table 3). Two accessions *viz*., IC117222 (CI=3.7) and IC118149 (CI=7.8) have shown resistant reaction consecutively for last three years (Fig. 1). All other resistant accessions have been listed in Table 6. The mean number of whiteflies infestation per five leaves ranged from 0.8 to 6.4. Three accessions IC117222, IC117251 and EC329369 were found superior as the infestation level was < 2 mean number of whiteflies per five leaves.

2.1.2.1.3 Evaluation of *Brassica* germplasm against mustard aphid and major diseases

a) Screening of *Brassica* germplasm for resistance to mustard aphid: A total of 460 accessions of different *Brassica* sp. along with 5 checks were screened for resistance to mustard aphid, *Lipaphis erysimi* (Kalt.) in ABD. The infestation assessed as mean no. of aphids/ top 10 cm inflorescence ranged from 13.67 to 458.33. Forty five accessions were found promising as the infestation was < 20 mean no. of aphids/ top 10 cm inflorescence. Promising accessions were identified (Table 6).

b) Screening of *Brassica* germplasm against major diseases: Three hundred and seventy germplasm accessions including checks were screened against *Alternaria* blight (AB) [causal organism (c.o.): *A. brassicicola*], white rust (WR) (c.o. *Albugo candida*) and powdery mildew (PM) (c.o. *Erysiphe cruciferarum*) diseases. Incidence of *Alternaria* blight and white rust was low whereas, powdery mildew was moderate. All the diseases appeared during late maturity stage of crop. Only 38 accessions were infected (score d" 2) and 253

Table 3: Reaction of okra germplasm to YVMD

Disease reaction	Total accessions	CI range*	AUDPC**
Highly Resistant (HR)	2	2.0 – 3.7	323.5 – 409.1
Resistant (R)	4	6.6 – 8.2	456.3 – 567.9
Moderately Resistant (MR)	3	10.8 – 12.7	445.0 – 728.0
Moderately Susceptible (MS)	20	20.0 – 38. 8	496.9 – 948.8
Susceptible (S)	10	39.2 – 52.3	685.1 – 1345.2
Highly Susceptible (HS)	-	-	-

*CI= Coefficient of infection; **AUDPC= Area under disease progress curve

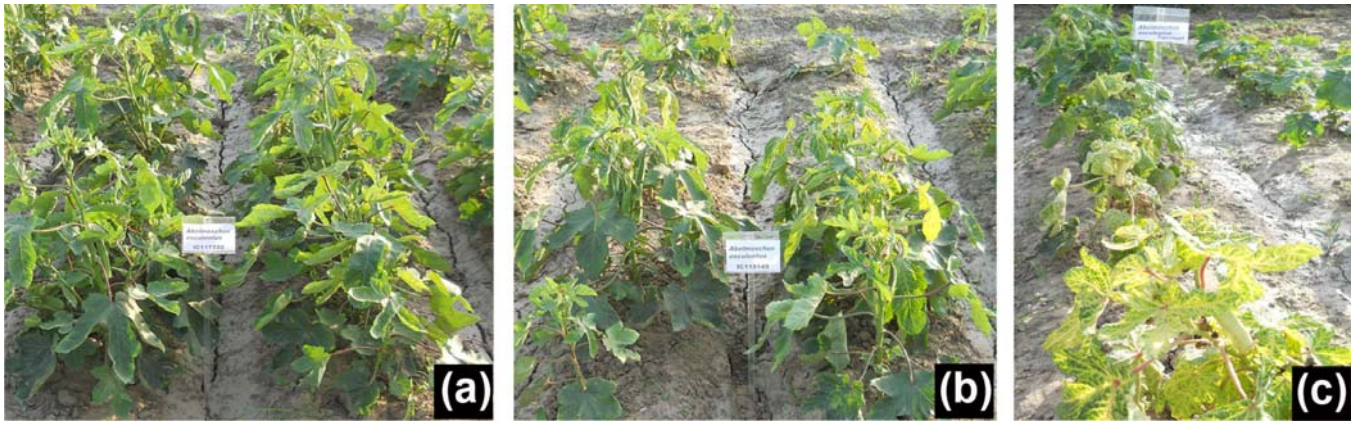


Fig. 1. Resistant reaction (for consecutive 3 years) of two promising okra accessions (a) IC117222 and (b) IC118149 and (c) susceptible check (cv. Pusa Sawani)

accessions were free from AB disease whereas WR infection was observed in 48 accessions (score 1-5) and 243 accessions were free of white rust. PM disease was severe (score e" 3) and observed in 194 accessions while 97 accessions were free from the disease. Promising accessions free from all the three diseases were identified (Table 6).

c) Evaluation of *Brassica* germplasm against a new leaf curl disease: Evaluation of 130 accessions of rapeseed-mustard germplasm grown at Issapur farm, during *Rabi* 2011-12 revealed occurrence of a new leaf curl disease in sixteen plants of seven germplasm accessions. No such disease has been reported earlier in this group of crops. The characteristic symptoms were upward leaf curl, leaf rolling, thickening of veins and stunted growth of the plants (Fig. 2). During *Rabi* 2012-13, the occurrence of the disease was recorded in 62 out of 525 accessions evaluated. Severe rolling of leaves and stunted growth were observed in *B. rapa* var. yellow sarson and *B. rapa* var. brown sarson while mild upward leaf curl symptoms were observed in *B. nigra.* Though, considerable population of whitefly was observed in the field but uniform spread of the disease was not observed in germplasm accessions of different species, indicating differential response of these accessions. Among the symptomatic germplasm accessions, majority belonged to *B. rapa* var. yellow sarson (including three check varieties) while none of the accessions belonging to *B. rapa* var. toria, *B. juncea*, *B. napus* and *B. carinata* showed any leaf curl disease consecutively for two years indicating possibility of resistance in these species.

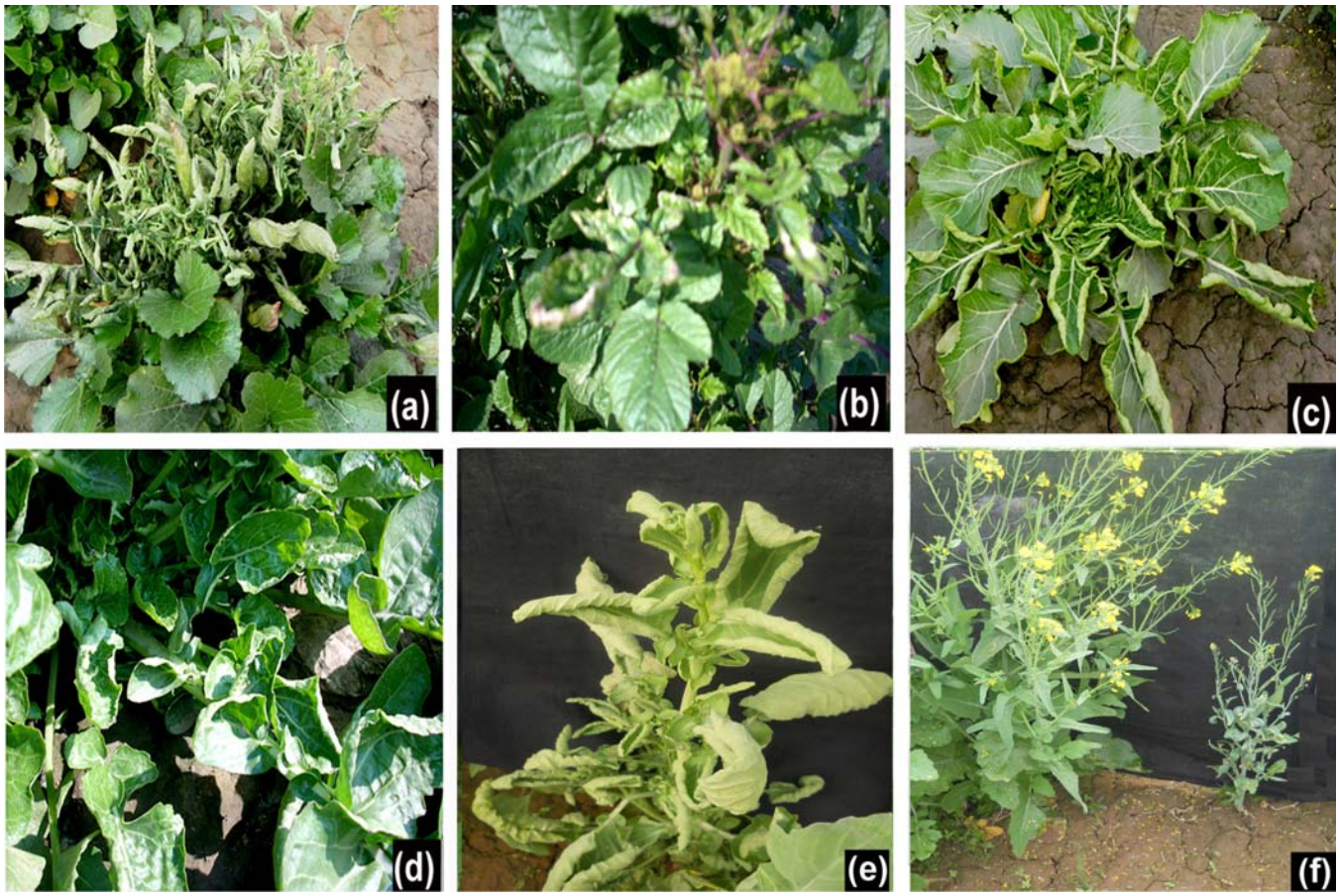


Fig. 2 Leaf curl symptom of rapeseed-mustard germplasm in field. (a) *Brassica rapa* var. brown sarson, (b) *B. nigra*, (c) *B. rapa* subsp. *chinensis*, (d) *B. juncea* subsp. *rugosa*, (e) *B. rapa* var. yellow sarson, (f) Stunted growth of *B. rapa* var. yellow sarson plant (right) in comparison with asymptomatic plant under field conditions (left).

2.1.2.1.4 Detection and characterization of a begomovirus-betasatellite complex involved in leaf curl disease of rapeseed-mustard germplasm: Involvement of a monopartite begomovirus and betasatellite was established with the symptomatic plants through whitefly transmission and PCR amplification (Fig. 3). The complete nucleotide sequences of the begomovirus (JX270684, 2745 nucleotide), obtained through rolling circle amplification, showed highest sequence identity (98.1%) with a weed-infecting begomovirus, *Croton yellow vein mosaic virus* (CYVMV). Analysis of recombination indicated probable occurrence of many overlapping inter- and intra-specific recombination events. The sequence of betasatellite (JX270685, 1355 nucleotide) showed the highest sequence identity (95.7%) with CYVMV betasatellite. So far begomoviruses are not known to naturally infect rapeseed-mustard. Present findings constitute the first report of emergence of a weed-infecting begomovirus-betasatellite complex in rapeseed-mustard germplasm in India.

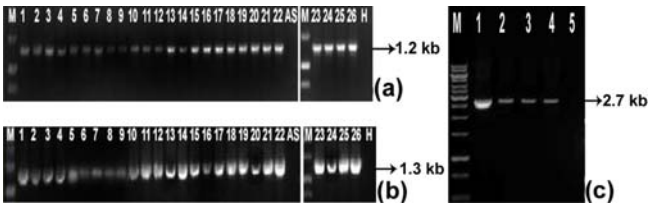


Fig. 3. Detection of begomovirus (a), and betasatellite (b) in rapeseed-mustard field samples (lane 1-6: *Brassica rapa* var. brown sarson, lane 7-15: *B. rapa* var. yellow sarson, *lane* 16-18: *B. rapa* subsp. *chinensis*, lane 19-20: *B. nigra*, lane 21-22: *B. juncea* subsp. *rugosa*) and glasshouse samples (lane 23-26). No amplification obtained with asymptomatic (AS) plant from field and healthy (H) plant from glasshouse samples. Rolling circle amplified product digested with *Bam*HI yielded 2.7 kb genome-length molecule of begomovirus (c, lane 1-4). Healthy samples did not produce any such fragment (c, lane 5).

2.1.2.1.5 Advanced screening of promising *Brassica* germplasm against aphid, *Alternaria* blight and white rust: In *Brassica,* 16 promising germplasm selected from *Rabi* 2011-12 were screened along with five checks for resistance to mustard aphid, *Lipaphis erysimi* (*Kalt.*) in replicated trial. The mean no. of aphids infestation / top 10 cm inflorescence ranged from 300.66 to 45.9 and one accession, IC424421 was found tolerant to aphid infestation as infestation was < 50 mean no. of aphids/ top 10 cm inflorescence. The same set of germplasm was also screened for resistance to *Alternaria* blight (AB) and white rust (WR) disease. Due to low disease pressure under natural field conditions, artificial screening against *Alternaria* blight by leaf detached method and white rust by cotyledon infection test, was done with susceptible check, Varuna. Accessions, IC338523 and IC360723 have shown slight water soaked lesion after seven days indicating resistant whereas, Varuna has shown characteristic target shape lesion indicating susceptible reaction against *Alternaria* blight. IC296685 and IC338523 have shown >80% survival indicating resistance as compared to Varuna with < 8% survival indicating susceptible reaction against white rust. IC338523 was found resistant against both AB and WR disease.

2.1.2.1.6 Preliminary evaluation of brinjal germplasm against fruit and shoot borer (FSB): A total of 192 accessions of brinjal along with seven checks were evaluated for resistance to FSB, during *Rabi* 2011-12. The per cent infestation ranged from 4.65 to 66.67 by number basis and 1.17 to 60% on weight basis (Table 6). Twelve accessions were found promising to FSB recording < 10% infestation both by number and weight basis. In another study, brinjal core set of 181 accessions of evaluated for resistance to FSB. The per cent infestation ranged from 1.37 to 65% by number basis and 1.87 to 74.14% on weight basis. Six accessions were found promising recording < 10% infestation both by number and weight basis (Table 6).

2.1.2.1.7 Advanced screening of promising brinjal germplasm for leaf spot disease and (FSB): A total of 14 accessions, selected from the two consecutive years screening, were screened along with six checks for resistance to leaf spot disease. Screening was done following 1-9 scale. Four accessions were identified as resistant with score of d"3 (Table 6). IC090940 was highly resistant with score 1 as compared to susceptible check variety Arka Nilkanth with a score of 8. In another study, 48 accessions (selected from previous year's preliminary screening) were screened along with 6 checks for resistance to leaf spot disease. Seven accessions were found as resistant with score d" 2 (Table 6). Accessions, EC316283 and IC374873 were found as highly resistant with score of 1 as compared to highly susceptible check variety Punjab Sadabahar with a score of 7.

Fourteen accessions, selected from the previous two years screening were screened along with 6 checks for resistance to FSB in a replicated trial. Fruits were harvested six times at marketable maturity. Number of

healthy and infested fruits and weight of fruits at each harvest were recorded. Infestation of FSB ranged from 9.58 to 34.03% on number basis and 10.87 to 42.44% on weight basis. Three accessions, IC111415, EC385380 and EC038474 were found resistant as the infestation level was less than 12%. In another study, forty eight accessions, selected from the previous year screening were screened along with six checks for resistance to FSB. Infestation of FSB ranged from 3.88 to 37.05% on number basis and 6.35 to 47.91% on weight basis. Six accessions, EC383372, IC074196, EC316294, IC394877, IC090144 and IC279555 were found resistant as the infestation was less than 10% by both number and weight basis.

2.1.2.1.8 Evaluation of tomato germplasm against fruit borer: In tomato, 191 accessions along with seven checks were screened for resistance to fruit borer, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera) during *Rabi* 2011-12. Infestation ranged from 11.01 to 48.90% on number basis and 9.71 to 51.07% on weight basis. Ten accessions were found promising having infestation < 20% both by number and weight basis (Table 6). In another study, 26 accessions along with 5 checks were screened for resistance to fruit borer in a replicated trial. Infestation ranged from 12.34 to 45.01% on number basis. Four accessions, EC654725, EC686545, EC608403 and EC686553 were found promising having infestation < 15%.

2.1.2.1.9 Evaluation of cucumber germplasm against downy mildew and viral disease and detection of virus

(a) Evaluation of cucumber germplasm: Evaluation of cucumber germplasm in summer and *Kharif* seasons 2012 showed incidence of two major diseases, yellow mosaic with severe stunting (severe during summer season) and downy mildew (mainly during *Kharif* season) (Fig. 4). Forty one accessions of cucumber germplasm along with two checks were screened against the diseases. Both downy mildew and yellow mosaic

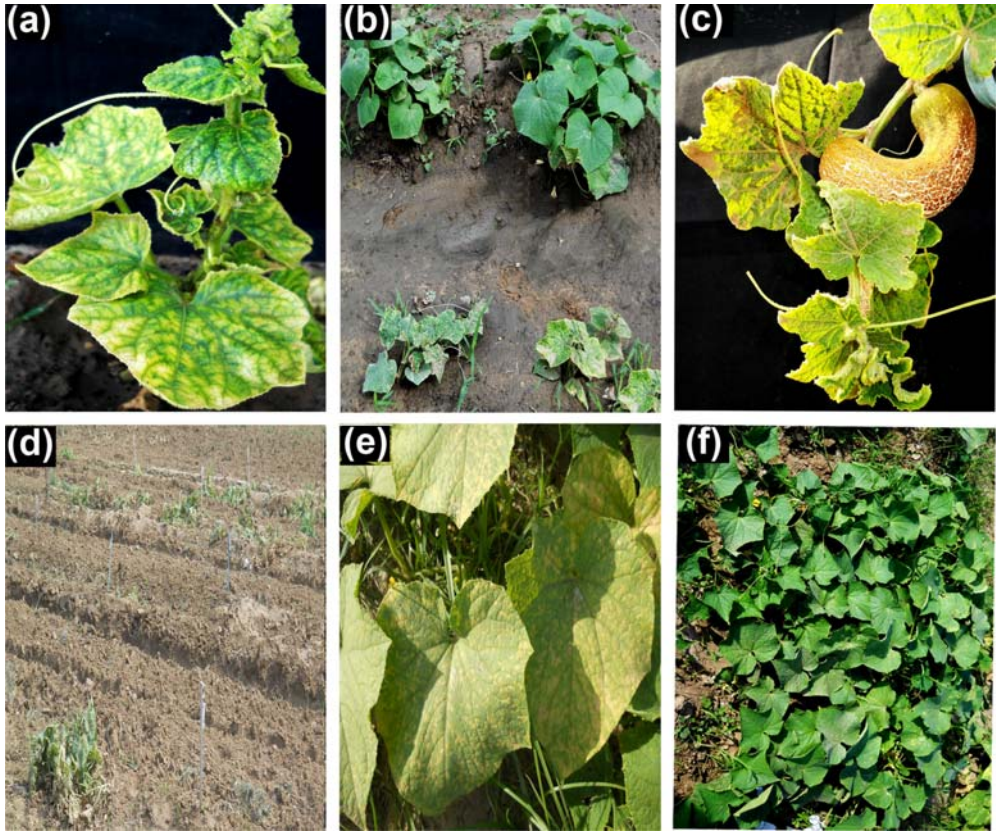


Fig. 4 Symptom of yellow mosaic and downy mildew disease in cucumber germplasm. (a) Yellow mosaic, (b) Stunting in diseased cucumber accession as compared to non-symptomatic one (upper), (c) Deformity in fruit due to yellow mosaic disease, (d) Severe infection of yellow mosaic disease and death of plant during summer season, (e) Downy mildew symptom, (f) Accession of cucumber showing field resistance against yellow mosaic and downy mildew

diseases were present in severe form (PDI = 100) in 20 accessions. Downy mildew disease was screened using SES scale (0- 4). Fifteen accessions showed resistant reaction against downy mildew disease (score d"2), three accessions (IC527404, IC527419 and IC538137) were highly resistant (score 0) and six accessions (IC410617, IC527400, IC527404, IC527431, IC538121 and IC538186) were found free from any virus disease symptom. One accession (IC527404) was observed free from both downy mildew and virus. The checks, Pusa Uday (score = 4) and Pusa Harit (score = 3) were susceptible to downy mildew while, Pusa Harit was susceptible to yellow mosaic disease (PDI = 80). Promising accessions were identified (Table 6).

(b) Detection and characterization of the virus: For detection and characterization of virus(s) present in infected cucumber samples, rolling circle amplification (RCA) followed by restriction digestion was performed. The 2.7 kb full genomic length fragments generated by *Pst*I (Fig. 5) was purified and cloned. Recombinant clones containing desired fragments were screened using different restriction enzymes. Two distinct clones (cucumber 1 and 2) with different restriction profiles were sequenced and sequences were deposited in GenBank (www.ncbi.nlm.nih.gov) with accession number, KC545812 (DNA A) and KC545813 (DNA B). Sequence analyses showed that cucumber 1 and cucumber 2 shared highest sequence identity with DNA-A and DNA-B of *Tomato leaf curl New Delhi virus*. Besides, the virus betasatellite was also detected by PCR (Fig. 5).

2.1.2.1.10 Evaluation of black gram germplasm against yellow mosaic disease: In black gram, 197 accessions were evaluated against yellow mosaic disease during *Kharif* 2012. The disease reaction was assessed

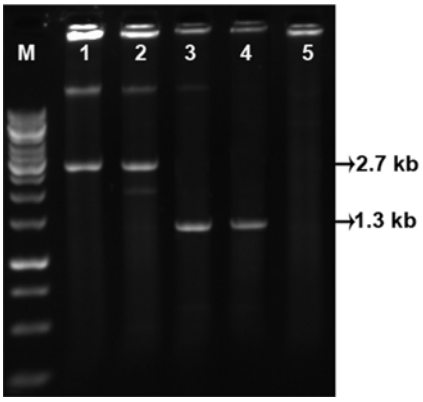


Fig. 5. Detection of Tomato leaf curl New Delhi virus and satellites by RCA and PCR technique. Lane 1-2: 2.7 kb genomic component of DNA-A and DNA-B using RCA, Lane 3-4: 1.3 kb amplicon of betasatellite

based on co-efficient of infection (CI) and area under disease progress curve (AUDPC). Only 30 (15.4%) of total accessions showed resistant reaction (CI d" 8.8 and AUDPCd"669.1) of which 13 accessions were symptom less, 5 accessions were highly resistant and 12 accessions were resistant (Table 4). The superior accessions are given in Table 6. Out of 158 accessions grown during 2011 and 2012, only eight (8) accessions viz., IC144901, IC001545, IC001572, IC011613, IC020818, IC007544, IC250262 and IC485638 had shown resistant reaction during both years. CI of susceptible check (cv. Barabanki local) was 83.8 and AUDPC was 2068.5.

2.1.2.1.11 Evaluation of wild black gram germplasm against yellow mosaic disease: Out of 89 wild accessions of black gram grown for preliminary evaluation, 51 survived, which were screened against yellow mosaic disease. Percent disease incidence ranged from 0 to 100. Seven accessions were found promising (PDI = 0 – 28.6) have been identified (Table 6).

Table 4: Reaction of black gram germplasm against yellow mosaic disease

Disease Reaction	Total accessions	PDI range	PDS range	CI range	AUDPC range
No symptom	13 (6.6%)	0	0	0	0
Highly Resistant (HR)	5 (2.5%)	5.0 – 14.3	8.3 – 71.7	1.6 – 4.0	37.5 – 347.8
Resistant I	12 (6.1%)	6.9 – 23.1	20.9 – 100.0	4.5 – 8.8	115.4 – 669.1
Moderately Resistant (MR)	18 (9.1%)	14.3 – 64.7	4.0 – 84.8	9.1 – 18.4	250.0 – 1525.0
Moderately Susceptible (MS)	13 (6.6%)	20.0 – 50.0	31.8 – 85.6	20.0 – 37.5	578.8 – 2024.4
Susceptible (S)	24 (12.2%)	42.1 – 100.0	37.7 – 100.0	41.7 – 65.6	500.0 – 3000.0
Highly Susceptible (HS)	112 (56.9%)	76.0 – 100.0	57.8 – 100.0	69.4 – 100.0	1416.7 – 3000.0

2.1.2.1.12 Evaluation of promising black gram germplasm against yellow mosaic disease under artificial inoculation condition

(a) Artificial inoculation through whitefly transmission: Out of 158 black gram accessions screened for consecutive two years, eight accessions, showing consistent resistant reaction in field, were further evaluated under artificial inoculation through whitefly transmission of the virus. Four accessions *viz*., IC144901, IC001572 and IC011613 and IC485638 have shown resistant reaction and remaining has shown susceptible reaction (Table 5). Among them, IC144901 and IC001572 showed highly resistant reaction as very minute yellow flecks developed in a few plants (Fig. 6).

(b) Development of infectious virus construct and agro-inoculation for confirmation of resistance

Partial tandem repeat (PTR) constructs of viral genomic components, DNA-A and DNA-B of *Mungbean yellow mosaic virus* (MYMV) were constructed by directional cloning of a fragment of the genome (*Pst*I-*Hind*III fragment for DNA-A and *Hind*III-*Bam*HI fragment for DNA-B) followed by further cloning of the appropriate full length DNA-A or DNA-B in the same construct. The PTR constructs of DNA-A (*Pst*I-*Pst*I-*Hind*III) and DNA-B (*Hind*III- *Hind*III-*Bam*HI) (Fig. 7) in pCAMBIA 2300 vector were transformed into *Agrobacterium* strain EHA105 using Chloramphenicol (25 µg/ml) and Kanamycin (50 µg/ml) as antibiotic selection markers. Positive clones with correct orientation were confirmed through restriction analysis (Fig. 7) and infectious nature of the constructs agro-inoculation was confirmed on 2-day-old sprout seeds of black gram cv. Barabanki, green gram cv. Pusa Baisakhi, cowpea cv. Pusa Komal and soybean cv. Pusa-16. Symptoms appeared after 11-25 days of inoculation (Fig. 8). The presence of the virus was confirmed through southern hybridization using the DNA-A of the virus as probe.

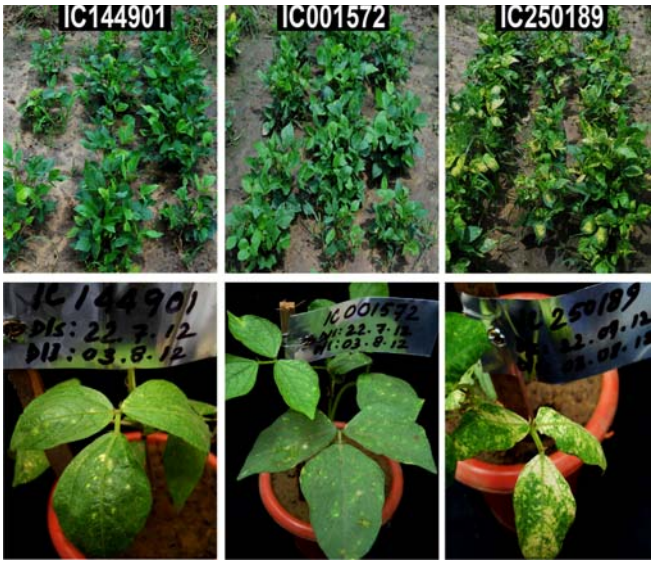


Fig. 6. Differential disease response of two resistant accessions (IC144901 and IC001572) and one susceptible accession (IC250189) of black gram under natural field condition (upper panel) and glasshouse, after whitefly transmission (lower panel)

The infectious construct was then inoculated onto one resistant (IC144901) and one susceptible (IC250189) accession. Even after one month, very mild chlorotic flecks appeared in the resistant accession confirming its true resistance (Fig. 9). The relative concentration of the viral load was determined in a time-scale by semi-quantiative PCR using a specific primer. It was observed that incase of resistant accession, the virus was detected only after 21 days and replication rate of virus was much lower than that of the susceptible accession (Fig. 8).

Table 5: Result of artificial inoculation of yellow mosaic virus to black gram germplasm through whitefly transmission under glasshouse condition

Accession	No. of symptomatic plant/ no. of plant inoculated	Symptoms	Disease reaction
IC144901	1/10	Minute yellow fleck	HR
IC001572	3/12	Minute yellow fleck	HR
IC011613	7/8	Yellow fleck and spot	R
IC485638	10/14	Yellow fleck and spot	R
IC001545	7/10	Yellow mosaic (50-75% area of the leaves)	S
IC007544	11/13	Yellow mosaic (50-75% area of the leaves)	S
IC020818	7/11	Yellow mosaic (more than 75% area of the leaves)	S
IC250262	5/6	Yellow mosaic (more than 75% area of the leaves)	S
IC250189 (Susceptible check)	8/10	Yellow mosaic (more than 75% area of the leaves) and stunting	S

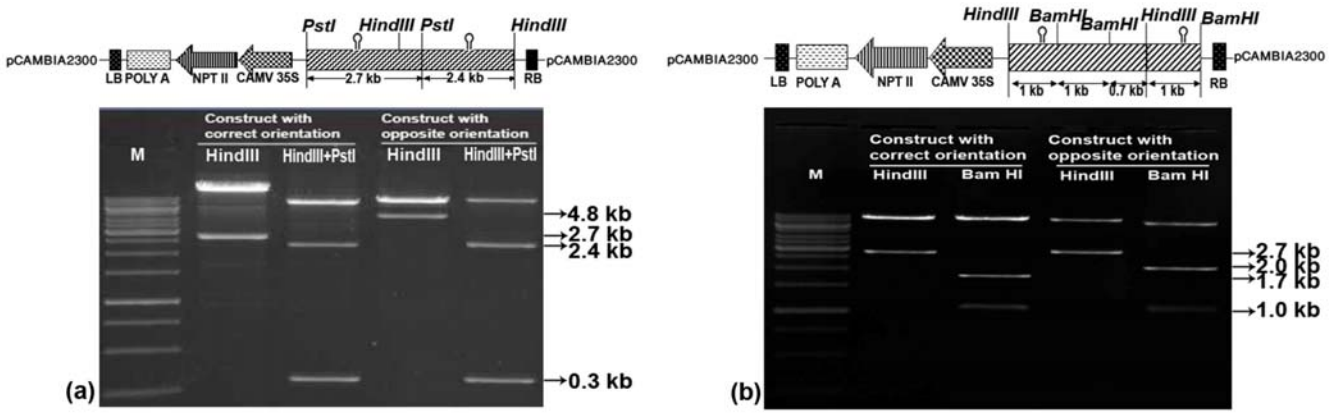


Fig. 7. Schematic diagram of agro-infectious construct of DNA-A (a, upper panel) and DNA-B 9b, upper panel) in pCAMBIA2300. Confirmation of orientation by restriction digestion (a,b; lower panel)

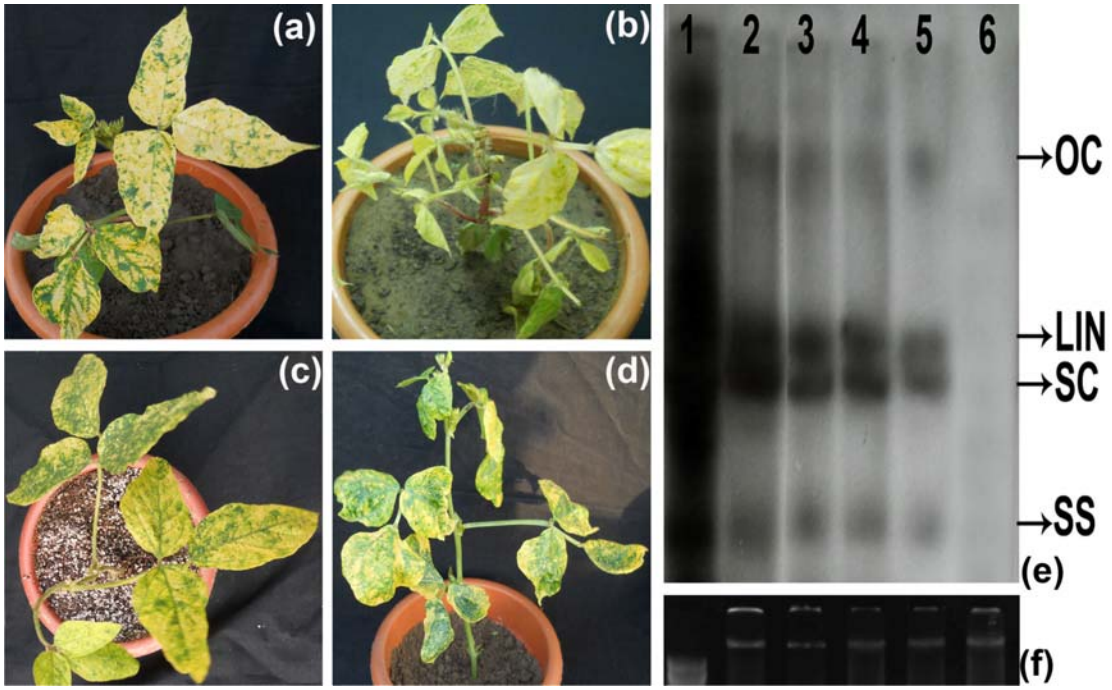


Fig. 8. Development of symptom after agro-inoculation of infectious construct in (a) black gram, (b) mungbean, (c) soybean, (d) cowpea. (e) Confirmation of presence of virus by southern blot (lane 1: positive control, lane 2-5: agro-inoculated symptomatic sample of black gram, mungbean, soybean and cowpea, lane 6: healthy black gram) and (f) loading of the equal amount of sample

2.1.2.1.13 Advanced screening of pearl millet germplasm against major diseases: In pearl millet, 32 accessions that have shown highly resistant reaction against blast [*Pyricularia grisea* (Cooke) Sacc.], during *Kharif* 2011, were further screened in a replicated trial during *Kharif* 2012 along with 3 checks viz., PC443, PC612 and PC605. The accessions were screened following 0-9 scale and superior accessions resistant to blast disease were identified based on per cent disease incidence (PDI). Location severity index (LSI) was moderately high (5.9) indicating moderately high disease pressure. Overall PDI was 1.1 – 93.3. Six accessions were found resistant (PDI < 15) and 4 accessions moderately resistant (PDI < 30) against blast (Table 6).

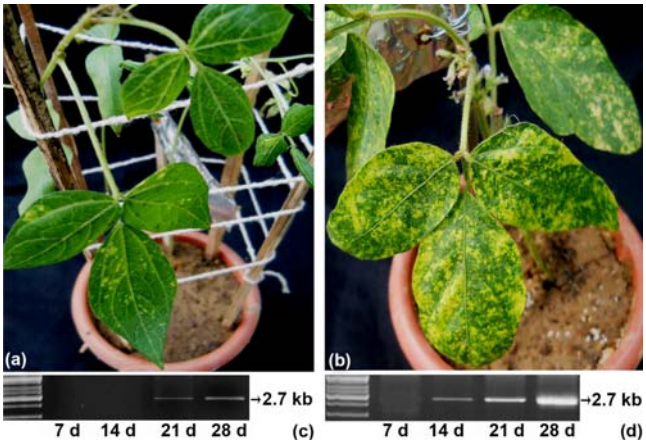


Fig. 9. Confirmation of resistance of IC144901 after agroinoculation (a) as compared to susceptible accession Barabanki (b). Semi quantitative PCR indicating time scale viral load in resistant (c) and susceptible (d) accessions

IC309064 (PDI=1.1), IC393365 (PDI=2.2), IC306465 (PDI=5) and IC283866 (PDI=5.6) were found resistant over two years. The susceptible check PC605 has shown PDI 84.4. Other two important diseases viz., downy mildew (*Sclerospora graminicola)* was recorded in 2 accessions and rust (*Puccinia substriata* var. *indica*) in 7 accessions with a score of 1-5. The blast resistant accessions were free from both downy mildew and rust (Table 6).

2.1.2.1.14 Screening for wild *Cicer* against biotic stresses

(a) *Ascochyta* blight: Eighty six accessions of various annual *Cicer* species were screened against *Ascochyta* blight at CSKHPKV, RS, Dhaulakuan. Most of the wild *Cicer* accessions were found resistant and moderately

Table 6: Superior accessions in various crops identified for major biotic stresses

Crop (acc.)	Biotic stresses	Criteria	Selected superior accessions
Preliminary screening			
Wild Okra (72)	Yellow vein mosaic disease (YVMD)	CI = 4.5 – 8.3	*Abelmoschus ficulneus*: IC310641 I, IC361264 (MR); *A. moschatus esculentus*: IC090049, IC090262, IC085593 (MR); *A. crinitus*: IC255484 (MR); *A. moschatus*: IC333520, IC140986 I; IC141067, IC470454 (MR); *A. caillei*: EC305725, EC306731-P (R); EC305743, EC306724, EC305736, EC306722, EC306706 (MR); *A. tetraphyllus*: IC117175, IC331214, IC433667, IC344598 I; IC433438, IC344738, IC344672, NIC9402 (MR); *A. pungens* **:** IC257740 I ; *A. tuberculatus*: IC467696 (R)
Cucumber (66)	Downy mildew disease (DM)	Score d" 2	IC527404, IC527419, IC538137 (HR; Score=0); IC410682, IC527394, IC527397, IC527400, IC527413, IC527418, IC527423 (R, Score=1); IC527391, IC527402, IC527431, IC538121 (MR, Score=2)
	Virus disease	PDI < 10	IC410617, IC527400, IC527404, IC527431, IC538121 and IC538186 (HR, PDI=0); IC410658, IC410682, IC527394, IC527410, IC538145, IC538155 (R, PDI<10)
	DM & Virus disease	Resistant	IC527400, IC527404, IC410682, IC527394
Brinjal (192)	Fruit and shoot borer	<10% infestation	EC305163, EC490062, EC316275, EC305048, EC038474, IC099731, IC099691, IC111443, IC281112, IC249319, IC354707 and IC090811
Brinjal core set (181)	Fruit and shoot borer	<10% infestation	EC384970, IC279555, IC281104, IC383195, IC281112 and IC090026
Brassica (460)	*Alternaria* blight, white rust and powdery mildew disease	Free from all three disease	EC481037, EC481048, EC481055, EC481058, EC481060, EC481065, EC481068, EC499890, EC500176, EC500182, EC501599, EC501600, EC501605, EC501611, EC513428, EC522224, EC657043, EC699001, EC699022, IC255385, IC262892, IC264824, IC278224, IC296747, IC320645, IC341164, IC347200, IC361508, IC361511, IC372259,IC398656, IC399684, IC405232, IC411520, IC411530, IC411537

	Mustard aphid	< 20 aphids/ 10 cm inflorescence	IC278023, IC191597-A, IC281691, IC279252, IC491243
Tomato (191)	Fruit borer	< 20% infestation	EC608294, EC608450, EC610643, EC610651, EC631962, EC654725, EC677080, EC677106, EC677109, EC677118, EC686531, EC686532, EC686545, IC395461 and IC452863
Black gram (197)	Yellow mosaic disease	CI (0.0- 9.0)	IC250232, IC250256, IC251958, IC471989, IC471990, IC471994, IC471995, IC471999, IC472000, IC472002, IC485432, IC485443, IC485447 (Symptom less) (CI=0); IC251957, IC144901, IC007544, HPU-180, IC251913 (Highly resistant) (CI=1.6-4.0); IC011613, IC020818, IC250263, IC485451, IC001572, IC485438, IC081865, IC250197, IC250199, IC250262, IC485638, IC049218 (Resistant) (CI=4.5-8.8)
Wild black gram	Yellow mosaic disease	PDI (0 – 28.6)	IC251447, IC277021, IC541388, IC351407, IC583655, IC583683, IC583700
Advanced screening			
Okra (39)	YVMD	CI < 12.7	IC433718, IC117222 (HR; CI=2.0-3.7)); EC169319, IC118149, IC332232, IC015036-B (R; CI=6.6-8.2); IC469671, IC117242, EC305619 (MR; CI= 10.8-12.7)
	Whitefly	<2 whiteflies/ 5 leaves	IC117251, IC117222, EC329369
Tomato (26)	Fruit borer	< 15 % infestation	EC654725, EC686545, EC608403, EC686553
Pearl millet (32)	Blast	PDI ≤15 (Resistant)	IC309064, IC393365, IC306465, IC283866, IC283866 and IC335902
		PDI ≤30 (Moderately resistant)	IC283692, IC283841, IC343737 and IC335901
Brinjal (14) (3rd year)	Leaf spot disease	Score 1- 3	IC090940 (HR; mean score 1); EC393239, IC111019(R; mean score 2); IC261843 (R; mean score 3)
Brinjal (48) (2nd year)	Leaf spot disease	Score 1- 2	EC316283, IC374873 (HR; mean score 1); IC090144, IC104096, IC112779, IC144145, IC249296 (HR; mean score 2)
Brinjal (14) (3rd year)	Fruit and shoot borer	< 12 % infestation	IC111415, EC385380 and EC038474
Brinjal (48) (2nd year)	Fruit and shoot borer	< 10% infestation	EC383372, IC074196, EC316294, IC394877, IC090144 and IC279555
Brassica juncea	*Alternaria* blight	Resistant	IC338523 and IC360723
(16)	White rust	Resistant	IC296685 and IC338523
	Mustard aphid	< 50 aphids/ 10 cm inflorescence	IC424421

resistant to *Ascochyta* blight. Eight accessions, belonging to *C. reticulatum* (ILWC229), *C. judaicum* (ILWCs-20, 30, EC720484, 256 and 274) and *C. bijugum* (ILWCs- 240, 34 and 7) were highly resistant (score 1) and 3 were resistant (Table 7).

(b) *Botrytis* grey mould: The same set of wild *Cicer* species was screened against botrytis gray mold at PAU, Ludhiana. Fifteen accessions of *C. echinospermum* (ILWC-246), *C. judaicum* (ILWC-30, 256, 275, 50, 207 and EC720484) and *C. pinnatifidum* (ILWC-212, 9, 22,

236, 225, 251, 289 and 248) were highly resistant and eighteen of *C. reticulatum* (ILWC- 242, 247 and 253), *C. judaicum* (ILWC-20, 223, 273 and 38), *C. pinnatifidum* (ILWC-49, 261, 263, 29, 250, 51 and EC720504 and EC720505) and *C. bijugum* (ILWC-240, 34 and 32) were resistant (Table 7).

(c) Root knot nematode : Out of 86 wild *Cicer* accessions, seven accessions one each of *C. reticulatum* (ILWC-247), *C. pinnatifidum* (ILWC-29), *C. bijugum* (ILWC-217) and two each of *C. echinospermum* (ILWC-238 and 46) and *C. judaicum* (ILWC-50 and 48) were resistant to root knot nematode, *Meliodogyne incognita*. Similarly, 10 accessions belonging to *C. judaicum* (ILWC-20, 30, 256, 275 and 274) and *C. pinnatifidum* (ILWC-261, 249, 33 and 248 and EC720504) were found moderately resistant (Table 7).

2.1.2.2 Evaluation for abiotic stress (terminal heat tolerance) in wheat: A total of 145 wheat accessions were grown under two sowing dates at IARI Farm, New Delhi on 20 November and 20 December, 2011. Observations were recorded for 25 morpho- physiological characters related to terminal heat tolerance. The values of all morpho-physiological traits under late sowing conditions were lower as compared to those of normal sowing due to temperature stress. Promising accessions of various traits were identified.

Based on the morphological characters related to terminal heat tolerance viz., erect plant type (15 acc.), long peduncle (5), leaf rolling (10), stay green colour (7), waxy peduncle (7), bold ears (6), more no. of tillers (8) and tip sterility (5) were selected. In addition 34 wheat accessions from 4,500 PEQN entries and 51 from 800 accessions grown at IARI Farm were selected.

2.1.2.2.1 Evaluation for abiotic stress in maize, pearl millet, black gram and rice bean: Based on the morphological characters related to abiotic stress (drought and heat), a total of 172 accesions were selected. Chlorophyll concentration index was estimated based on which promising accessions were identified, in maize (PBS/PR/21 and AS/PBS/NAIP/RS/KG/29), in pearl millet (IC283847 and IC283788), in black gram (IC472002 and IC530633) and in rice bean (EC10887-1, EC48542).

Table 7: Promising accessions of wild annual *Cicer* species for various biotic stresses

Disease reaction	*Cicer reticulatum*	*Cicer judaicum*	*Cicer pinnatifidum*	*Cicer bijugum*
Ascochyta blight	-	ILWCs-30,256 (HR)*, ILWCs-223, 48, 38, 50 (R),	ILWCs-212, 225, 251, 248 (R)	ILWCs-240, 34 (HR)
Botrytis gray mold	ILWC 247	ILWCs-30, 256 (HR), ILWCs- 223, 38 (R)	ILWCs-212, 225, 251, 248 (HR)	ILWCs-240, 34 (R)
Root knot nematode	ILWC247	ILWCs-50, 48 (R)	———————	———————

*HR= Highly resistant and R= resistant

Stay green **Waxy peduncle** **Tip sterility (IC252927)**

Important morphological traits related to heat tolerance in wheat

2.1.3 Biochemical Evaluation

2.1.3.1 Oil content of and fatty acid profiling in oil seeds: The quality of oilseeds is dependent on oil content and fatty acid composition, 1,084 accessions of rapeseed-mustard consisting of *B. juncea* (562), *B. rapa* var. yellow sarson (50), *B. rapa* var. brown sarson (83), *B. rapa var*. toria (132), *B. napus* (68), *B. juncea var. rugosa* (44), *B. rapa* (32) and *B. nigra* (69), *B. chenensis* (27), *B. carinata* (59), *Lepidium sativum* (4) and *Eruca sativa* (4) were analyzed for total oil content. The range, mean and value rich accessions for oil content in different species are given Table 8. Twenty five accessions of different sp. of *Brassica* were analyzed for fatty acid profile and range, mean and value rich accessions are given Table 9.

2.1.3.2 Quality analysis of linseed, walnut, grain amaranth and buck wheat germplasm: One hundred and fifty accessions of linseed were analyzed for oil content. Out of these, 27 samples having higher oil content were further analyzed for the fatty acid profile. Twenty four accessions of amaranth were analyzed for the oil content and fatty acid profile in duplicate**.** One hundred accessions of amaranth were analyzed for the oil content and thirty four accessions in duplicate were analyzed to study the fatty acid profile. One hundred accessions of buckwheat were analyzed for the oil content and thirty two accessions in duplicate were analysed to study the protein content and fatty acid profile. The value rich accessions are given in Table 10.

Table 8: Variation in oil content in different *Brassica* species

Brassica species (Acc.)	Oil (%) Range	Mean	Value rich accessions
B. juncea (562)	24.10-40.83	35.50	IC400240 , IC405234, EC699047
B. rapa var. *yellow sarson (50)*	27.97-45.07	37.65	IC276251, IC331817, IC355382
B. rapa var. *brown sarson (83)*	30.98-46.45	37.99	IC355343, IC491643, IC113122, IC191597, BSH-2
B. rapa var. *toria (132)*	30.78-44.34	37.92	IC586785, IC267270
B. napus (68)	29.80-42.30	36.99	IC405232, IC399681, IC405232, EC657049
B. juncea var. *rugosa (44)*	30.83-41.02	35.42	IC364031, IC276011
B. rapa (32)	30.60-40.42	35.51	IC262823 , IC538642
B. nigra (69)	20.72-37.94	29.33	IC262089, IC262089, IC341108, IC341114
B. chinensis (27)	29.34-42.18	36.05	IC313380, IC386475
B. carinata (9)	26.83-37.16	31.61	IC420371, IC296346
Lepidium sativum (4)	23.68-28.13	25.85	RDV-33
Eruca sativa (4)	28.69-33.42	30.47	-

Table 9*:* Fatty acid profile in *Brassica* sp.

Fatty Acid	Range (%)	Mean (%)	Value rich accessions
Palmitic	2.22-3.79	2.74	IC560704
Stearic	0.91-3.07	1.483	IC335858
Oleic	5.89-13.59	9.97	IC555891
Linoleic	12.88-21.18	16.14	IC560704
Linolenic	7.97-14.29	10.05	IC560704
Ecosenoic	2.58-5.08	3.61	IC560704
Erucic	49.01-58.15	56.14	IC027914

Table 10: Oil content and fatty acid profile of linseed, walnut, grain amaranth and buck wheat germplasm

Crop	Trait	Range (%)	Mean (%)	Value rich accessions
Linseed	Oil content	38.70-45.12	42.82	IC564609, IC564624
	Palmitic acid	5.71-7.47	6.21	IC564622
	Stearic acid	5.05-10.42	6.64	IC564678
	Oleic acid	22.40-33.16	27.19	IC564678
	Linoleic acid	9.24-15.12	12.29	IC564222
	Linolenic acid	43.26-50.96	47.79	IC564597
Walnut	Oil content	46.5-73.31	65.77	EC028426
	Palmitic acid	4.12-7.44	5.95	EC038828
	Stearic acid	1.65-3.92	2.55	IC020115
	Oleic acid	8.26-47.70	21.37	IC020075
	Linoleic acid	38.75-69.96	58.34	EC038834
	Linolenic acid	5.93-20.28	12.04	NIC020070
Grain	Oil content	7.87-10.05	9.11	IC38155, IC038109
amaranth	Palmitic acid	15.48-21.10	18.73	IC35678
	Stearic acid	0.74-5.68	2.81	IC274446
	Oleic acid	24.85-30.28	27.29	IC22550-1
	Linoleic acid	41.13-52.15	49.01	IC274445
	Linolenic acid	0.31-5.14	1.66	IC22553
Buck wheat	Protein content	6.57-14.17	8.99	IC16552
	Oil content	0.75-5.4	2.53	IC26600
	Palmitic acid	12.91-18.47	15.75	EC386607
	Stearic acid	1.9-6.31	3.29	IC26584
	Oleic acid	29.23-47.53	40.11	IC16579
	Linoleic acid	30.13-47.86	36.99	EC288737
	Linolenic acid	1.13-12.63	5.13	IC104485

2.1.3.3 Crude protein and tryptophan content in wheat and kodomillet germplasm: Crude protein (%) and tryptophan content (mg/100g) were estimated in 13 genotypes (checks) of wheat from different species including eight from *T. aestivum*, one each from *T. turgidum* ssp. *dicoccum*, *T. poloniicum*, *T. sphaerococcum* and two from *T. turgidum* ssp. *durum*. The crude protein ranged from 8.7-15.6 percent and tryptophan content ranged from 103-205 mg/100g. kodomillet samples (66) were also analysed for tryptophan content which ranged from 28.35-235.5 mg/100g. JK-48 and G Puk-3 used as checks had 92.7 and 154 mg/100g tryptophan content, respectively. Some of the promising kodomillet genotypes for tryptophan content include IC567453, IC395752, IC331108.

2.1.3.4 Estimation of antinutritional factors in rapeseed-mustard germplasm: Three hundred and twenty three rapeseed-mustard samples were analyzed for the total glucosinolate content using palladium complex method. The glucosinolate content within accessions ranged from 10.68-145 µmole/g defatted seed meal. Two accessions namely IC296827 and IC405232 were identified with low glucosinolate content i.e. <30 µmole/g defatted seed meal. Both the accessions reported with low glucosinolate content belonged to *B. napus*. Phytic acid and phosphorus content was estimated in 23 rapeseed-mustard samples which ranged from 0.6-1.99 g/100g and 0.17-0.49 g/100g, respectively. Accession IC385675 was reported with the lowest i.e. 0.6 g/100g phytic acid content. Further, 30 samples of pearl millet were also analyzed for phytic acid which ranged from 0.53-1.684 g/100g.

2.1.3.5 Antioxidant potential of walnut germplasm: Eleven walnut accessions were analyzed for their

antioxidant potential through estimation of %DPPH radical scavenging activity, Total phenol, O-dihydric phenol, flavonoid, total sugar and ascorbic acid content. Promising accessions EC036748 and IC316411 were reported with high antioxidant potential.

2.1.3.6 Quality analysis of maize, faba bean, lentil and brinjal germplasm: A total of 130 accessions of maize, 181 of fababean, 180 of lentil and 168 of brinjal corset were analyzed for the various quality characteristics. The details of quality parameters and value rich accessions are given in Table 11.

Table 11: Quality analysis of maize, fababean, lentil and brinjal

Crop	Biochemical parameter	Range	Mean	Value rich accessions
Maize	Protein content	9.76-13.61	11.49	IC405278, IC563963, EC639240, EC497581, EC639354, EC637995
	Oil (%)	2.72-5.06	4.03	IC563765, IC405278, IC396382, IC568703, IC75053, EC447940, EC477356, EC639230, EC452456, EC452460
	Sugar (%)	3.23-5.16	3.73	IC251359, IC563765, IC563963, EC452456, EC453612, EC452458, EC452460
	Starch (%)	67.73-72.73	70.5	IC251359, IC75064, EC639047, EC497581, EC 639163, EC444483, EC639348, EC637995
Fababean	Protein content (%)	8.9 – 46.1	32.1	EC591675, EC243443, EC343694, EC10843,
	Starch (%)	9.5 – 34.3	23.5	EC628922
	Soluble sugars (%)	1.5 – 6.3	3.6	
	Total minerals (%)	3.5- 8.3	6.6	ET2107, ET3121, EC628929
	Total phenol (mg/g)	2.3– 16.2	10.7	EC10719, EC005873, EC591770
	Flavanol mg/100g	4.3 – 48	15.9	
Brinjal	Moisture (%)	87.2 – 94.3	90	-
	Total minerals (%) (dry wt. basis)	3.8-12.7	9.2	IC261801, IC090806, IC381562, IC427025, NIC023962, IC112950, IC099691
	Soluble sugar (%)	1.5 – 9.3	5.3	IC354612, IC089949-B, IC354564, NIC023957, IC354525
	Total phenol (%)	0.08-0.82	0.5	IC074239, IC111439, EC386589, IC427025
	Vitamin C (%)	0.03-0.53	0.3	IC112313, IC545897, EC304072, IC427008
Lentil	Total mineral content (%)	2.1 - 5.5	3.6	L7938, L3572, IC559876 (>5%)

2.1.4 Phytochemical Evaluation

2.1.4.1 Phytochemical evaluation of medicinal and aromatic plants: A total of 509 samples of different medicinal and aromatic plants germplasm were evaluated for their quality traits. The details of major crops and range of active compound present in them along with superior accessions are given in the Table 10.

Kaempferia galanga accession IC550136 collected from Karnataka was found to contain high essential oil content of 1.21% in rhizomes on DWB compared to two local check varieties for two consecutive *Rabi* seasons of 2010-11 and 2011-2012.

2.1.4.1.2 Analysis of aroma compounds in aromatic plants: The volatile essential oils of aromatic plants (167 samples) were analyzed by GC and GC-MS to identify aroma compounds present in them. The details of major compounds identified in major aromatic plants are given in Table 13. Based on two years of chemical evaluation of *O.* species/ varieties showed promising accessions in *O. citriodorum* (EC338785) and *O. pilosum* (EC387836, EC387835) were identified for methyl chavicol rich (>90%).

2.2 Multi-Location Evaluation of Germplasm

A total of 3,790 accessions comprising of wheat (1,100), rice (915), maize (175), mustard (240) brinjal (200), okra (200), chickpea (205), pigeonpea (305) and lentil (450) were evaluated at different locations (103 centres) across the country involving NAGS, AICRPs and SAUs. The trait specific promising accessions were identified.

Table 12. Quality analysis of different medicinal and aromatic plants

Plant Name (Acc.)	Active compound (plant part)	Range (% DWB)	Superior Accessions
Alpinia galanga (12)	Essential oil (Rhizomes, Roots, Aerial leafy, shoots)	0.21-0.41% 0.33-0.66%Traces	IC565488, IC349746, IC402361
Alpinia calcarata (16)	Essential oil (Rhizomes, roots + parts of rhizomes, aerial leafy)	0.29-0.96% 0.88-1.85%0.26-0.93%	IC373610, IC468880, IC210421
Kaempferia galanga (17)	Essential oil (Rhizomes, roots, leaves)	0.17 – 1.21% 0.23 – 0.59%Traces	IC550136, IC373685
Mucuna pruriens (11)	L-DOPA (seeds)	4.20-6.11%	IC589220, IC589208
Andrographis paniculata (42)	Andrographolide (Herbage)	1.28 – 1.86%	IC471916, IC471919

Table 13: Chemical composition of essential oils from aromatic plants

Plant Name (acc.)	Major compounds identified	Superior accessions
Alpinia galangal (12)	1,8-cineole,á-pinene,á-terpineol, â-farnescene, Terpinen-4-ol	IC557436, IC265610
Alpinia calcarata (16)	1,8-cineole, á-fenchyl acetate, á-pinene, camphene, camphor, á-terpineol, terpinen-4-ol, methyl cinnamate	IC373610, IC210421
Kaempferia galangal (19)	Trans-ethyl cinnamate, trans- ethyl p-methoxy cinnamate, 1,8-cineole	IC373685
Ocimum species/varieties (*difforme, purpurascens, glabratum, citriodorum, basilicum, pilosum, gratissimum* and *viride*) (30)	Linalool, methyl chavicol, citral, camphor, eugenol	EC338785, EC387836, EC387835
Citrus aurantifolia (1)	Limonene, neral, geranial, nerol	-
Oregano vulgare (1)	Thymol, carvacrol, p-cymene, ã-terpinene	-

2.3 Pre-breeding and Genetic Enhancement

2.3.1 Characterization of wild annual *Cicer* species for morphological traits: Characterization of seven wild annual *Cicer* species showed wide variation, , plant pigmentation exhibited variation in *Cicer reticulatum*, *C. judaicum* and *C. pinnatifidum*. Light pubescent leaves were observed in all the seven annual *Cicer* species. Number of leaflets/ leaf also showed remarkable variation in majority of *Cicer* species. In most of the species, seed shape was angular, except in *C. bijugum*, where it was pea shaped. Testa texture was rough in *C. arietinum*, *C. reticulatum, C. judaicum, C. pinnatifidum* and *C. yamashitae* while it was tuberculated in *C. echinospermum* and *C. bijugum*. There was substantial variation in the seed colour of *C. reticulatum*, *C. judaicum* and *C. pinnatifidum*.

2.3.1.1 Hybridity confirmation of lentil F_1 crosses using morphological and molecular markers: True nature of hybrids in nine F_1 crosses was confirmed by morphological as well as molecular (ISSR) markers to determine the purity of each cross-combination for developing reliable F_2 populations. A total of 120 ISSR primers were screened out of which only three were found useful for confirming the true hybridity. The remaining ones produced monomorphic amplicons between parents (Fig 10). Crosses I to V could be confirmed with the primer ISSR 25 (5'-TCTCTCTCTCTCTCTCG-3'), VI with the primer ISSR 23 (5'-ACACACACACACACACG-3') and VII to IX with the primer ISSR 22 (5'-ACACACACACACACACT-3').

2.3.1.2 Hybridity confirmation of chickpea F_1 crosses using morphological and molecular markers: Four interspecific cross combinations were tested using morphological and molecular (RAPD and SSR) markers. RAPD was found useful in two crosses (Pusa 1103 x ILWC 46 and Pusa 256 x ILWC 46) while

SSR markers were found useful in two crosses (Pusa 256 x ILWC 239 and (JG 11 x ILWC 239).

2.4 Documentation

A total of 6,287 accessions of various crops were characterized and evaluated during *Rabi* 2010-11 season at NBPGR, New Delhi (3,339 acc.) and its Regional Stations namely Akola (1,128 acc.), Bhowali (250 acc.), Cuttack (41 acc.), Hyderabad (2,289 acc.), Shimla (365 acc.) Srinagar (420 acc) and Thrissur (515 acc.). The same was compiled and documented as "Annual Report on Characterization and Evaluation of *Rabi* Crops (2010-11)". Similarly, a total of 4,262 accessions were characterized and evaluated during *Kharif* 2011 season at NBPGR, New Delhi, (1,100 acc.) and its Regional Stations namely Akola (411 acc.), Bhowali (330 acc.), Hyderabad (185 acc.), Jodhpur (702 acc.) Shillong (553 acc.), Shimla (901 acc.) and Thrissur (80 acc.). The same was compiled and documented in the form of "Annual Report on Characterization and Evaluation of *Kharif* Crops (2011)".

Under Multi-location Evaluation Programme conducted during 2010-11, a total of 1000 accessions comprising of wheat were characterized and evaluated at different hot spot locations for agro-morphological traits, abiotic and biotic stresses. The promising accessions for different traits were compiled and brought out in the form of a catalogue, "Multi-location Evaluation of Wheat (2010-11)".

2.5 Germplasm Supply

Utilization of germplasm of various crops by breeders and other scientists in the country for crop improvement programme is an important aspect in sustainability of crop production. During the reporting period, a total of

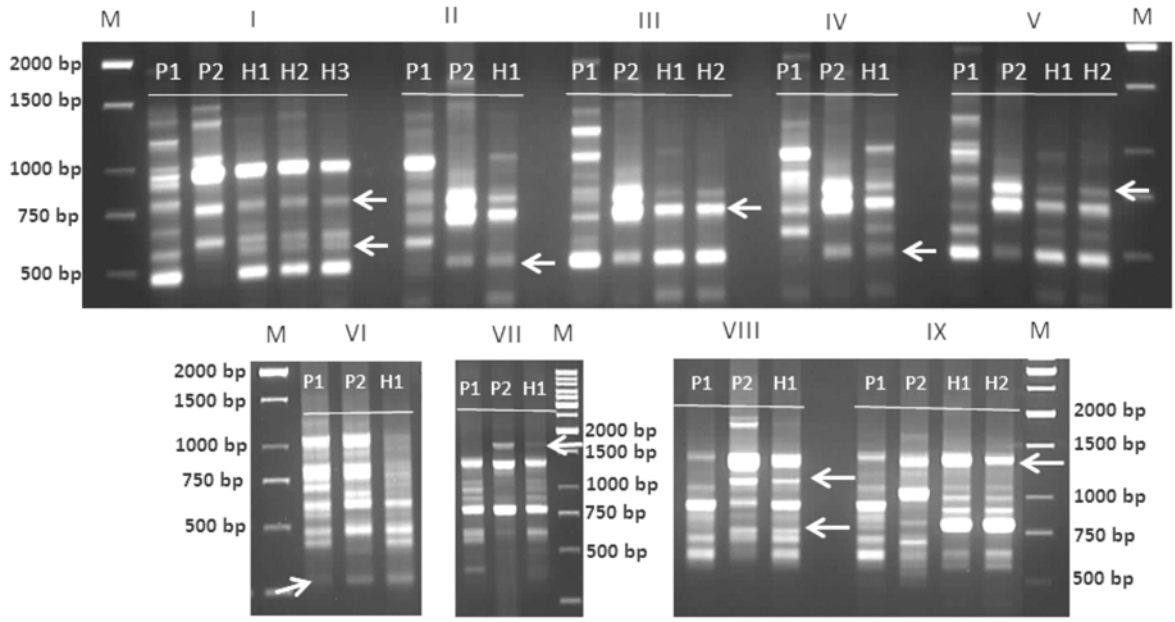


Fig. 10: Confirmation of hybridity of inter sub-specific and interspecific crosses using Inter-Simple Sequence Repeat (ISSR) markers. The roman numerals (I-IX) at top in the figure are: I = three hybrids and the parents *L. culinaris* ssp.*culinaris* (cv. L830) (P1) and *L. culinaris* spp. *orientalis* (ILWL7) (P2); II = one hybrid and the parents *L. culinaris* ssp.*culinaris* (cv.ILL10829) (P1) and *L. culinaris* spp. *orientalis* (ILWL7) (P2); III = two hybrids and the parents *L. culinaris* ssp.*culinaris* (cv.ILL8006) (P1) and *L. culinaris* spp. *orientalis* (ILWL62) (P2); IV = one hybrid and the parents *L. culinaris* ssp.*culinaris* (cv.Precoz) (P1) and *L. culinaris* spp. *odemensis* (ILWL 20) (P2); V = two hybrids and the parents *L. culinaris* ssp.*culinaris* (cv. ILL10829) (P1) and *L. culinaris* spp. *odemensis* (ILWL81) (P2); VI = one hybrid and the parents *L. culinaris* ssp. *culinaris* (cv.L830) (P1) and *L. lamottei* (ILWL14) (P2); VII = one hybrid and the parents *L. culinaris* ssp.*culinaris* (cv.ILL10829) (P1) and *L. lamottei* (ILWL14) (P2); VIII = one hybrid and the parents *L. culinaris* ssp. *culinaris* (cv.ILL10829) (P1) and *L. ervoides* (ILWL30) (P2); and IX = two hybrids and the parents *L. culinaris* ssp.*culinaris* (ILL8006) (P1) and *L. ervoides* (ILWL55) (P2). M is 1 kb molecular weight size standard (MBI Fermentas). Arrows depict male parent-specific diagnostic dominant markers for hybridity confirmation. P1 is female parent, P2 is male parent and H1, H2, and H3 stand for hybrids.

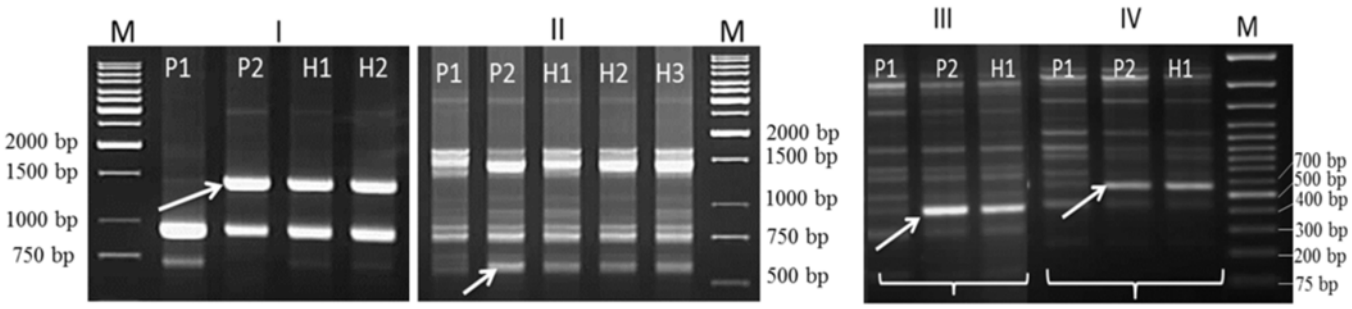


Fig. 14: Confirmation of hybridity of inter-specific crosses of *Cicer* using molecular markers. I-IV at top of the figures represent different inter-specific crosses, I: two hybrids between *C. arietinum* (Pusa 256) (P1) and *C. echinospermum* (ILWC239) (P2); II: three hybrids between the parents *C. arietinum* (JG11) and *C. echinospermum* (ILWC239); III: one hybrid between the parents *C. arietinum* (Pusa 1103) (P1) and *C. reticulatum* (ILWC46) (P2), and IV: one hybrid between the parents *C. arietinum* (Pusa 256) (P1) and *C. reticulatum* (ILWC46) (P2). Crosses in panel I and II were confirmed through ISSR markers, whereas in panel III and IV were confirmed through RAPD markers. M is 1 kb molecular weight size standard (MBI Fermentas). Arrows depict male parent-specific diagnostic dominant markers useful for true hybridity confirmation. P_1 is female parent, P_2 is male parent and H_1, H_2, and H_3 stand for hybrids.

4,425 accessions of various crop groups namely, cereals (3,535), pulses (353), oilseeds (109), vegetable crops (315), underutilized crops (26) and medicinal and aromatic plants (87) were supplied to 88 indenters belonging to ICAR Institutes, State Agricultural Universities and other research organizations engaged in crop improvement programmes.

2.6 Active Germplasm Holding in MTS

A total of 37,643 accessions of various field crops comprising cereals (18,110), millets and forages (437), pulses (6,165), oilseeds (5,381), vegetable crops (5,932), underutilized crops (1,360), and medicinal and aromatic plants (258) were maintained in medium term storage during the period under report.

Research Programme (Programme Code: Title, Leader)

PGR/GEV-BUR-DEL-01.00 Characterization,Evaluation, Maintenance, Regeneration and Documentation of Germplasm Resources of Various Crops **(M Dutta)**

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

PGR/GEV-BUR-DEL-01.01 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of wheat, barley and triticale (**BS Phogat,** TP Singh, MC Singh, Sundeep Kumar, Sandeep Kumar and YS Rathi)

PGR/GEV-BUR-DEL-01.02 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of maize (**Ashok Kumar,** Jyoti Kumari, Sandeep Kumar, Harender Singh and RK Sharma)

PGR/GEV-BUR-DEL-01.03 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of pulse crops (**NK Gautam**, Mohar Singh, A Roy, Z Khan, TV Prasad, Rakesh Bhardwaj, OP Dahiya and Babu Ram

PGR/GEV-BUR-DEL-01.04 Characterization, evaluation, maintenance, regeneration and documentation of Germplasm Resources of oil seeds (**Ranbir Singh,** MK Bag, Sangita Yadav, Rashmi Yadav and Poonam Suneja)

PGR/GEV-BUR-DEL-01.05 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of *Rabi* vegetable crops (**Pragya**, KK Gangopadhyay, A Roy, Z Khan, TV Prasad, M Arivalagan, MK Bag and BL Meena)

PGR/GEV-BUR-DEL-01.06 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of *Kharif* vegetable crops (**KK Gangopadhyay,** Pragya, SK Yadav, A Roy, Z Khan, TV Prasad, MK Bag, M Arivalagan and BL Meena)

PGR/GEV-BUR-DEL-01.07 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of medicinal plants (**Ashok Kumar,** Archana Raina, Arivalagan, Harender Singh and Ombir Singh)

PGR/GEV-BUR-DEL-01.08 Biochemical evaluation of germplasm resources of various field crops (**Sangita Yadav,** Rakesh Bhardwaj, Sandeep Kumar, Ranbir Singh, NK Gautam, Zakir Hussain and Poonam Suneja)

PGR/GEV-BUR-DEL-01.09 Characterization, evaluation, maintenance, regeneration and documentation of germplasm resources of under-utilized crops (**BS Phogat**, Rashmi Yadav, Hanuman Lal and Ranbir Singh)

PGR/GEV-BUR-DEL-01.10 Studies on Statistical Techniques for Efficient Management of Plant Genetic Resources (**Hanuman Lal**)

PGR/GEV-BUR-DEL-01.11 Genetic Resources Information Programme (**Hanuman Lal,** Madhu Bala and Rajiv Gambhir)

PGR/GEV-BUR-DEL-01.12 Characterization, Evaluation, Maintenance, Regeneration and Documentation of Germplasm Resources of Aromatic Plant (**Archana Raina**, Ashok Kumar and Ombir Singh)

PGR/GEV-BUR-DEL-01.13 Development of core set in Brinjal (*Solanum melongena* L.) (KK Gangopadhyay, SK Yadav, Pragya and IS Bisht)

PGR/GEV-BUR-DEL-01.14 Prebreeding and genetic enhancement in lentil and chickpea genetic resources (**Mohar Singh**, Jyoti Kumari, M Dutta, IS Bisht, TP Singh and Mukesh Rana)

PGR/GEV-BUR-DEL-01.15 Evaluation for abiotic stress (terminal heat tolerance) in wheat germplasm (**TP Singh,** Mohar Singh, Rashmi Yadav, Rakesh Bhardwaj and Jyoti Kumari)

PGR/GEV-BUR-DEL-01.16 Standardization of agro-techniques of elite medicinal plants (Giloe and Shatavar) (**MC Singh,** BS Phogat, Archana Raina, M Arivalagan and BS Panwar)

Externally Funded Projects

1. Harmonizing biodiversity conservation and agricultural intensification through integration of plant, animal and fish genetic resources for livelihood security in fragile ecosystems. (NAIP/JEF, **IS Bisht *et al.***)
2. Pre-breeding and genetic enhancement for breaking yield barriers in centre and kabuli chickpea (DAC- ICARDA –ICAR, **Mohar Singh** and IS Bisht)
3. Biochemical and molecular characterization of amaranth and buckwheat genetic resources from north-west Himalaya region (DST, **Sangita Yadav** and JC Rana)
4. Use of machine vision for distinguishing among crop varieties. (NFBSFARA, Nachiket Kotwaliwale, SK Chakraborty and **KK Gangopadhyay**)
5. Development of guidelines for the conduct of test for distinctiveness, uniformity and stability (DUS) on grain amaranth, buckwheat and fababean (PPVFRA, **Rashmi Yadav**, BS Phogat, Sangita Yadav and JC Rana)
6. Establishment of Referral Laboratory for conducting special biochemical tests. (PPVFRA, **Sangita Yadav,** Sandeep Kumar, Archana Raina, Rakesh Bhardwaj)

3. GERMPLASM CONSERVATION

Summary: A total of 12,970 accessions of germplasm including varieties to be notified and released and trait-specific registered germplasm of various crops were received for long-term conservation in the National Genebank. These were processed following the international genebank standards, adding another 6,767 accessions to the base collection raising the total germplasm holding to 3,95,753. Monitoring of seed germination and quantity in stored germplasm (8,390 accessions) and distribution (14,678) for evaluation/ regeneration/ research/ restoration of active collections were the other priority activities. Dormancy breaking methods were standardized for *Vigna* spp. (9) and *Solanum lasiocarpum.* Three new species of barley (*H. brevisubulatum, H. brevisubulatum* subsp. *violaceum* and *H. jubatum*) and one species of wild wheat (*Triticum fungicidum*) were procured for conservation in the National Genebank. Taxonomic validation and seed multiplication of thirty species of wild wheat accessions conserved in the National Genebank was done. Storability of seeds of 19 crops belonging to different crop groups was assessed at Chang-La (naturally cold low energy conservation conditions) and two other controlled environments *viz.* Leh and National Genebank (-18^{0}C). A total of 19 accessions with unique traits were approved for registration.

Long-term storage (LTS) of seeds of various agri-horticultural crops in the National Genebank (-18^{0}C), and medium-term storage (MTS at +8^{0}C) of reference samples of germplasm introduced from various countries as well as collected indigenously were 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 have been the other important activity to facilitate their use in crop improvement programmes. Necessary corrections were incorporated in the data of conserved germplasm retrieved after porting for incorporation in the national database. Supportive research directed towards understanding and manipulation of factors that prolong the storage life of seeds in a cost-effective manner and overcoming seed germination problems continued. Seeds of 19 crops belonging to different crop groups (cereals, grain legumes, pseudo cereals, millets and forages, fibre crops, oilseeds, vegetables, fruits, medicinal and aromatic plants & narcotics, spices and condiments, and agro forestry) and conditioned to 7% moisture were monitored after one year of storage at four locations *viz.* LTS module (at -18^{0}C), inside the storage facility at Chang La, outside the chamber and at Defence Institute for High Altitude Research (DIHAR), Leh.

3.1 Germplasm Augmentation

A total of 12,970 germplasm accessions of various agri-horticultural crops were received for LTS in the National Genebank. These included 3,000 repatriated germplasm of paddy regenerated at Banaras Hindu University Centre, Varanasi, under the DBT project 'Establishment of National Rice Resources Database'.

A total of 6,767 accessions qualified for conservation as per the genebank standards and were conserved at –18^{0}C as base collections. The details of the various crop germplasm added to the genebank are listed in Table 1 and the crop-group-wise comparison has been depicted in Fig.1. Cereals comprised a major portion (61%) of the accessions added to the genebank, followed by oilseeds (14%), millets and pulses (7% each). The crop groups *viz.* vegetables, fibres, forages, spices and condiments and medicinal plants each contributed between 1-6% of the total accessions added to the genebank.

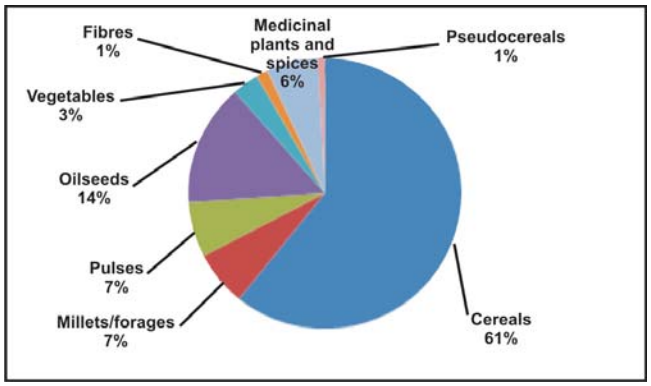


Fig. 1. Crop group-wise accession added to the genebank (LTS)

The genetic stocks and improved cultivars are given high priority in seed conservation since they are the potential genetic resources that can be directly utilized in breeding programmes. Paddy, wheat, maize, pearl millet, sorghum, groundnut and mustard were the predominant crops in which elite accessions were conserved in the genebank (Fig. 2).

The total germplasm holding in the National Genebank has increased to 3,95,753 representing 1,584 species. In addition, a total of 6,840 accessions of exotic germplasm were received and stored as reference samples in the MTS module.

Table 1: Status of Base Collections in National Genebank (-18°C)

Crop/ Crop Group	No. of Acc. conserved (from 1.01.12 to 31.12.12)	Present status of accessions conserved
Paddy	2872	94691
Wheat	236	40081
Maize	728	9479
Others	279	12267
Cereals	**4115**	**156518**
Sorghum	28	20414
Pearl millet	155	8395
Minor millet	153	22303
Others	108	5344
Millets and forages	**444**	**56456**
Amaranth	19	5558
Buckwheat	22	880
Others	10	387
Pseudo Cereals	**51**	**6825**
Chickpea	13	16894
Pigeonpea	198	11427
Mung bean	23	3704
Others	210	26135
Grain Legumes	**444**	**58160**
Groundnut	17	14610
Brassica	255	10642
Safflower	18	8048
Others	694	24163
Oilseeds	**984**	**57463**
Cotton	64	6815
Jute	3	2914
Others	28	2214
Fibre Crops	**95**	**11943**
Brinjal	38	4084
Chilli	-	2011
Others	176	18968
Vegetables	**214**	**25063**
Custard apple	'-	59
Papaya	-	23
Others	-	448
Fruits	**-**	**530**
Opium poppy	-	350
Ocimum	32	465
Tobacco	1	1483
Others	135	4472
Medicinal & Aromatic Plants & Narcotics	**168**	**6770**
Coriander	46	701
Sowa	-	91
Others	205	2555
Spices & Condiments	**251**	**3347**
Pongam oil tree	-	395
Others	1	2048
Agro-forestry	**1**	**2443**
Lentil	-	7712
Pigeonpea	-	2523
Duplicate Safety Samples	**-**	**10235**
Total	**6,767****	**3,95,753***

*The figure includes 4,122 Released varieties and 2,213 Genetic stocks
No. of crop species conserved – 1,584
**The figure includes 158 Released varieties and 74 Genetic stocks

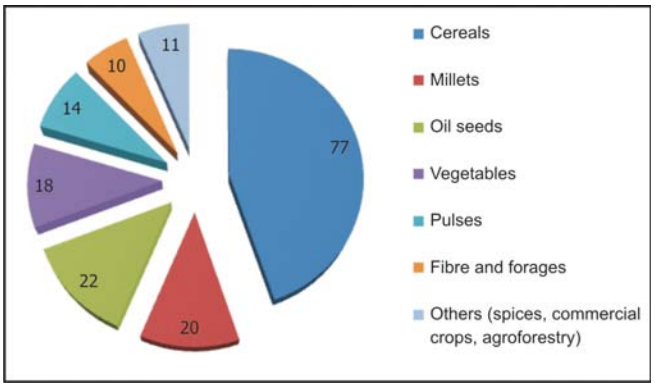


Fig. 2. Promising genetic resources (genetic stocks and improved cultivars) added to the National Genebank in each crop group

3.2 Documentation and Database Management

Data of about 3.9 Lakh accessions have been updated with regard to their taxonomic identity, biological status and other relevant passport data. The edited information has been ported to new web-enabled database system to integrate the same with PGR portal of NBPGR. Data entry of 6,767 new accessions added to the National Genebank has been incorporated into the database.

3.3 Monitoring of Germplasm

Germplasm stored in the long-term storage module for 10 years or more (8,390 accessions) were monitored for seed viability and seed quantity to ensure the status of the conserved germplasm as per recommended genebank standards. The details of the viability tests are given in Table 2.

3.4 Distribution and Use of Germplasm

A total of 14,749 accessions were distributed for various purposes. Most of the accessions were distributed for regeneration, characterization and evaluation, while 1,359 accessions were supplied for research purpose.

3.5 Supportive Research

3.5.1 Conservation of crop wild relatives:

***Standardization of protocols for breaking physical dormancy in Vigna* spp.**

Protocols were worked out to remove hardseededness (a form of physical dormancy) in 26 accessions

Table 2: Monitoring of viability of germplasm conserved in LTS for > 10 years.

Crop	Number of accessions tested for viability	Initial viability	Present viability	No. of accessions with viability <85%
Paddy	2000	80-100	20-100	315
Safflower	50	88-100	88-100	-
Sunflower	50	85-100	85-100	-
Castor	200	90-100	90-100	-
Groundnut	50	90-100	90-100	-
Sesame	30	80-100	80-100	-
Maize	1057	88-100	80-100	3
Barley	802	92-100	88-100	-
Cotton	461	65-100	52-96	65
Jute	424	85-100	74-98	23
Mesta	11	85-100	85-100	-
Sunhemp	2	85-100	85-100	-
Chickpea	336	86-100	88-100	-
Pea	150	82-88	86-90	-
Amaranth	160	88-96	88-100	-
Pearl Millet	675	86-100	86-100	-
Sorghum	535	86-100	86-100	-
Finger Millet	514	86-100	86-100	-
Prosomillet	102	86-100	86-100	-
Barnyard Millet	103	86-100	86-100	-
Foxtail Millet	111	86-100	86-100	-
Spices (*Trigonella, Foeniculum, Capsicum, Cuminum*, carom)	27	80-85	78-84	27
Medicinal and Aromatic Plants	355	75-85	70-85	82 (opium poppy)
Pearl millet (Forage)	42	88-100	88-100	-
Sorghum (Forage)	102	50-100	10-100	40
Lucerne (Forage)	26	85-100	60-100	10
Cowpea (Forage)	3	85-90	80-90	1
Maize (Forage)	1	100	100	-
Sesbania (Forage)	11	65-100	36-92	5
Total	8,390			571

comprising nine species of *Vigna viz. V. vexillata* (2 accessions), *V. wightii* (1), *V. pilosa* (2), *V. dalzelliana* (7), *V. hainiana* (2), *V. trinervia* var. *bourneo* (2), *V. radiata* var. *sublobata* (3), *V. radiata* var. *setulosa* (2) *V. mungo* (1) and *V. trilobata* (2). Hot water treatment at 50^{0}C could break dormancy in most species with the treatment duration varying from 30 to 15 minutes Out of the 26 accessions effect of hot water treatment (50^{0}C for 30 min.) on breaking hardseededness was good (i.e. >50%) for 16 accessions, fair (40-50%) for 4 accessions and poor (<40%) for 6 accessions; effect of soaking at 50 ^{o}C for 25 min on breaking hardseededness was good for 14 accessions, fair for 4 accessions and poor for 8 accessions; effect of 50^{0}C for 15 min was good for 15 accessions, fair for 2 accessions and poor for 9 accessions over a control value of 0-38%. Only 2 accessions belonging to *V. radiata* var. *sublobata* and *V. hainiana* could withstand (80^{0}C) for 30 min. giving germination of 80 and 40% respectively, over no germination in control.

Seeds of S*olanum lasiocarpum* remain in fresh ungerminated condition for more than 30 days. Physico-chemical treatments *viz*. pre-soaking of seeds in distilled

water and GA_3 200 ppm for 24 h at 30^{0}C enhanced germination up to 72% and 68%, respectively, as compared to control (46%).

New wild species of wheat and barley introduced in the National Genebank

In order to ensure the conservation of maximum genetic diversity in each crop species, an assessment was carried out on the gaps in conservation in the National Genebank as compared to the global genebanks. Consequently, three new species of barley (*Hordeum brevisubulatum, Hordeum brevisubulatum* ssp. *violaceum* and *Hordeum jubatum*) and one species of wheat (*Triticum fungicidum*) were procured from the National Small Grains Collection, USDA, USA, and processed for conservation in the National genebank.

3.5.2 Nutrient profiling of wheat varieties: Seeds of fifty wheat varieties which are currently in the seed production chain were profiled for their nutrient status with regard to protein, zinc and iron. Substantial variation was observed in the zinc efficiency and inherent iron content of wheat cultivars.

3.5.3 Low-energy conservation strategy: An experiment was conducted to assess the suitability of permafrost conditions for long term conservation. Storability of seeds of 19 crops belonging to different crop groups was assessed (by testing seed viability and vigour) after one year of storage at four locations *viz.* long-term storage module at -18^{0}C, NBPGR, inside the storage chamber at Chang La (permafrost conditions), outside the chamber at Chang La and at DIHAR, Leh.

3.6 Germplasm Registration

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, germplasm with unique traits were registered. Out of 99 proposals considered 19 were approved for registration by the Plant Germplasm Registration Committee. The details of registered germplasm are given in Table 4.

Standardization of Seed Multiplication of Wild Wheat Germplasm under Regulated Conditions

The wild wheat accessions conserved in the National Genebank have been procured from exotic locations, in small quantity and require specific multiplication strategies for the purpose of taxonomic validation and subsequent long-term conservation. Hence, 40 wild wheat accessions belonging to 30 species were grown under regulated temperature and extended photoperiod of various durations. The standardization of flowering and seed multiplication requirements of these wild species will help to multiply the seeds required for conservation and also to screen the wild germplasm for further utilization.

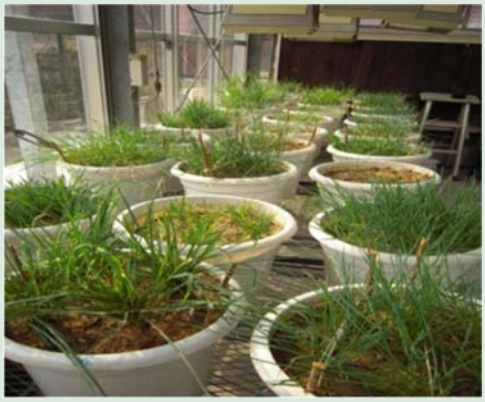


Fig. 4. Wild and exotic wheat accessions grown for multiplication under regulated temperature and photoperiod conditions at Division of Seed Science and Technology, IARI

Table 4: Germplasm registered with unique traits in various crop groups

Crop group	Registered during 2012	Total accessions registered	No. of species
Cereals & Pseudo-cereals	5	376	11
Millets	-	67	4
Grain Legumes	2	115	16
Oilseeds	1	138	25
Fibres and Forages	5	81	15

Vegetables	3	63	23
Fruits and Nuts	-	32	14
Medicinal, Aromatic and Spice Plants	-	48	39
Commercial crops	3	62	7
Ornamentals	-	41	17
Tubers	-	23	9
Agro-forestry species	-	3	3
Total	**19**	**1,049**	**183**

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 **(RK Tyagi)**

Research projects (Co PI; Associate/s)

PGR/GCN-BUR-DEL-01.01: Management of Information and National Germplasm Conservation Network (**RK Tyagi**, Anjali Kak, Sunil Archak ,BP Dahiya, Rajvir Singh, Rita Rani, Smita Jain and Rajiv Gambhir)

PGR/GCN-BUR-DEL-01-02: Conservation of grain legume germplasm using conventional seed storage methods (**Neeta Singh**, Chitra Pandey and Sherry Rachel Jacob)

PGR/GCN-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods (**Kalyani Srinivasan**, RK Tyagi, Sherry Rachel Jacob, AD Sharma)

PGR/GCN-BUR-DEL-01-04: Conservation of oilseed and fruit crops germplasm using conventional seed storage methods (**J Radhamani**, Neeta Singh)

PGR/GCN-BUR-DEL-01-05: Conservation of cereal germplasm excluding paddy, using conventional seed storage methods (**Sherry Rachel Jacob**, K Srinivasan and J Radhamani)

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

PGR/GCN-BUR-DEL-01-07: Conservation of millets germplasm using conventional seed storage methods (**Sushil Pandey**, Chitra Pandey)

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

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

Externally-funded projects

Collection, conservation and genetic diversity analysis of noni (*Morinda citrifolia*) from other than coastal regions of India. (**Veena Gupta**, Anjali Kak, Lalit Arya and Chitra Pandey)

Field level conservation of germplasm with community participation and establishing nurseries on shared basis with community to improve rural incomes: A project for Jharkhand. (**RK Tyagi** and J Radhamani)

Implementation of PVP legislation: National Plant Variety Repository (**Kalyani Srinivasan**)

Establishment of national rice resources database (**Kalyani Srinivasan**, Rakesh Singh and Sunil Archak)

4. PLANT QUARANTINE

Summary: A total of 1,18,659 samples (1,01,738 processed at New Delhi and 16,921 at Hyderabad) of imported germplasm accessions as well as trial material 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 (1,511)- comprised insects (485), nematodes (127), fungi/ bacteria (805), viruses (20) and weeds (74). Of the 1,511 infested/ infected/ contaminated samples, 1,378 were salvaged through physico-chemical methods *viz.*, fumigation, hot water treatment (HWT), X-ray radiography, pesticidal dip, mechanical cleaning and growing-on test. One hundred and thirty three (93 mango stones from Israel due to rotting/ decay, 39 samples of paddy from USA due to *Neovossia horrida*, one sample of *Brassica napus* from Australia due to *Phoma lingam* and one sample of *Vigna unguiculata* from Italy due heavy *Callosobruchus maculatus* infestation) were rejected. A total of 1,773 samples were processed for export of which 40 infested/ infected samples were salvaged and 8 Phytosanitary Certificates were issued. Four hundred and twenty one 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 viral symptoms only was released to the indenters. Quarantine processing of 946 samples of imported transgenic planting material revealed, fungi and insect infestation in maize and rice; absence of terminator gene was ensured and all samples were salvaged prior to release. A total of 9,644 samples were received from Germplasm Conservation Division for seed health testing of which 604 samples were subjected to X-ray radiography and a total of 183 samples were rejected as they could not be salvaged.

4.1 Import Quarantine

4.1.1 Quarantine examination: A total of 1,18,659 samples (1,01,738 processed at New Delhi and 16,921 at Hyderabad) 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, and mites, plant parasitic nematodes, plant pathogens (fungi, bacteria, viruses) and weed seeds by various detection techniques. Of the import samples, 3,997 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids. A total of 1,511 samples were found infested/ infected/ contaminated. Of these, 485 samples were found infested with insects/ mite including 184 with hidden infestation; 127 samples infected with nematodes, 805 found infected with fungi/ bacteria, 20 with viruses and 74 with weeds. A number of pests of quarantine importance were intercepted (Table 1).

4.1.2 Salvaging of infested/ infected/ contaminated germplasm: Of the total 1,511 infested/ infected/ contaminated samples, 1,378 were salvaged by various disinfestation techniques/ treatments like mechanical cleaning to remove damaged/ abnormal seeds, soil clods, plant debris etc., fumigation with ethylene dichloride-carbon tetrachloride (EDCT) mixture @ 320 mg/ litre for 48 h at 30^0C under normal air pressure against insect infestation and hot water treatment (HWT) at 52^0C for 30 minutes for various seed-borne bacterial pathogens and nematodes and X-ray screening for hidden infestation, pesticidal dip/ spray for vegetative propagules. Samples infested with insects/ mites (484) were salvaged through fumigation (189), X-ray radiography (183) and pesticidal dips (165); 127 samples infected with nematodes were salvaged by nematicidal dip treatments; 673 samples infected with fungi/ bacteria were salvaged by fungicidal seed treatment and ethyl alcohol wash; and samples infected with viruses (20) were salvaged through grow-out test and 74 samples contaminated with weed seeds were salvaged by mechanical cleaning. A total of 132 samples (93 mango stones from Israel due to rotting/ decay, 39 samples of paddy from USA due to *Neovossia horrida*, one sample of *Brassica napus* from Australia due to *Phoma lingam*) were rejected.

4.1.3 Prophylactic treatments: A total of 495 seed samples were subjected to fumigation, 409 vegetative propagules to pesticidal dip and spray and 16,996 samples of paddy and 35 samples of *Brassica* were given mandatory hot water treatment. In order to prevent the introduction of new strains of tobamoviruses through seeds, all the introduced germplasm samples of chilli (320), tobacco (7) and tomato (328) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate.

4.1.4 Post-entry quarantine (PEQ) growing in nursery/ greenhouses and inspection at indenter's site: International nurseries trial material of wheat (7,048 entries) from CIMMYT (Mexico), CIMMYT (Turkey) were grown in PEQ nursery at NBPGR and inspected regularly for presence of disease symptoms. Loose smut of wheat was detected in two lines (45^{th} IBWSN-1120

and 45th IBWSN-1172) from CIMMYT (Mexico). The infected plants were first covered in a paper bag and then uprooted and incinerated to prevent spread of the inoculum. None of the lines showed the presence of virus-like symptoms.

A total of 421 samples of exotic germplasm comprising *Glycine max* (6), *Phaseolus lunatus* (5), *P. vulgaris* (365), *Vicia benghalensis* (1), *V. hirsuta* (2), *V. villosa* (6), *Vigna radiata* (6), *V. unguiculata* (362) were grown in contained conditions. The plants showing virus-like symptoms were tested by electron microscopy and using specific antiserum against various seed-transmitted viruses using enzyme-linked immunosorbent assay. The harvest from only healthy plants of different accessions was released to the indenters. The interceptions made are presented in Table-1.

A total of 5,247 accessions of corn imported from Chile and meant for Pioneer Overseas Corporation, Bangalore were released after joint inspection on an undertaking and PEQ inspection was undertaken at indenter's site. The plants were found to be free from quarantine pests.

4.2 Export Quarantine

A total of 1,773 samples of various crops intended for export to various countries were processed for detection of associated pests. Of these, 40 samples were found infected/ infested and all were salvaged. The pathogens detected include *Alternaria padwickii*, *Drechslera oryzae, Fusarium moniliforme, Nigrospora oryzae, Pyrenochaeta oryza* in *Oryza sativa; D. sorokiniana, F. moniliforme* in *Triticum aestivum*. A total of 17 samples were found contaminated with weed seeds viz., *Chenopodium album, Echinochloa crus-galli, Melilotus indica* and *Phalaris minor* and all were salvaged by mechanical cleaning. Eight Phytosanitary Certificates were issued.

4.3 Seed Health Testing for Pest Free Conservation of Indigenously Collected Planting Material

A total of 9,644 samples accessions of indigenously collected seed material and multiplied material at various centres were processed for pest-free conservation. Of these, 55 samples were found infected visually/ under stereo-binocular microscope and 1310 through blotter test. A total of 341 samples were found infested with insect pests visually and 604 samples were subjected to X ray radiography of which 404 samples were infested. Twenty two samples were rejected due to fungal infection, 161 due to heavy insect infestation and could not be salvaged. Several indigenous pests were deleted.

In addition, a total of 149 accessions of different crops conserved in cryo-bank for the last >10 years were processed in quarantine for detection of pests associated with the conserved material. Of these, 31 accessions were found infected with various fungi and all the infected samples were salvaged before handing over to Cryo-preservation Unit. The fungi detected are presented in the Table 2.

4.4 Detection of Viruses in *In Vitro* Cultures of Germplasm Meant for Conservation

Strawberry samples were collected from RS Bhowali for *in vitro* conservation. DAS-ELISA for 54 samples conducted, against 6 associated viruses for which antisera kits were available viz. *Arabis mosaic virus* (ArMV), *Raspberry ring spot virus* (RpRSV), *Strawberry latent ringspot virus* (SLRV), Strawberry mild yellow edge virus (SMYEV), *Tobacco necrosis virus* (TNV), and *Tomato black ring virus* (TBSV), gave negative results implying no virus present in any of 54 samples tested as per ELISA results.

4.5 Supportive Research

4.5.1 Detection of *Colletotrichum capsici* (Syd.) Butler & Bisby in decade-long cryo-preserved chilli seeds: *Colletotrichum capsici*, the anthracnose fungus, survived in/ on a chilli seed sample cryo-preserved for more than ten years. Abnormal and unhealthy-looking seeds showing black spots were subjected to blotter test and examined on eighth day for presence of fungal pathogen(s) and the fungus, *C. capsici*, was identified on the basis of colony characters, fruiting bodies and conidia under stereo-binocular microscope and compound microscope. Pure cultures obtained from infected seed ascertained the identification**.** It shows that the fungus can survive even at this ultralow temperature (-180^{0}C) and such detection highlights the importance of seed health testing before conserving seed material with quality assurance for minimizing the risk of spreading disease through seed.

4.5.2 A simple and sensitive technique for isolation of pure-cultures of seed-borne fungi developed: A simple and sensitive hand-made needle technique

(Fig. 1) for obtaining pure cultures directly from a mixed population of fungi was developed which resulted in purification of several seed-borne fungal species producing exogenous macrospores on seeds of different crops within a minimum possible time *viz*., *Alternaria*, *Bipolaris*, *Botrytis* and *Cercospora.* In this technique, frequency of isolation in pure form ranged from 50.00 (*Corynespora cassicola*) to 87.50 per cent (*Bipolaris oryzae* and *Bipolaris halodes* each) (Fig. 2), whereas, in fungi producing fruiting bodies or sclerotia, frequency of obtaining pure cultures ranged between 37.50 (*Colletotrichum graminicola*) to 100 per cent (*Leptosphaeria sacchari*). This sensitive technique may be useful for quick isolation of specific group of fungi even from their mixed population on seeds.

4.5.3 Mapping of seed-borne fungi of sorghum germplasm in India: Studies on seed mycoflora of sorghum germplasm from six states revealed the presence of 29 fungal species belonging to 14 genera. Out of these, *Bipolaris sorghicola*, *Fusarium verticillioides, Phoma sorghina, Curvularia trifoli* and *C. lunata* were recorded as dominant species with highest level of infection in sorghum germplasm from Maharashtra representing two agro-climatic zones of the country i.e. Western Plateau & Hills and West-coast Plains & Ghat. Thus, the present findings may play greater role in devising resistance breeding strategies of sorghum against different diseases in our country.

4.5.4 Development of multiplex-PCR based methodology for detection of seed-borne fungi of rice: Optimization and development of multiplex-PCR methodology for early detection of major seed-borne fungal pathogens of rice under quarantine from both indigenous and exotic germplasm samples and successfully identified *Fusarium verticillioides* (147 bp), *Alternaria padwickii* (231 bp) and *Rhizoctonia solani* (473 bp) through this technique (Fig. 3).

4.5.5 Standardization of universal rice primer-PCR technique for analysis of genetic diversity in isolates of *Alternaria alternata* (Fr.) Keissler infecting different hosts

Universal rice primer-polymerase chain reaction (URP-PCR) technique were standardized and developed for genetic diversity analysis of *A. alternata* pathogens infecting wide hosts. Thirteen primers were screened for genetic variability studies of 38 isolates of *A. alternata* pathogen obtained from nine states of India

Fig 1. (a) Hand-made needle and (b) dissecting needle

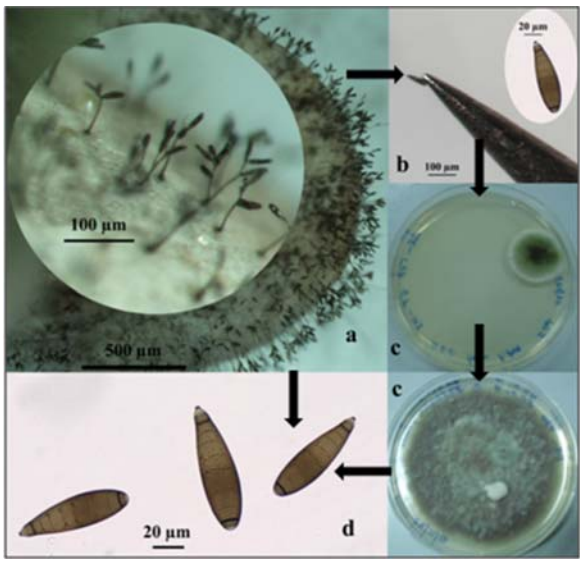


Fig 2. (a) *Bipolaris halodes* on seed
(b) single spore on hand-made needle
(c) growth on Petri dish
(d) spore morphology under compound microscope

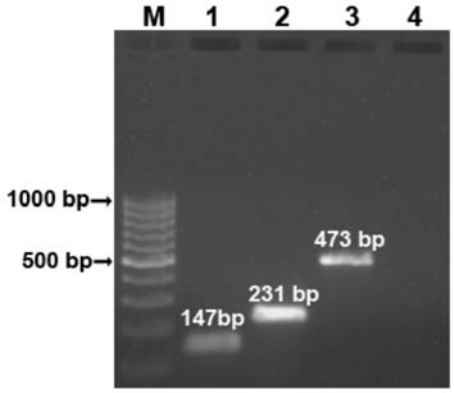


Fig. 3. Species-specific multiplex PCR amplification products generated with three primer pairs. Lane M – 100 bp marker, Lane 1 - *Fusarium verticillioides* (147 bp), Lane 2 - *Alternaria padwickii* (231 bp), Lane 3 - *Rhizoctonia solani* (473 bp) and Lane 4 – negative control.

and three other countries. The dendrogram derived from the UPGMA analysis grouped all the *A. alternata* isolates into 4 major clusters with 25% genetic similarity coefficient and *A. alternata* cultures from tomato (Taiwan) shows high variability compared to other isolates. Among the four major clusters all the Indian

isolates were grouped into three clusters and isolates from Taiwan grouped as fourth cluster with four Indian *A. alternata* isolates. This study may be useful for study of population genetic structure of this *A. alternata* pathogen.

4.5.6 Development of ISSR-PCR technique for analysis of genetic diversity in *Bipolaris oryzae* (Breda de Haan) Shoemaker isolates infecting rice in India: Inter Simple Sequence Repeats (ISSR)-PCR based genetic characterization of *Bipolaris oryzae* were optimized and developed methodology for 36 isolates isolated from rice seeds belonged to different climatic zones of India. Twenty ISSR primers were screened and representative DNA profiles of primer ISSR-10 were given below (Fig. 4). A total of 105 bands were scored showing 80-100% polymorphisms among the ISSR primers. The dendrogram derived from UPGMA analysis grouped the *B. oryzae* isolates into 4 major clusters and 5 isolates as individual grouping with 40 genetic similarity coefficient. Both ISSR-1 and -11 primers gave 100% polymorphisms, whereas ISSR-18 gave 80% polymorphisms among 30 isolates of *B. oryzae*.

4.5.7 Development of molecular diagnostics for plant viruses: Multiplex RT-PCR protocols were developed for simultaneous detection of viruses of quarantine significance for India such as *Arabis mosaic virus* (ArMV), *Cherry leaf roll virus* (CLRV), *Tomato ring spot virus* (ToRSV) and *Grapevine fan leaf virus* (GFLV), CLRV and ToRSV. Also, developed singleplex RT-PCR protocols for detection of five viruses of quarantine significance for India such as ArMV, *Bean pod mottle virus* (BPMV), CLRV, GFLV and ToRSV. Real-time RT-PCR and Helicase Dependent Amplification (HDA) protocols for detection of BPMV and Loop Mediated Isothermal Amplification (LAMP) protocol for detection of *High plains virus* (HPV), not reported from India, have been developed.

4.5.8 Potential quarantine pests for India in edible oilseeds: Information on pests of grain legumes were 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. one hundred and ninety nine potential quarantine pests such as insects (79), mites (6), nematodes (3), fungi and bacteria (48), viruses, viroids and phytoplasma (26) and weeds (29) infecting/ infesting/ contaminating 16 edible oilseeds and their wild relatives.

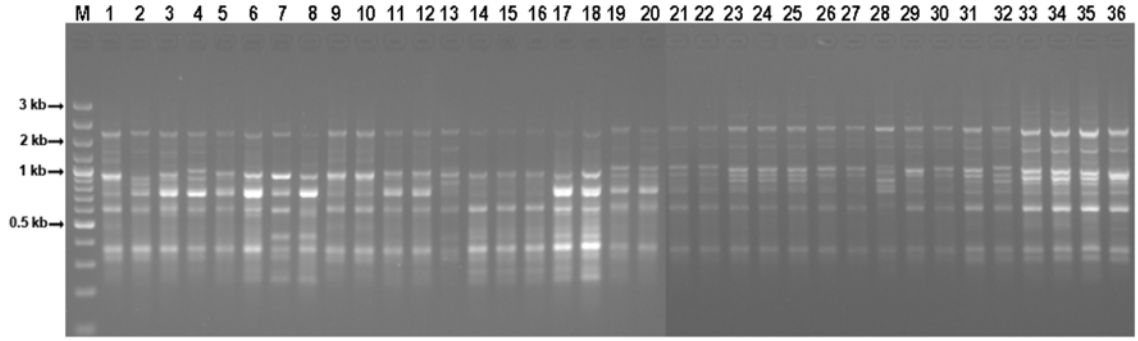


Fig. 4. DNA profiles by primer ISSR-10, lane M – 100 bp plus marker (Fermentas), Lane 1-36 isolates of *B. oryzae.*

Table 1: Pests Intercepted in Exotic Germplasm during 2012

Pest	Host	Country
Insects/ mites		
Acanthoscelides obtectus	*Phaseolus vulgaris*	USA
Callosobruchus chinensis	*Vigna unguiculata*	Italy
Callosobruchus maculatus	*V. unguiculata*	Italy
Rhizopertha dominica	*O. sativa*	Philippines, Brazil
	Atriplex numularia	USA
Sitophilus oryzae	*O. sativa*	Philippines, Benin
	Lolium rigidium	USA
	Zea mays	Chile

Sitophilus zeamais	*Z. mays*	Thailand
Sitotroga cereallela	*O. sativa*	Philippines, Brazil
Tribolium castaneum	*O. sativa*	Philippines, Brazil, USA
Mites	*Theobroma cacao*	UK
	Prunus armeniaca	USA
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Philippines and USA
Pratylenchus penetrans	*P. armeniaca*	USA
Aphelenchus avenae	*P. persica*	USA
Pathogens		
Alternaria brassicae	*Brassica oleracea* var. *capitata*	Netherlands
A. brassicicola	*B. carinata*	Canada
	B. junceea	UK
	B. oleracea var. *capitata*	Netherlands
A. padwickii	*Oryza sativa*	Brazil and Philippines
Bipolaris halodes	*O. sativa*	USA
B. maydis	*Z. mays*	Brazil, Philippines and Thailand
B. oryzae	*O. sativa*	Brazil and USA
B. sacchari	*Lolium rigidum*	USA
B. setariae	*Pennisetum glaucum*	USA
B. sorghicola	*P. glaucum*	USA
B. sorokiniana	*Triticum aestivum*	USA (8) and Australia
Cephalosporium maydis	*Zea mays*	Chile
Colletotrichum capsici	*Abelmochus esculentus*	Taiwan
Fusarium dimerum	*O. sativa*	Brazil and USA
F. oxysporum	*Triticum aestivum*	UK
F. semitectum	*Camelina sativa*	Ireland
Macrophomina phaseolina	*Mangifera indica*	Israel
	Sorghum bicolor	Ethiopia
Melanospora zamiae	*Z. mays*	Chile
Neocosmospora vasinfecta	*S. lycopersicum*	Taiwan
Nigrospora oryzae	*Oryza sativa*	USA
	Momordica charantia	Thailand
Pestalotia guepini	*Leucadendron safari sunset*	Australia
Phoma exigua	*B. oleracea* var. *capitata*	Netherlands
P. leceillei	*Chamaecytisus palmensis*	Australia
P. lingam	*B. napus*	Australia
	B. rapa	Canada
P. medicaginis	*Sorghum* spp.	Japan
P. sorghina	*B. juncea*	UK
Puccinia carthami	*Carthamus tinctorius*	USA
Rhizoctonia solani	*Z. mays*	Chile
Sclerotinia sclerotiorum	*Cucumis* spp.	USA
Tilletia barcklayana	*O. sativa*	USA
Ustilago virens	*O. sativa*	Brazil, Philippines and USA
Verticillium albo-atrum	*O. sativa*	USA
Xanthomonas campestris pv. *campestris*	*B. carinata*	Canada
	B. oleracea var. *capitata*	Netherlands
Viruses		
Bean common mosaic virus	*Glycine max*[c]	AVRDC, Taiwan
	Vigna radiata	AVRDC, Taiwan
Cowpea mild mottle virus	*G. max*	AVRDC, Taiwan
	V. radiata	AVRDC, Taiwan
Cowpea mosaic virus	*G. max*	AVRDC Taiwan
Grapevine fan leaf virus	*G. max*[c]	AVRDC, Taiwan
	V. radiata[c]	AVRDC, Taiwan
	V. unguiculata[c]	Nigeria

Weed seeds		
Acetosella vulgaris	*Oryza sativa*	USA
Agropyron cristatum	*Pennisetum glaucum*	USA
Bromus diandrus	*T. aestivum*	Australia,USA
**Carrichtera annua*	*T. aestivum*	Australia
Centaurea melitensis	*T. aestivum*	Mexico
Convolvulus arvensis	*Phaseolus vulgaris*	USA
Corrispora tenella	*O. sativa*	USA
Echinochloa crus-galli	*Parthenium argentatum*	USA
Galium aparine	*O. sativa*	USA
Ipomoea plebeia	*T. aestivum, O. sativa*	Mexico, USA
I. purpurea	*O. sativa*	USA
Malva parviflora	*T. aestivum*	Mexico
**Setaria magana*	*O. sativa*	Brazil
Sorghum almum	*O. sativa*	USA
**Trifolium bifidum, T. incarnatum*	*Pennisetum purpureum*	Ethiopia

* Pest not yet reported from India
[c] Pest present in India but not recorded on the host on which intercepted

Table 2: Pathogens detected in Cryo-conserved Germplasm

Crop	Pathogen
Amaranthus spp.	*Phoma sorghina*
Brassica juncea	*Xanthomonas campestris* pv. *campestris*
B. rapa	*X. campestris* pv. *campestris*
Sesamum spp.	*Alternaria sesame, Fusarium semitectum, F. verticillioides, P. exigua, Phoma sorshina, Phomopsis* sp., *Sclerotium rolfsii*
Solanum melongena	*F. verticillioides, P. exigua*
Vigna spp.	*Botryodiplodia theobromea, Colletotrichum gloeosporioides, F. semitectum, F. verticillioides, Myrothecium verrucaria, P. exigua*

4.6 Achievements in Externally- funded Projects

4.6.1 National Containment/ Quarantine Facility for Transgenic Planting Material (DBT): With the approval of RCGM 1,149 samples of imported transgenic planting material and examined for association of quarantine pests and transgenes.

Seeds of transgenic material were subjected to various tests in containment for detection of insects, mites, nematodes, bacteria, fungi, viruses and weeds. Important pests intercepted included, fungus *Fusarium moniliforme* in *Zea mays* from the Brazil, Philippines and USA and in *Brassica oleracea* from USA.

Oryza sativa samples (742) were given prophylactic hot water treatment at 52°C for 30 minutes against various seed-borne pathogens and nematodes. Besides, infected samples of *Zea mays* (58) and *Brassica oleracea* (1) were salvaged by giving fungicidal treatment with Bavistin and Thiram.

All 1,149 imported GM lines of maize, rice, cotton, cabbage and *Arabidopsis* were tested for the absence of embryogenesis deactivator gene employing primers specific for *cre* recombinase gene. None of these lines showed the presence of terminator gene technology.

Five post-entry quarantine inspections were undertaken for *Oryza sativa*(1) from Belgium grown at Devgen Seeds & Crop Technology, Medak, A.P; for *Zea mays* (4) from Philippines and USA at Monsanto India, Medak District A.P. (3) and from USA at Dupont India Pvt. Ltd. RR Dist. Hyderabad (1). The crops were visually inspected for symptoms of pests/ diseases. Suspected infected leaf and soil samples were tested at NBPGR.

Maize leaves showing virus-like symptoms during growing in containment facility and PEQ inspection were tested against four viruses using ELISA. The results revealed the presence of *Maize dwarf mosaic virus* in samples from USA.

Major pests which may accompany the seeds of

Arabidopsis thaliana from USA and Japan; *Brassica oleracea* from USA; *Glycine max* (powder) from USA; *Gossypium hirsutum* from USA; *Oryza sativa* from Belgium, USA; *Zea mays* from the Brazil, Italy, Philippines and USA but not yet reported from India were listed by studying the available literature.

4.6.2 Exploiting potential of electron beam irradiation as phytosanitary treatment against pulse beetles in seeds of selected grain legumes (BRNS, DAE): The cultures of test insect pests viz**.,** *Callosobruchus chinensis* and *C. maculatus* were raised on cowpea, lentil and urdbean under the controlled conditions of temperature (28±1°C) and relative humidity (60±5%). The seeds of different legumes were artificially infested with their target pest stages viz., egg, early larva, middle larva, late larva and pupa. The infested and uninfested seeds were irradiated at seven different doses of electron beam radiation using the Electron Beam facility at Raja Rammana Centre for Advanced Technology, Indore. The infested seeds were observed insect parameters viz., adult mortality, longevity, fecundity and adult emergence from irradiated seeds. The uninfested cowpea seeds were studied for the effect of irradiation on physiological and biochemical parameters of seeds. Dose dependent effects of irradiation were observed on insect and seed parameters. Results have been compiled and are being analysed. The irradiated cowpea seeds (about 5000 seeds per treatment) were also raised at Issapur Experimental Farm and collected M_1 progeny from individual plant.

4.6.3 Development of Farmer Friendly Diagnostic Kits for Transgenic Event Seed Purity: ELISA-based kit developed CICR, Nagpur for detection of Cry1C was tested and Cry1C was detected successfully.

4.6.4 ICAR-CABI collaborative project on the study of biological control of invasive plant species and Indian natural enemies

4.6.4.1 Component A: **Himalayan balsam (*Impatiens glandulifera*):** Undertook one survey at various sites in Kullu region and collected balsam seedlings infected with stem rust (*Puccinia* sp.) and *Septoria* sp. This was later sent to CABI, UK under Material Transfer Agreement (MTA). Experiments were conducted using various parameters to inoculate balsam seedlings with these two fungi.

4.6.4.2 Component B: ***Hedychium* spp. complex (*H. gardneriarum*, *H. flavescens*, *H. coronarium*)**: Two surveys were undertaken in Sikkim areas for collection of fungal pathogens and insect pests infecting/ infesting wild ginger by NBPGR and CABI staff. Collected plant materials as well as infected/ infested samples were studied for their potential as natural enemies under controlled conditions at NBPGR. Insect specimens submitted to National Pusa Collection at Division of Entomology, IARI for identification and pathogens submitted to Herbarium Cryptogamae Indiae Orientalis (HCIO) at Division of Plant Pathology, IARI for national accessioning. Thereafter, insect specimens and fungal pathogen infected material sent to CABI, UK under MTA.

4.6.4.3 Component C. *Rubus ellipticus* var. *obcordatus*: Twenty-one distinct populations of *R. ellipticus* were surveyed during the 14-day survey. Fifteen sites were sampled in the Shimla district with a further six sites sampled in the Kullu valley. At each site, extensive sampling was conducted for both arthropod and fungal natural enemies. A total of nine

Survey Team in foothills of Himalaysa

Leaf spot: *Phomopsis* spp. (Ascomyceta)

***Coraebus coerulens* Kerremans (Coleoptera: Buprestidae)**

insects namely *Coraebus coerulens, Adoretus* sp, *Colasposoma downesi, Chaetocnema basalis, Lagria* sp., *Hoplistodera virescens, Zicrona caerulea, Trabala vishnou, Thyatira batis,*and two pathogens *viz.,Phragmidium* sp. and *Phomopsis* sp.were identified.

Research Programme (Programme Code: Title, Leader)

PGR/PQR- BUR-DEL-01.00 Quarantine Processing of Plant Germplasm Under Exchange and Supportive Research (**PC Agarwal)**

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

PGR/PQR- BUR-DEL-01.01 Quarantine processing of Germplasm for Joint inspection (**PC Agarwal**, Usha Dev (till June, 2012), DB Parakh, Mool Chand Singh, Kavita Gupta, Charan Singh, Dinesh Chand and Ashok Maurya

PGR/PQR- BUR-DEL-01.02 Post-entry Quarantine Processing of Exotic Germplasm (**PC Agarwal,** Arjun Lal, B Lal, DB Parakh, V Celia Chalam, Charan Singh and Ashok Maurya)

PGR/PQR- BUR-DEL-01.03 Quarantine Processing of Imported Transgenic Germplasm and Supportive Research (**Manju Lata Kapur**, Gurinder Jit Randhawa, Shashi Bhalla, Baleshwar Singh, V Celia Chalam, Z Khan and Ashok Maurya)

PGR/PQR- BUR-DEL-01.04 Detection and Identification of Insect and Mite Pests in Quarantine and Supportive Research (**Kavita Gupta**, Manju Lata Kapur, Shashi Bhalla and Charan Singh)

PGR/PQR- BUR-DEL-01.05 Detection and Identification of Nematode Pests in Quarantine and Supportive Research (**Z Khan** and Arjun Lal)

PGR/PQR- BUR-DEL-01.06 Detection and Identification of Fungi and Bacteria in Quarantine and Supportive Research (**Baleshwar Singh** (w.e.f July, 2012), **Usha Dev** (till June, 2012), , PC Agarwal, J Akhtar, A Kandan and Dinesh Chand)

PGR/PQR-BUR-DEL-01.07 Detection and Identification of Viruses in Quarantine and Supportive Research. (**V Celia Chalam**, DB Parakh and Ashok Maurya)

PGR/PQR-BUR-DEL-01.08 Quarantine Treatments for Disinfestation of Germplasm Under Exchange against Insect and Mite Pests and Supportive Research (**Shashi Bhalla**, Manju Lata Kapur, Kavita Gupta, TV Prasad, Charan Singh)

PGR/PQR-BUR-DEL-01.09 Quarantine Treatments for Disinfection of Germplasm Under Exchange against Nematodes and Supportive Research (**Z Khan** and Arjun Lal)

PGR/PQR-BUR-DEL-01.10 Quarantine Treatments for Disinfection of Germplasm Under Exchange against Pathogenic Fungi and Bacteria and Supportive Research (**Baleshwar Singh**, PC Agarwal, Usha Dev (till June, 2012), J Akhtar, A Kandan and Dinesh Chand)

PGR/PQR-BUR-DEL-01.11 Seed-health Testing for Conservation of Indigenous Germplasm Free from Pests (**J Akhtar** (w.e.f July 2012), **Usha Dev** (till June, 2012), Manju Lata Kapur, Veena Gupta, Baleshwar Singh, Shashi Bhalla, MC Singh, A Kandan, Sushil Pandey, Charan Singh, Dinesh Chand, Ashok Maurya and Smita Jain)

PGR/PQR-BUR-DEL-01.12 Detection of Viruses in *In vitro* Cultures of Germplasm Meant for Conservation (**DB Parakh,** V Celia Chalam, Sandhya Gupta and Ashok Maurya)

PGR/PQR-BUR-DEL-01.13 Identification of weed seeds intercepted in quarantine and supportive research (**Mool Chand Singh,** Anjula Pandey and Dinesh Chand, DS Meena)

Externally Funded Projects

- National Containment/ Quarantine Facility for Transgenic Planting Material **(DBT)** (**Manju Lata Kapur**, Gurinder Jit Randhawa, Shashi Bhalla, Baleshwar Singh, V Celia Chalam, Kavita Gupta, Z Khan and Ashok Maurya)
- Exploiting potential of electron beam irradiation as phytosanitary treatment against pulse beetles in seeds of selected grain legumes **(BRNS, DAE)** (**Shashi Bhalla**, Kalyani Srinivasan and TV Prasad)
- Development of Farmer Friendly Diagnostic Kits for Transgenic Event Seed Purity **(ICAR)** (completed on 31.3.2012) (**V Celia Chalam**)
- Study of biological control of invasive plant species and Indian natural enemies(**ICAR-CABI collaborative project**)
  - Component A: Himalayan balsam (*Impatiens glandulifera* (**J Akhtar,** Usha Dev (till June, 2012), Mool Chand Singh, Kavita Gupta)
  - Component B: *Hedychium* spp. complex (*H. gardneriarum*, *H. flavescens*, *H. coronarium*) **(Kavita Gupta,** J Akhtar, Mool Chand Singh)
  - Component C: *Rubus ellipticus* var. *obcordatus*. (**Mool Chand Singh,** Kavita Gupta and J. Akhtar)

5. GERMPLASM EXCHANGE

Summary: During the period under report 1,18,659 samples were imported which included 37,018 accessions (38,776 samples) of germplasm and 8,140 entries (79,883 samples) of CGIAR nurseries for trials. Requirements for germplasm from abroad were met by arranging material from different Indian sources and 1,773 samples of different crops were exported to ten countries under SMTA/ MTA after the approval of DARE/NBA. A total of 6,922 samples of different crops were supplied to national users for utilization in various crop improvement programmes in the country based on requests received from research workers under Material Transfer Agreement (MTA).

5.1 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 organizations and private sector with R&D and non-governmental organizations (NGOs). Plant genetic resources import/ introduction comprised material obtained on request from the scientists as well as from collaborators for international trials to be conducted in India. Introductions of seed/planting material made during the year were as follows:

Germplasm accessions procured and processed	:	37,018 accessions (38,776 samples)
CGIAR nurseries for trials	:	8,140 entries (79,883 samples)
Transgenic material imported	:	1,149 accessions
Countries involved	:	46
Import Permits issued	:	924

Cereals: *Aegilops cylindrica* (1), *A. geniculata* (1) *A. markgrafil* (1) *A. neglecta* (1) *A. peregrina* (1) *A. searsii* (1) *A. speltoides* (1) *A. tauschii* (1) *A. triuncialis* (2) *A. ventricosa* (1) all from USA; *Hordeum brevisubulatum* (2) *H. brevisubulatum* ssp. *violaceum* (3) from USA; *H. disticom* (2) from Syria; *H. jubatum* (4) from USA; *H. vulgare* (1) from UK; *H. vulgare* subsp. *vulgare* (10) from USA; *Oryza australiensis* (4) *O. barthii* (4) *O. brachyantha* (4) from Philippines; *O. glaberrima* (1) from Benin; (10) *O. latifolia* (4) *O. longiglumis* (4) *O. longistaminata* (4) *O. minuta* (6) *O. nivara* (13) all from Philippines; (5) *O.officinalis* (1) from USA; *O. ridleyi* (4) *O. rufipogon* (67) from Philippines; (6) from USA; *Oryza sativa* (636) from Belgium; (10) from Benin; (241) from Brazil; (4) from France; (11,141) from Philippines, (955) from USA; *Triticum aestivum* (361) from Australia; (1) from Canada; (30) from France; (714) from Mexico; (197) from UK, (194) from USA; *T. aestivum* subsp. *aestivum* (134) from USA; *T. dicoccum* (1) from Mexico; *T. fungicidum* (3) *T. monococcum* (128) *T. monococcum* subsp. *monococcum* (22) *T. monococcum* x *T. aegilopoides* (1,453) *T. turgidum* (1) all from USA; *Zea mays* (2) from Argentina; (253) from Brazil; (5,688) from Chile; (40) from Egypt; (52) from France; (1,258) from Mexico; (52) from Pakistan; (137) from Philippines; (34) from South Africa; (1,107) from Thailand; (985) from USA; (7) from Vietnam.

Trials: Wheat- 3rd HPYT, 4th HPAN, ISWDN, 45th IBWSN, 7th HTWSN, 1st CSISASBMNP1, 1CSISASBMNP2, 1CSISASBMNP3, 1CSISASBMNP4, IND-EMT12145, 20th FAWWON-IR, 20th FAWWON-SA, 16th IWWYT-IR, 7EBWYT, 33rd ESWYT, 45th IBWSN, 20th SAWYT, 14th FHBSN, 44th IDYN, 7THSTEMRRSN, 22nd ISEPTON, 4th CSISAHT-EM, 19th FAWWON-SA from CIMMYT, Mexico; Turkey; **Maize**-DTMA, 12TTWCYL26, 12CHTTY29 from CIMMYT, Mexico; **Rice:** GSR-IRLL-2012, GSR-RFLL-2012, IIRON-2012 (Module1), IIRON-2012 (Module 2), IRBBN-2012, IRBN-2012, IRBPHN-2012, IRFAON-2012, IRHTN-2012, IRLON-2012 (Module 1), IRSSTN-2012 (Module 1), IRSSTN-SS-2012 (Module 2), IRTON-2012, IURON-2012 from IRRI Philippines.**Millets:** *Eleusine coracana* (265) from Nepal, (5) from Tanzania, (429) from Uganda; *E. indica* (16) *E. intermedia* (3) *E. multiflora* (1) from Tanzania; *Pennisetum ciliare* (6) from Tanzania, *P. glaucum* (5) from Niger; (23) from Uganda; (22) from USA; *P. mezianum* (7) *P. polystachion* (10) from Tanzania**;** *P. purpureum* (27) from Ethiopia; (7) from Tanzania; (1) from USA; *P. sphacelatum* (3) *P. trachyphyllum* (2) from Tanzania; *Setaria viridis* (1) from USA; *Sorghum bentuorum* (7) from Bulgaria; *S. bicolor* (16) from Argentina; (28) from Brazil; (67) from Bulgaria; (12) from Ethiopia; (202) from Japan; (103) from Tanzania; (64) from Uganda; (122) from USA; (403) from Zambia; *S. caudatum* (2), *S. durra* (16) from Bulgaria; *Sorghum* sp. (7) from Ethiopia; *S. vulgare* (17) from Bulgaria.

Vegetables: *Abelmoschus esculentus* (3) from Bangladesh; (220) from Taiwan; *A. manihot* (2) *A. moschatus* (7) *Abelmoschus* sp. (11) from Taiwan; *Allium cepa* (19) from UK; (177) from USA; *Brassica oleracea* var. *botrytis* (148) from Netherlands; (1) from UK; *B. oleracea* var. *capitata* (89) from Netherlands; (1) from UK; (5) from USA; *Capsicum annuum* (200) from Israel; (14) from Korea; (1) from Netherlands; (190) from Taiwan; (158) from USA; *C. annuum* var. *glabriusculum* (8), *C. baccatum* var. *pendulum* (32) *C. chacoense* (1), *C. chinense* (41), *C. frutescense* (21), *C. galapagoense* (1), *C. pubescens* (4) all from USA; *Capsicum* sp. (16) from Taiwan; (4) from USA; *Citrullus lanatus* (4) *C. vulgaris* var. *citroide* (1) from USA; *Cucumis anguria* var. *anguria* (4), *C. melo* (4), *C. melo* subsp. *melo* (40), *C. melo* var *conomon* (2), *C. melo* var. *agrestis* (1) all from USA; *C. sativus* (3) from Bangladesh; (7) from Brazil; (231) from Netherlands; (69) from Taiwan; (314) from USA; (7) from Vietnam; *C. sativus* x *hardwickii* (1) *Cucumis* sp. (18) from USA; *Cucurbita maxima* (4) from Bangladesh; (6) from Taiwan; *Lactuca sativa* (3) from Switzerland; *Lagenaria siceraria* (2) from Netherlands; (9) from USA; *Luffa acutangula* (6) from Taiwan; (3) *L. aegyptiaca* (4) *L. graveolens* (1) from USA; *Lycopersicon esculentum* (10) from Bangladesh; (11) from France; (42) from Hungary; (14) from Netherlands; (1) from Spain; (78) from Taiwan; (22) from Thailand; (98) from USA; *L. pimpinellifolium* (5) from USA; *Momordica charantia* (5) from Taiwan; (13) from Thailand; *Solanum arcanum* (1) *S. cheesmaniae* (3), *S. chilense* (6), *S. chmeilewskii* (2), *S. corneliomulleri* (1), *S. habrochaites* (5), *S. huaylasense* (1) from USA; *S. lycopersicum* (68) from Jordan; (92) from Taiwan; (116) from USA; (32) from Vietnam; *S. melongena* (8) from Bangladesh; (12) from Taiwan; *S. neorickii* (4), *S. pennellii* (3), *S. peruvianum* (1), *S. pimpinellifolium* (5) all from USA; *S. tuberosum* (1) from Australia; (3) from China; (3) from Netherlands; (5) from New Zealand; (54) from Peru.

Grain legumes : *Cicer arietinum* (30) from Bulgaria; (191) from Nepal; (4) from USA; *C. chorassanicum* (1) *C. nuristanicum* (1) from USA; *Glycine max* (6) from Taiwan; (3) from USA; *Phaseolus coccineus* (1) *P. lunatus* (2) from USA; *P. vulgaris* (1) from Colombia; (357) from USA; *Vigna* sp. (25) from Nigeria; *Vigna unguiculata* (110) from USA; *V. unguiculata* subsp. *unguiculata* (203) from Italy; (6) from Taiwan.

Oilseeds: *Arachis hypogaea* (78) from Senegal; *Brassica carinata* (91) from Canada; (1) from UK; *B. juncea* (1552) from UK; (1) from USA; *B. napus* (19) from Australia; (655) from UK; *B. nigra* (21) from Canada; *B. rapa* (86) from Canada; (2) from USA; *Brassica* sp. (20) from Australia; (609) from UK; *Carthamus tinctorius* (30) from Mexico; *Helianthus annuus* (200) from Argentina; (9) from Australia; (43) from Belgium; (266) from France; *Ricinus communis* (1) from USA. **Forages:** *Acacia crassicarpa* (8) from Australia; *Actaea asiatica* (1) *Ageratina altissima* (1) from Germany; *Anigozanthos flavidus* (2) *A. manglesii* (1) from Australia; *Atriplex nummularia* (6) from USA; *Casuarina cunninghamiana* ssp. *cunninghamiana* (14) *C. equisetifolia* ssp. *equisetifolia* (3) *C. glauca* (7) *C. junghuhniana* ssp. *junghuhniana* (10) all from Australia; *Clitoria* sp (1) *C. ternatea* (11) from Colombia; *Desmanthus acuminatus* (4), *D. bicornutus* (3), *D. covillei* (2), *D. fruticosus* (2), *D.illinoensis* (2) *D. leptophyllus* (97), *D. paspalaceus* (6), *D. pernambucanus* (17), *D. pubescens* (10), *Desmanthus* sp. (10), *D. subulatus* (4), *D. tatuhyensis* (3), *D. virgatus* (56) from Colombia; *Eucalyptus alba* (1) *E. bakeri* (1) *E. cholorophylla* (1), *E. curtisii* (2), *E. deglupta* (2), *E. exserta* (3), *E. gamophylla* (3), *E. gillenii* (1), *E. grandis* (3) from Australia; (2) from South Africa; *E. herbertiana* (1), *E. horistes* (1), *E. infera* (1), *E. longirostrata* (2), *E. mannensis* ssp. *mannensis* (1), *E. normantonensis* (1), *E.nudicaulis* (1), *E.oxymitra* (3), *E. pachyphylla* (2), *E. polybractea* (1), *E. socialis* (2), *Eucalyptus* sp. (2) from Australia; *E. urophylla* (73) from South Africa; *E. viridis* (1) from Australia; *Leucospermum cordifolium* (3) *L. glabrum* (1) *Leucospermum* sp. (1) all from Australia; *Lupinus albus* (2) *L. angustifolius* (7), *L. luteus* (2), *L. mutabilis* (1), from Australia; *Platycodon grandiflorus* (1) *P. oleracea* (3) from USA; *Protea lacticolor* (1), *P. nerifolia* (1) *Protea* sp. (1) from Australia; *Stokesia laevis* (20) from USA; *Stylosanthes angustifolia* (2), *S. capitata* (6), *S. fruticosa* (1), *S.gracilis* (4), *S. guianensis* (10), *S. hamata* (24), *S. humilis* (9), *S. scabra* (15), *S. subsericea* (3), *S. sympodialis* (4), *S. viscosa* (12) from Colombia; *Symphyotrichum novae-angliae* (4) from USA.

Fruits: *Asimina triloba* (1) from USA; *Carya illinoinensis* (2) from USA; *Cydonia oblonga* (2) from USA; *Dahlia merckii* (1) from Germany; *Diospyros kaki* (2) from USA; *Fragaria* sp. (1) from USA; *Juglans regia* (2) from USA; *Malus domestica* (14)

from Switzerland; *M. floribunda* (2) from USA; *Mangifera indica* (8) from Israel; *Musa* sp. (1) from Mauritius; *Olea europaea* (2) from USA; *Prunus amygdalus* (1), *P. armeniaca* (13), *P. persica* (14), *Prunus* sp. (3) *Psidium guajava* (1), *Punica granatum* (2), *Pyrus* sp. (4), *Ranunculus japonicas* (1) all from USA; *Rubus* sp. (4) *Rubus* x *loganobaccus* (3) from USA; *Vaccinium* sp. (2) from USA; *Vitis vinifera* (4) from USA; *Ziziphus jujuba* (3) from USA.

Fibres: *Gossypium australe* (2) from Australia; *Gossypium hirsutum* (54) from USA.

Ornamentals: *Anisodontea* sp. (1), *Antirrhium barrelieri* (1), *A.braun-blanquetii* (1) *A. graniticum* (1), *A. hispanicum* (1), *A. majus* (12), *A. majus* subsp. *cirrhigerum* (2), *A. majus* subsp. *linkianum* (2), *A. meonanthum* (2), *A. siculum* (1), *Aquilegia canadensis* (4) *A. coerulea* (2), *A. formosa* (1), *A. olympica* (1), *A. oxysepala* (1), *Aquilegia* sp. (3) all from USA; *Arivela viscose* (1) from USA; *Asclepias incarnate* (1), *A. syriaca* (1) *Banksia hookeriana* (1) *Banksia menziesii* (1) from Australia; *Begonia albopicta* (1) *B. cardiocarpa* (1), *B. cucullata* var. *cucullata* (1), *B. dipetala* (1), *B. hydrocotylifolia* (1), *B. kellermanii* (1), *Begonia* sp. (2), *B. subvillosa* (1) *Begonia venosa* (1) from USA; *Bidens connata* (1) from Germany; *Bidens polylepis* (2) from USA; *Bidens tripartite* (1) from Slovenia; *Brachypodium distachyon* (1) from USA; *Camelina sativa* (1) from Ireland; (4) *Campanula lactiflora* (1), *C. medium* (1), *C. persicifolia* (1), *C. punctata* (1), *C. rapunculus* (1), *C. rotundifloia* (1) from USA; *Chamaecytisus palmensis* (1), *C. alba* (1), *Chamelaucium* sp. (2) both from Australia; *Chrysanthemum zawadskii* subsp. *latilobum* (1) from USA; *Cleome hirta* (3) *Cleome rubella* (1), *Cleome* sp. (1) from USA; *Coreopsis grandiflora* (1) from Slovenia; (1), *C. lanceolata* (3) *C. leavenworthii* (2), *C. major* (1), *C. palmata* (3), *C. pubescens* (1), *C. pulchra* (1), *Coreopsis* sp. (2), *C. tinctoria* (2), *C. tripteris* (9) all from USA; *Corymbia citriodora* ssp. *citriodora* (5), *C. citriodora* ssp. *variegeta* (11), *C. torellina* (1) from Australia; *Cosmos bipinnatus* (1), *C. sulphurous* (1) from USA *Dianthus arenarius* (1) *D. armeria* (3) *D. barbatus* (3) *D. capitatus* (1) *D. carthusianorum* (5) *D. caryophyllus* (2), *D. chinensis* (10), *D. deltoids* (4), *D. giganteiformis* subsp. *pontederae* (1) *D. giganteus* (1), *D. hybris* (8), *D. longicalyx* (1), *D. lumnitzeri* (1), *D. orientalis* (1), *D. pancicii* (1), *D. plumarius* (8), *D. serotinus* (1), *Dianthus* sp. (10) *D. superbus* (5), *D. sylvestris* (1), *Echinacea purpurea* (1) all from Slovenia; *Echinaceae pallida* (1) from**;** *Euphorbia cyathophora* (1) *E. heterophylla* (1) from USA; *Gaillardia aristata* (1) from Czech; (1) from USA; *Gynandropsis gynandra* (31) *Gypsophila acutifolia* (1), *G. fastigata* (1) *G. globulosa* (1), *G. muralis* (2), *G. oldhamiana* (2), *G. pacifica* (1), *G. paniculata* (5), *G. perfoliata* (1), *G. repens* (1), *G. scorzonerifolia* (2), *Helenium amarum* (1) all from USA; *Helianthella quinquenevis* (1) from Czech ; *Hosta minor* (1) from USA; *Hygroryza aristata* (2) from Philippines; *Iris pumila* (1), *I. sibirica* (1), *I. songarica* (2) *Iris* sp. (5) *I. spuria* subsp. *glusenstaedtiana* (1), *I.tenuifolia* (1), *I. wilsonii* (1) all from USA; *Iva xanthifolia* (1) from Slovenia; *Leonotis nepetaefolia* (1) from USA; *Leucadendron discolor* (1) *Leucadendron* sp. (2) from Australia; *Leucanthemum adustum* (1), *L. maximum* (1) *L.praecox* (1), *L. vulgare* (82) all from USA; *Liatris graminifolia* (1) from Slovenia; *L. platyepis* (1) from Czech; *L. pycnostachya* (1) from Germany; (2) from USA; *L. spicata* (1) from Czech; *Lilium concolor* var. *pulchellum* (1) *Lobelia siphilitica* (1) *Lolium rigidum* (1) from USA; *Melampodium leucanthum* (1) from USA; *Myosotis sylvatica* (1) from USA; *Oenothera biennis* (2), *O. drummondi* (1) *O. a oakesiana* (1), *O. rosea* (1), *Penstemon comarrhenus* (2), *P. leiophyllus* (1), *P. mensarum* (2), *P. palmeri* (1), *Penstemon* sp. (1) *P. spectabilis* (1), *P. strictus* (5), *P. unilateralis* (1), *P. watsonii* (1), *Petunia axillaris* (2), *P. exserta* (1), *P. integrifolia* var. *integrifolia* (1), *Petunia* x *atkinsiana* (14) *Phaseolus aconitifolius* (4) all from USA; *Rhynchoryza subulata* (1) from Philippines; *Rudbeckia fulgida* (6), *R. fulgida* var. *speciosa* (1), *R. grandiflora* (1), *R. hirta* (38) from USA; *R. laciniata* (1) from Czech; (5) *R. laciniata* var. *ample* (1), *R.mollis* (1), *R. occidentalis* (1), *R. scarbrifolia* (1) *Rudbeckia* sp. (3), *R. subtomentosa* (1), *R.texana* (1), *R. triloba* (10) all from USA; *Sigesbeckia orientalis* (1) from Slovenia; *Silene compacta* (1), *S. conica* (1), *S. pygmaea* (1), *S. sibirica* (1), *S. vulgaris* subsp. *vulgaris* (1) all from USA; *Tagetes erecta* (4), *T. patula* (2), *Tagetes* sp. (12), *T. subulata* (1) all from USA; *T. tenuifolia* (1) from Slovenia; *Tallinum fruticosum* (1), *Tarenaya hassleriana* (1) all from USA; *Turnera subulata* (1) from USA; *Verbasina helianthoides* (1) from Czech**,** (1) from Germany; *Verbena halei* (1), *V. hastate* (1), *V. urticifolia* (1), *Veronica daurica* (1), *V. spicata* (1), from USA; *Viola*

tricolor (3) from USA; *Xanthium strumarium* (1) from Germany; *Zinnia acerosa* (1), *Z. angustifolia* (1), *Z. angustifolia* var. *angustifolia* (1), *Z. citrea* (1), *Z. elegans* (1), *Z. peruviana* (6) all from USA.

Medicinal & Aromatic plants : *Arnica montana* (1) from Germany; *Eriophyllum lanatum* (1) from Germany; *Eupatorium aromaticum* (1) from Slovenia; *E. canabinum* (1) from Germany; *Origanum vulgare* (15) from USA; *Pelargonium frutetorum* (1) *P. zonale* (2) from USA; *Silphium trifoliatum* (1) from Czech Republic; *S. integrifolium* (1), *S.perfoliatum* (1) from Slovenia; *Tithonia rotundifolia* (1), *T. tagetifolia* (1) from Slovenia.

Under-Utilized Crops: *Chenopodium quinoa* (9) from USA.

Sugar yielding: *Miscanthus ecklonii* (1) from USA.

Narcotics & beverages: *Nicotiana* sp. (1) from USA; *Nicotiana tabacum* (3) from Germany; (1) from Netherlands; *Theobroma cacao* (50) from UK.

Others: *Arabidopsis thaliana* (3) from Japan; (193) from USA; *Parthenium argentatum* (14); *P. patens* subsp. *californica* (1), *P. patens* subsp. *magdalenae* (1) *P. patens* subsp. *patens* (7) and *P. patens* subsp. *readeri* (1) from Germany.

Table 1: Trait specific germplasm introduced during 2012

Crop/EC No./Country	Specific Traits	Distribution
***Triticum aestivum* (Wheat)**		
EC731579 to 731636/ USA	Nullisomic/ tetrasomic/ monosomic Chinese spring wheat lines	DWR, Karnal, GCD, NBPGR
EC732856/ USA	Winter variety Anton with enhanced end -use quality and low levels of polyphenol oxidase (PPO)	NBPGR RS, Bhowali
EC736143-736162/ USA	Substitution/deletion/aneuploid lines	GCD, NBPGR
EC755279/ USA	Wheat genetic stock with ph 1b mutant allele into an adapted Kansas winter wheat, GS -170 , PI 663870, which will accelerate the evaluation and utilization of wheat alien recombinants in cultivar improvement	NGRC, NBPGR
EC758755/ USA	Alien disomic substitution 1E(1A) line DGE-2 in wheat (Reg. No.GS-171, PI 663216), a unique chromosomal constitution and a unique allele Glu-E1b, DGE-2 may be useful in basic research	DWR, Karnal, GCD, NBPGR
EC758756/ USA	Good yield potential, grain protein levels similar to other hard red spring wheat cultivars and acceptable milling and baking characteristics	DWR, Karnal, GCD, NBPGR
EC759227/ Australia	Drought tolerant higher yielding and early maturing variety' Waagan'	GCD, NBPGR
EC762316-17/ USA	Registered lines provide spring wheat and winter wheat breeding programs with access to genes from elite cultivars possessing the alternate growth habit	DWR, Karnal, GCD, NBPGR
EC753236/ Canada	Registered cultivar 'Fieldstar'-combination of high yield, resistance to wheat midge, leaf rust and stem rust	DWR, Karnal, GCD, NBPGR
***Oryza sativa* (Paddy)**		
EC733828 to 733846 EC736365to736471/ IRRI, Philippines	Salinity tolerant lines	CRRI, Cuttack, GCD, NBPGR
EC733948 to 733954/ IRRI, Philippines	Heat tolerant	IRRI India Office, GCD, NBPGR
EC734714 to 734788 EC739648 to 739657/ IRRI, Philippines	Submergence tolerant lines	CRRI, Cuttack, GCD, NBPGR
EC752621 to 752830/ USA	Drought tolerant lines	Savannah Seeds, New Delhi, GCD, NBPGR

EC750230 to EC750257/ IRRI, Philippines	Lines tolerant to iron toxicity and phosphorus deficiency, resistant to brown plant hopper and bacterial blight	Barwale Foundation, MSGCD, NBPGR
EC751605 to EC751645/ IRRI, Philippines	Maintainer and restorer lines in paddy	PAN Seeds, Kolkatta, GCD, NBPGR
EC758366 to EC758368/ USA	Resistance to sheath blight and blast diseases	NGRC, NBPGR
***Sorghum bicolor* (Sorghum)**		
EC750258-750459/ Japan	Core set	TNAU, Coimbatore GCD, New Delhi
***Ricinus communis* (Castor)**		
EC736481/ USA	Low toxin ricin variety	DOR, Hyderabad
***Carthamus* spp. (Safflower)**		
EC755659 - EC755688/ Mexico	Breeding lines with high oleic acid content	DOR, Hyderabad
Vigna unguiculata* subsp. *unguiculata (Cowpea)		
EC738076- EC738278/ Italy	Core collection	PEQN
Cucumber		
EC738814-739038/ Netherlands	Recombinant lines	Syngenta Seeds Pvt. Ltd, Pune, GCD, NBPGR
Lycopersicon esculentum		
EC737661 to 737662/ Taiwan	Resistant to gray leaf spot, race 1 of fusarium wilt, tobacco mosaic virus, susceptible to late blight, FW race 2, TyLCV type 1, 2, 3.	Nuziveedu Seeds Private Limited
EC753215 to 32/ Taiwan	Resistant to tomato yellow leaf curl disease, late blight, race 2 of the fusarium wilt, gray leaf spot resistance round blocky, semi determinate type.	Rasi Seeds (P) Limited, Gurgaon GCD, NBPGR GED, NBPGR,
EC751801to EC751813/ Taiwan	Lines resistant to tomato yellow leaf curl, late blight Fusarium wilt race 2, gray leaf spot, fruit shape round blocky	Ajeet Seeds Limited, MS, GCD, NBPGR

Table 2: Details of transgenic seed material introduced

Accession No./ Country	Genes/ Events	Supplied to
Arabidopsis		
EC730196-730198/ Japan	Lines 418 (1), PMDC 83, PCAMB1A03052	Rajiv Gandhi Centre for Biotechnology, Kerala
Cabbage		
EC753911- 753915/ USA	HO4 and Cry 1B genes	Syngenta Biosciences Limited, Pune
Cotton		
EC751766- 751777/ USA	Combination of Cry 1Ab, vip3a, aph4, epsps,cry1Ab,cry2Ae and bar genes	Bayer BioScience Private Limited, Gurgaon
Maize		
EC730199/ USA	DP-32138-1 Inbred	Pioneer Overseas Corporation, Delhi
EC732443-732477/ USA	Event MON89034	Monsanto India Limited,, New Delhi
EC732433- 732437/ Philippines	Event NK603	Monsanto India Limited,, New Delhi

EC732438- 732477/ USA	Event MON89034	Monsanto India Limited,, New Delhi
EC736527- 736546/ USA	Stacked event MON 89034 x TC1507xNK603	Dow AgroSciences India Pvt. Ltd., Mumbai
EC736547- 736555/ USA	Event TC1507	Dow AgroSciences India Pvt. Ltd., Mumbai
EC753565/ USA	Event DP 32138-1	Pioneer Overseas Corporation, Chikkaballapur
EC753566- 753571/ USA	Events DP406428-8 and DP064226-4	EI Dupont India Private Limited, Hyderabad
EC757304, 62977/ Brazil	Cry 1 Ab x MEPSPS x Vip 3 a genes(triple stack of Bt11 x GA 21 x MIR 162) events	Syngenta Biosciences Limited, Pune
EC757829- EC757853/ USA	MON-00810-6, DAS-01507-1, MON-00603-6	Pioneer Overseas Corporation, Chikkaballapur
Paddy		
EC729870-729997, EC729998-730194/ Belgium	Null segregants events of constructs RPD 5-17, 25	BASF India Limited, Mumbai
EC730200-730207/ USA	A1aAT gene conferring enhanced nitrogen use efficiency (NUE)	Maharashtra Hybrid Seeds Company Limited, Delhi
EC738279-280/ USA	Traits for higher yield	Bioseed Research India Private Limited, Hyderabad
EC745235- 745352/ USA	Trait for higher yield (20 events each of N1 and N3 gene; 25 events each of Y1, Y2, W1 and N4; 50 events each of W2 gene; 150 events of O1 gene and 50 events of each gene Y1-M, Y2-M, W2-M, O1-M	Bioseed Research India Private Limited, Hyderabad
EC745648/ Belgium	Events (OSLR-21 to OSLR-30), Cry1C (DG) gene	Devgen Seeds and Crop Technology Pvt. Limited, Secunderabad
EC758416-758671, EC758672-758711/ Belgium	Yield enhanced rice events and their null segregants	BASF India Limited, Mumbai
Tobacco		
EC757828/ Netherlands	Bacterial artificial chromosome library	I T C Limited, Bangalore

5.2 Export of Plant Genetic Resources

The seed and plant material of agricultural and horticultural crops were exported on the basis of (i) requests received by the Bureau ICAR headquarters (ii) requests received from the scientists working in ICAR institutes/agricultural universities in India under various protocols/ work plans memoranda of understanding with different countries/ CGIAR institutions.

The plant material intended for export were procured from known Indian sources through correspondence and the same were forwarded to the indentors in foreign countries alongwith phytosanitary certificates issued by the Plant Quarantine Division of the Bureau and import permit, if any, only after approval from ICAR/DARE as per the guidelines. The details of export of seed/ planting material during 2012 are indicated below.

Number of countries to which material exported: 5
Number of samples exported: 1,773

Cereals: *Oryza sativa* (215 DNA samples and 178 seed samples) to IRRI, Philippines; *Triticum aestivum (*604) to National Plant Breeding Centre, Kenya; (604) to Ethiopian Institute of Agricultural Research, Ethiopia (68) to CIMMYT, Mexico

Others: 104 samples of insects (live & dead) to CABI-Europe, UK

5.3 Inland Supply of Plant Genetic Resources

The seed and planting material of diverse agri-horticultural crops were supplied to IARI institutes/ coordinated projects, agricultural universities and other users in India. Based on specific requests received, 6,961 samples were supplied under the Material Transfer Agreement (MTA).

A total of 15,517 samples was supplied to NBPGR Regional Stations, NAGS for regeneration/multiplilcation/ morphological characterization, toxonomic identification, preliminary evaluation and viability testing through Germplasm Conservation Division and Germplasm Evaluation Division.

Programme (Programme Code: Title, Leader)

PGR/GEX-BUR-DEL-01.00- Exchange of Plant Genetic Resources with foreign countries (import/export) and national supplies of the Plant Genetic Resources and related information to the scientist/users in the country **(Arjun Lal)**

Research projects (Co PI; Associate/s)

PGR/GEX-BUR-DEL-01.01: Import, export and inland supply of PGR in Cereals, Pseudo cereals, Oilseeds, Fibers, Medicinal & Aromatic Plants, Millets, Sugar yielding crops and exchange of related information to the scientists and users in the country (**Vandana Tyagi**; Pratibha Brahmi, Anitha Pedapati, SP Singh, Surender Singh)

PGR/GEX-BUR-DEL-01.02: Import, export and inland supply of PGR in Fruits, Grain Legumes, Tubers, Narcotics and Beverages and exchange of related information to the scientists and users in the country. (**Nidhi Verma**; SK Yadav, SP Singh, Surender Singh)

PGR/GEX-BUR-DEL-01.03-Import, export and inland supply of PGR in Vegetables, Forages, Under Utilized Plants, Ornamentals, Spices and Condiments, Plantation crops and exchange of related information to the scientists and users in the country. (**SK Yadav**; Nidhi Verma, Anitha Pedapati, SP Singh, Surender Singh)

PGR/GEX-BUR-DEL-01.04: Documentation and dissemination of information on germplasm both imported and collected in the form of Plant Germplasm Reporter and preparation of Crop Inventories. (**Pratibha Brahmi**, Vandana Tyagi, Nidhi Verma, SK Yadav, Anitha Pedapati, SP Singh, Surender Singh)

PGR/GEX-BUR-DEL-01.05: Survey and assembly of literature on Plant Genetic Resources and its documentation for procurement of elite/trait specific germplasm**. (Arjun Lal**; Vandana Tyagi, Nidhi Verma, SK Yadav, Anitha Pedapati, SP Singh, Surender Singh)

6. TISSUE CULTURE AND CRYOPRESERVATION

Summary: During the year, a total of 2,086 accessions belonging to fruit crops, bulb and tuber crops, medicinal, aromatic and rare/endangered plants, spices, plantation and industrial crops, and others were conserved as *in vitro* cultures, under culture room conditions (25±2^{0}C; 16/8h) and/or at low temperature (4^{0}C). The average subculture duration ranged from 3 to 24 months, depending on the species. Plantlet regeneration was achieved in new species viz., *Allium albidum* and *A. clarkei*. In *Picrorrhiza scrophuliflora,* cultures were conserved for 20 weeks at low temperature (5^{0}C and 10^{0}C). In *Kaempferia galanga,* encapsulated shoot bases were stored in cryovials without nutrient medium, up to 60 days at 20^{0}C and 25^{0}C (16/8h photoperiod). Cryopreservation experiments using vitrification or droplet vitrification technique, led to varying degree of pre- and post-freezing regrowth in *Allium* spp., *Gladiolus* cv., *Musa* sp. and *Rauvolfia serpentina.* The genetic stability assessment was carried out in post-thaw regenerated plantlets of *A. chinense* and *A. hookeri* using SSR markers. There were no significant differences between the post-thaw regenerated plants and their controls. A total of 21 accessions comprising *Allium sativum* (10), *Dioscorea deltoidea* (4) and *Musa* sp. (7) were cryostored as shoot tips or meristems. A total of 105 accessions comprising temperate fruits and nuts, medicinal and aromatic plants, industrial crops and spices were cryostored as seeds, embryonic axes and dormant buds during the year, totalling 9,946 accessions in the cryogenebank. Periodic testing for viability of 200 accessions of orthodox and non-orthodox seeds, and 20 accessions of dormant buds of *Morus* species revealed retention of original viability in most of the accessions after 3-8 years of cryostorage.

6.1 *In Vitro* Conservation and Cryopreservation

During the year, 12 accessions were added in the *in vitro* Genebank and these include: *Allium chinense* (1), *Alocasia indica* (1), *Colocasia esculenta* (2), *Dioscorea bulbifera* (1), *Hedychium spicatum* (2), *Ipomoea batatas* (2), *Swertia chirayita* (1), *Valeriana wallichii* (1) and *Xanthosoma sagittifolium* (1). A total of 2,086 accessions belonging to different crop groups were maintained *in vitro* and subcultured at periodic interval (Table 1).

6.1.1 Tropical fruits: Work on conservation of germplasm of 416 accessions of *Musa* (in the form of ~ 10,000 cultures) was carried out which entailed subculture, rooting of selected cultures and in a few cases, rescuing of infected material. The average subculture period varied from 3-12 months, depending on the genotype and the requirement for experimentation.

Concerted efforts for cryopreservation of *Musa* sp. were continued. During the period, cryopreservation of 20 indigenous and exotic *Musa* accessions was attempted. The exotic germplasm comprised accessions belonging to wild species (3), genomic groups AAA (5), ABB (1), AAA highland bananas (1) and AA (4) whereas Indian accessions belonged to ABB (3) and AAB (3) groups. Out of the 20 accessions, cryopreservation was done using proliferating meristems (scalps) of 14 accessions, using droplet vitrification technique, whereas in the remaining six accessions, single meristems from *in vitro* rooted plants were used. Amongst the 20 tested accessions, post-thaw shoot regeneration (22- 83%) was obtained in seven accessions (with probability of 95% or more of obtaining at least one explant regeneration) and these accessions were cryobanked. Accessions in which single meristems were used, there was no post-thaw regeneration as all the explants turned white and remained non-responsive. Amongst the accessions

Table1. Status of in vitro-conserved germplasm (as on December 31, 2012)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)
Tropical Fruits (banana)	2	14	10,000	**416**
Temperate and Minor Fruits (apple, apricot, blackberry, blueberry, pear, strawberry)	9	41	6,700	**327**
Tuber crops (sweet potato, yam, taro)	5	12	9,800	**618**
Bulbous and other crops (garlic, gladiolus)	4	12	3,300	**171**
Medicinal and aromatic plants (Species of *Coleus, Rauvolfia, Tylophora, Valeriana*)	21	28	5,000	**174**
Spices and industrial crops (ginger, turmeric, pepper, cardamom, hops, jojoba)	7	27	5,800	**380**
TOTAL	**48**	**134**	**40,680**	**2,086**

cryopreserved, three were regenerated, plantlets developed, hardened and subsequently transferred to the field for testing its genetic stability. (Fig 1). Morphological data of ratoon crop of plants cryopreserved earlier were recorded in one accession (ABB) of *Musa*.

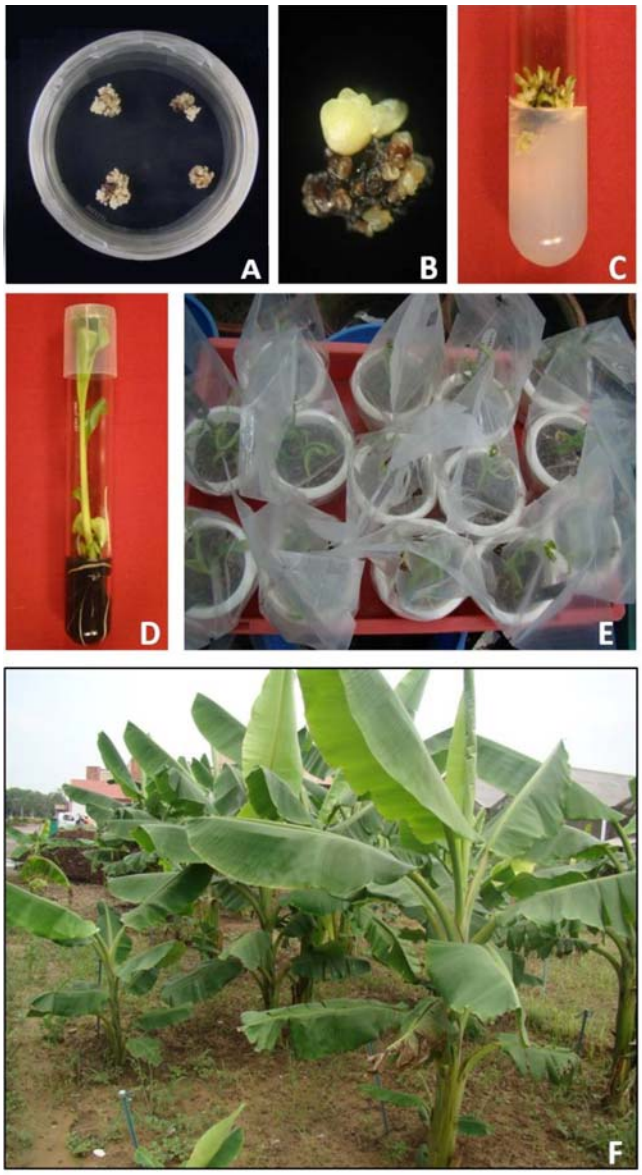


Fig. 1. Cryopreservation in *Musa acuminata* AA

- **A. Proliferating meristems precultured on 0.4 M sucrose medium and subjected to cryopreservation by droplet vitrfication**
- **B. Post-thaw regeneration of explants after 8 weeks on MS + 0.22 ìM BAP medium**
- **C. Regenerated shoots on MS medium cultured on MS + 1 ìM BAP medium**
- **D. Rooting of regenerated shoots on MS +activated charcoal (0.5%) medium**
- **E. Hardening of rooted plantlets**
- **F. Field transferred 6-month-old plants derived from cryopreserved meristems**

The international collaborative project between ICAR, India and Bioversity International, Montpellier, funded by the Global Crop Diversity Trust, Rome and entitled 'Conserving banana diversity for use in perpetuity' was concluded during this year. The participating institutes were NBPGR, NRC on Banana (NRCB) and the Katholieke Universiteit Leuven (KUL), Leuven, Belgium. At NBPGR, germplasm of 50 *Musa* accessions procured from the world collection of KUL, were cryopreserved using droplet vitrification technique. During the year, 20 accessions were cryobanked and sent to KUL, Leuven, in a Dry Shipper, for long-term conservation. This is the first example of cryobanking of meristems of a vegetatively-propagated crop, and its successful transfer long-distance for safety duplication.

Rejuvenation of *Musa in vitro*-conserved cultures, initiated in 2011, was continued further. The objective was to re-initiate the cultures of accessions conserved for ten or more years. Plantlets of 45 such accessions were rooted *in vitro,* transferred to pots and hardened in a net house. From the plants hardened in 2011, cultures were successfully re-initiated from field suckers in 6 accessions comprising *Bainsa*, *Boothi Bale*, *Champa*, *Kali Bale*, *Mysore Bale* and *Nattu Vazhai*.

6.1.2 Bulb crops: A total of 171 accessions (~3300 cultures) were conserved in the *in vitro* Genebank through periodic subculture or through resterilization, under culture room conditions (25±2^{0}C; 16/8h) and/or at low temperature (4^{0}C).

During the period under report, one accession of *A. chinense* was added in the *in vitro* Genebank. In *A. albidum*, optimal root induction (100%) was obtained on MS medium supplemented with NAA and regenerants were subsequently established in pots under net house conditions. In another species, *A. clarkei*, rooting of shoots was optimized (100%) on B5 basal medium. In 50 accessions of *A. sativum* (from a total of 96 accessions procured from Directorate of Onion & Garlic Research, Pune), analyzed so far, preliminary results (owing to limited quantity of germplasm; 30-40 cloves/accession) indicated that post-thaw survival of shoot tips (isolated from cloves), ranged from 0-100% with shoot recovery varying from 0-70%. Cryopreservation experiments continued with *A. chinense* revealed that shoot base explants excised from mother cultures, maintained on shoot multiplication (SM) medium, pre-grown on high sucrose, exhibited 20%

regrowth after liquid nitrogen (LN) freezing with 20 mins PVS2 dehydration. In *A. hookeri, in vitro* shoot bases [excised from mother cultures maintained on shoot multiplication medium (SM1)] failed to survive LN freezing with or without PVS2 treatment. However, non-frozen controls exhibited 100-20% survival and 80-20% regrowth following 10-50 mins PVS2 dehydration. Following pregrowth on SM1, non-frozen controls exhibited 60% regrowth upto 30 mins PVS2 with progressive decline in shoot quality with increased duration of PVS2. Following LN freezing, there was 10% shoot recovery with 20 mins PVS2 treatment. Experiments are continued to improve post-thaw shoot recovery. For long term conservation, cryobanking of *A. sativum* was initiated in 10 accessions (2 or 3 replicates each).

In *Gladiolus* cv., shoot base explants (excised from mother cultures preconditioned on high sucrose), pregrown on high sucrose and treated with loading solution prior to PVS2 dehydration, exhibited 10% regrowth following LN freezing.

6.1.3 Medicinal, aromatic and rare/ endangered plants: *In vitro* maintenance of existing cultures of 174 accessions (~4,500 cultures) was achieved through periodic subculture and resterilization (4-24 months) either under culture room conditions (25±2^{0}C; 16/8h) and/or at low temperature (4^{0}C). A total of four accessions from comprising the new genera, *Hedychium spicatum* (2), *Swertia chirayita* (1) and *Valeriana wallichii* (1) were added to the *in vitro* repository. In *Picrorrhiza scrophuliflora,* incubation of cultures at low temperature (5^{0}C and 10^{0}C) could extend subculture duration upto 20 weeks compared to 3 weeks under culture room conditions. In *Kaempferia galanga,* encapsulated shoot bases, stored for 60 days at 20^{0}C and 25^{0}C (16/ 8h photoperiod) in cryovials without nutrient medium, exhibited ~50% regrowth. For long-term conservation of *Rauvolfia serpentina,* cryopreservation experiments using vitrification technique, indicated that non-frozen shoot tips could tolerate PVS2 dehydration up to 60 minutes.

6.1.4 Spices, plantation and industrial crops: *In vitro* maintenance of existing cultures of a total of 380 accessions (~5,600 cultures) of spices germplasm comprising 181 of *Zingiber* species, 162 of *Curcuma* species, eight of *Piper* species, five of *Elettaria cardamomum*, four of *Vanilla planifolia,* 12 of *Simmondsia chinensis* (6 each of male and female) and eight of *Humulus lupulus* were maintained under short- to medium-term storage. The average subculture period is 8-10 months for *Zingiber* species, 6-10 months for *Curcuma* species, 12-24 months for *Piper* species, 14-15 months for *Elettaria* species, 18-22 months for *V. planifolia*, 8-15 months for *S. chinensis* and 6 months for *H. lupulus*.

Efforts were made for rejuvenation of *Curcuma* spp. cultures, conserved for five or more years under *in vitro* conditions to overcome the loss of *in vitro* regeneration capacity and expression of latent bacteria, in some accessions. *In vitro* plantlets of 20 accessions were transferred to pots and hardened in the net house. The plants would be used for re-initiation of cultures for further experimentation.

An experiment was carried out for *in vitro* microrhizome formation in *Curcuma longa c*v. NDH-74 using various concentrations (3%, 5%, 7%, 9% and 11%) of sucrose in MS medium supplemented with 3 mg/l BAP and gelled with 0.45% Clarigar. Results indicated that increasing sucrose had no effect on rhizome formation in aforementioned species.

Total curcumin content was assessed in seven species of *Curcuma* viz., *C. aeruginosa, C. frutescence, C. zeodaria, C. amada,* C. *soloensis C. caesia, Curcuma longa and* eight varieties of *Curcuma longa* viz. Suvarna, NDH-98, Sona, Sobha, Palam Pitamber, Palam Lalima, Punjab Haldi-1, Punjab Haldi-2 using fresh rhizomes through acetone extraction. Amongst these eight varieties, maximum curcumin content (3.16%) was recorded in *C. longa* cv. Sona and minimum (1.72%) in *C. longa* cv. NDH-98 whereas amongst seven species, highest curcumin content (2.74%) was obtained in *C. longa* and lowest (0.34%) in *C. caesia.*

To study the variability among *Curcuma longa* accessions conserved in the i*n Vitro* Genebank, 50 accessions were selected. Variability with respect to number of shoots/ explant was observed across accessions with maximum number (4.83) observed in IC360183 from Andhra Pradesh and minimum number (1.67) in IC573929 from IISR, Calicut.

Copper salts are known to overcome fungal and bacterial

contamination and also promote shoot bud differentiation. To overcome bacterial contamination which often led to failure of cryopreservation experiments in *Curcuma* cultures, experiment was initiated with supplementation of copper sulphate (10-60 mg/l) in MS + 2.5 mg/l BAP medium. Reduction in bacterial contamination and improvement in plant growth were recorded on above medium containing 30 mg/l copper sulphate. On this medium, there were 3.59 shoots/explant compared to 1.00 shoot/explant on medium lacking copper sulphate, after 60 days of culture. Experiments are continued for optimization of results.

6.1.5 Temperate and minor tropical fruit crops: A total of 327 accessions (~6,500 cultures) belonging to nine genera and 41 species were conserved as *in vitro* cultures under culture room conditions and/or at low temperature. These are *Actinidia chinensis* (6), *Aegle marmelos* (2), *Fragaria* x *ananasa* (80), *Malus domestica* (24), *Morus* spp. (61), *Prunus* spp. (5), *Pyrus communis* (66), *Rubus* spp. (62) and *Vaccinium* spp. (21). The average subculture period varied from 6-12 months. Seventeen accessions of *Fragaria* were procured from the field genebank, Regional Station Bhowali for *in vitro* conservation.

6.1.6 Tuber crops: *In vitro* maintenance of existing cultures of a total of 618 accessions (~9,800) of tuber crops comprising four of *Alocasia indica*, 195 of *Colocasia esculenta,* 152 of *Dioscorea* spp., 257 of *Ipomoea batatas* and ten of *Xanthosoma sagittifolium* was carried out through periodic subculture and resterilization (4-12 months) under culture room conditions.

During the year, a total of seven accessions comprising *A. indica* (1), *C.esculenta* (2), *D. bulbifera* (1), *I. batatas* (2) and *X. sagittifolium* (1) were added in the *in vitro* Genebank. For long term conservation, cryobanking was done in four accessions of *Dioscorea* sp. (2 or 3 replicates each). Four accessions were multiplied for further cryobanking experiments.

6.2 Genetic Stability of *In Vitro* Conserved Germplasm

The protocol for simple sequence repeats (SSR) analysis was standardized in *Allium chinense*. Using this protocol, genetic stability assessment was carried out in above species using 15 SSR loci. No differences were observed in the profiles of cryopreserved regenerated plantlets and their respective controls. The SSR analysis was also done in one cryopreserved accession of *A. hookeri* using 19 SSR loci. No differences were observed in the SSR profiles of regenerated plantlets after cryopreservation and their respective controls.

Genetic stability assessment was done in five accessions (five samples each) of taro (*Colocasia esculenta*), using 10 SSR loci. There were no significant differences in the SSR profiles of *in vitro* conserved plants and their respective controls.

6.3 *In Vitro* Germplasm Supply

During the year, cultures of one accession (4 samples) of *Bacopa monnieri* were supplied to indentor for research purposes under MTA.

6.4 Seed, Pollen and Dormant Bud Cryopreservation

A total of 9,946 accessions comprising orthodox and non-orthodox (intermediate and recalcitrant) seed species were conserved in the cryogenebank (Table 2). A total of 130 accessions of diverse germplasm were received from NBPGR Regional Stations, Central Sericultural Germplasm Resources Centre (CSGRC), Hosur and Network project partners and also through collection trips and explorations. These belonged to fruits, nuts, industrial crops, medicinal and aromatic plants, and dormant buds of temperate/sub-temperate species. During the year, two exploration trips were undertaken and 79 accessions of germplasm of non-orthodox seeds of *Citrus* species and tropical underutilized fruits were collected from parts of Madhya Pradesh, Uttar Pradesh and Manipur.

A total of 91 accessions were cryostored as seeds and embryonic axes during this period at temperatures between –160 to –180°C. Cryostored accessions comprised temperate fruits and nuts (43), industrial crops (5), spices (3) and M&AP (19) which also included wild species and wild relatives of crop plants. In addition, 14 accessions of *Morus* spp. were cryostored as dormant buds. Studies on seed viability, moisture content, desiccation and freezing sensitivity were conducted on seeds of *Manilkara hexandra, Aegle marmelos, Diospyros melanoxylon, Prunus dulcis, Juglans regia, Citrus ichangensis* and *C. limonia* and these proved to be intermediate in seed storage behavior except

C. ichangensis which proved to be highly recalcitrant.

Two-step freezing and encapsulation-dehydration techniques were attempted in dormant buds of apricot (*Prunus armeniaca)*, almond (*P. amygdalus)* and walnut (*Juglans regia*) procured from Central Institute of Temperate Horticulture (CITH), Srinagar with about 35% survival in two accessions. Optimization of recovery percentage in cryostored *Morus* spp., almond and walnut were attempted with recovery ranging from 45-75% in *Morus* spp. A total of 79 accessions belonging to *Citrus* species and underutilized fruit spp. were characterized for fruit and seed characters as per IPGRI descriptors. Periodic testing for viability of 200 accessions of orthodox and non-orthodox seeds, and for dormant buds of 20 accessions of *Morus* species revealed retention of original viability in most of the accessions after 3 to 8 years of cryostorage. A total of 71 cryostored samples were multiplied in the fields of NBPGR HQ and of Regional stations for cryobanking and seed genebanking.

6.4.1 Transfer of *in vitro* conserved germplasm to crop-based institutes: As per the feedback on establishment of shifted germplasm to Central Tuber Crops Research Institute (CTCRI), Trivandrum, another set of 150 accessions of sweet potato, taro and yams were multiplied for transfer to CTCRI.

Table 2: Status of cryopreseved germplasm (As on December 31, 2012)

Categories	Accessions(no.)
Recalcitrant & Intermediate	
Fruits & Nuts	2,876
Spices & Condiments	151
Plantation Crops	22
Agroforestry & Forestry	1,640
Industrial Crops	1,325
Medicinal & Aromatic Plants	6
Total	**6,020**
Orthodox	
Cereals	248
Millets and Forages	287
Pseudo-cereals	76
Grain Legumes	636
Oilseeds	471
Fibers	66
Vegetables	433
Medicinal & Aromatic Plants	941
Narcotics & Dyes	34
Miscellaneous	16
Total	**9,228**
Dormant buds	373
Pollen grains	345
Total	**9,946**
Wild Relatives*	**1,018**
Rare & Endangered plants*	**80**
Varieties*	**655**
Elite*	**4**
Registered germplasm*	**23**
Number of species	**729**

*- Included in respective categories stored as orthodox seeds

Programme (Code, Title and Programme Leader)

PGR/TCCU-BUR-01 *Ex situ* conservation of genetic resources of vegetatively propagated crops using *in vitro* and cryopreservation techniques **(RK Tyagi)**

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

PGR/TCCU-BUR-01.01 *In vitro* conservation of tuber crops with special reference to sweet potato, yams and taro (**Neelam Sharma**, Zakir Hussain, DK Nerwal)

PGR/TCCU-BUR-01.02 *In vitro* conservation of spices, plantation and industrial crops (**Anju Jain,** RK Tyagi, RP Yadav)

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

PGR/TCCU-BUR-0104 *In vitro* conservation of medicinal and aromatic plants with special reference to rare and endangered species. (**Neelam Sharma**, Ruchira Pandey)

PGR/TCCU-BUR-01.05 *In vitro* conservation of tropical fruit crop species. (**Anuradha Agrawal**, RK Tyagi)

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

PGR/TCCU-BUR-01.07 Studies on genetic stability of *in vitro* conserved and cryopreserved germplasm. (**Zakir Hussain**, RK Tyagi, DK Nerwal)

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)

PGR/TCCU-BUR-02.01 Cryopreservation of non-orthodox and orthodox seed species in various forms using standard protocols (**Rekha Chaudhury**, SK Malik, DK Nerwal)

PGR/TCCU-BUR-02.02 Investigating desiccation and freezing tolerance in non-orthodox seed species, dormant buds and pollen for cryopreservation (**SK Malik**, Rekha Chaudhury, Z Abraham)

7. PGR POLICY PLANNING

The PGR Policy Planning Unit is functioning at NBPGR since 1996 with the objective to document and collect literature on concurrent international and national developments concerning plant genetic resources and related fields such as biosafety, germplasm utilization, exchange, and quarantine and to provide analytical inputs are per requirements of the policy makers for negotiations and formulations of policies at various national and international levels on issues related to PGR management.

7.1 PGR Management and related Issues

7.1.1 Processing application of extant varieties for registration (Protection) with the PPV &FR Authority

a. Forty eight applications of Extant-notified and New Varieties of ICAR- SAU system of crops notified by PPV& FR Authority, were scrutinized, documented and submitted to PPV &FR Authority during 2012. A total of 915 applications have been submitted so far.
b. All concerned Project Coordinators/ Project Directors, Directors and SAUs were sensitized about the process of filing applications. Inputs on correct filing procedure were provided on request for the new crops including three species of orchids.

7.1.2 The second meeting of the high level **National Advisory Board on Management of Genetic Resources (NABMGR)** was organized at National Bureau of Fish Genetic Resources, Lucknow, on 13th August, 2012, chaired by Dr. R. S. Paroda, Chairman TAAS and Co-chaired by Dr. S. Ayyappan, Secretary DARE and Director General, ICAR .The secretariat of the Board being located at NBPGR to organize and coordinate the NABMGR meetings. The deliberations focused on animal and fish genetic resources management issues. Inputs and guidance on policy issues related to these components of Agro-biodiversity were provided by the Board.

7.1.3 Technology Management Committee (ITMC) Two meetings of the ITMC were organized and guidelines for sharing benefits received at the Institute after technology transfer cases were discussed and developed as per ICAR guidelines.

- **Patent Granted**: NBPGR was granted a patent (254341) on October 26, 2012 titled 'Process enabling simultaneous detection of transgenes namely human serum albumin (HSA) and BAR genes in transgenic wheat'.
- **Copy Right application filed**: A copy right application was submitted from NBPGR on software for portable search engine for registered germplasm.

7.1.4 Technical inputs on the following PGR Policy issues provided to ICAR and other Ministries and Departments.

1. NBA-ICAR/DARE meeting at ICAR/DARE, Krishi Bhawan, New Delhi in May, 2012 to discuss issues of concern related to export of plant genetic resources.
2. Second Meeting of NABMGR at NBFGR, Lucknow on August 13, 2012
3. Joint Capacity Building Workshop for access and benefit sharing (CBD, MoEF and Treaty Secretariat) June 30 - July 1, 2012 at Vigyan Bhavan, New Delhi.
4. Eleventh CoP meeting of CBD at HITEX City, Hyderabad, October 8-12, 2012. The meeting was attended by NBPGR scientists as delegates and also exhibits of various components and activities related to agro-biodiversity conservation and management were displayed at the CoP 11 exhibition.
5. Expert Committee of NBA on access and benefit sharing of genetic resources in December, 2012 at Hyderabad.
6. Five meetings of the Sub-Committee constituted by NABMGR on Exchange related issues organized on behalf of NABMGR Secretariat on June 12, August 6, September 12, October 22 and December 31 2012.

7.2 Inputs on Policy Issues related to Biosecurity

7.2.1 Inputs provided to Department of Agriculture and Cooperation, MoA: Provided input to the Department of Agriculture and Cooperation on Plant Quarantine (Regulation for Import into India) Order 2003 on

- On Establishment of National Agricultural Biosecurity System under the MoA, prepared

comments and provided inputs during a Workshop on developing the NABS.

- Prepared comments on import of certain biocontrol agents, algae, bacterial cultures, bumblebees and other biocontrol agents.
- Provided inputs during the Indo-Canadian Joint Working Group Meeting at DPPQS, Faridabad for import of pulses into India.
- Reconfirmed the proposed phytosanitary arrangement between the 'Department of Agriculture and Co-operation' (DAC) India and the Canadian Food Inspection Agency (CFIA) for Canadian Pulse Imports into India.
    - Under the agreement; Canada would not be responsible for (a) testing (b) reporting or declaring pulse consignments as nematode free
    - Fumigation with Methyl Bromide on arrival; suggested and applied by DPPQS / DAC for nematodes is not effective
    - Extension of derogation, beyond September 2010 and signing of agreement on shipping of consignments under 'Phytosanitary Arrangement between the two Countries for Pulse Imports' needs to be reviewed

7.2.2 Inputs to Development Consortia for Invasive Species Compendium of CABI

- Launch of the Invasive Species Compendium and made efforts to give a future direction to the project within the research community.

7.2.3 Input to APFISN/ APCoAB

- Participated and provided inputs on updating the FAO publication on Biosafety Regulations in Asia Pacific Region to APAARI.
- Provided technical inputs and presented status of Invasive species management in India during a IUFRO International Diseases and Pests of Tropical Forest Trees Working Party Conference organized by Asia Pacific Forest Invasive Species Network from October 8-10, 2012.

7.2.4 Inputs to MoEF

- Inputs provided to Ministry of Environment and Forests on invasive alien species and its impacts on agricultural biodiversity in the CoP meeting held in Hyderabad in October 13-19, 2012.
- Inputs for inter-ministerial meeting on BWC Preparatory Committee for the Eight Review Conference held on December 6 2012.
- Inputs on Third National Report on the implementation of the Cartagena Protocol on Biosafety to be presented in the Meeting of Parties of the CBD in July, August 22, 2012.

7.2.5 Inputs to MoCI: Inputs also provided to Ministry of Commerce and Industries (MoCI) on current issues on export of Basmati Rice, Grapes and Honey to European Union- in an Inter Ministerial Meeting.

7.2.6 Inputs to ICAR:

- On suggestions by National Seeds Association of India for revision of the New Policy on Seed Development 1988.
- On measures taken and progress made in research and development to address SPS issues.

7.2.7 Inputs to NDMA, Ministry of Defence: As Member of the Task Force on agroterrorism and Biodisaster mitigation and road map provided to NDMA.

Research Programme (Programme Code: Title, Leader)

PGR/PPU-BUR-DEL-01: Policy planning and back-up research (**Pratibha Brahmi**)

Research Projects (Project Code, Title, Project Leader; Associates

PGR/PPU-BUR-DEL-01-01: PGR management and related issues (**Pratibha Brahmi**, Vandana Tyagi)

PGR/PPU-BUR-DEL-01-02: Policy issues related to plant biosecurity (**PC Agarwal**, Kavita Gupta)

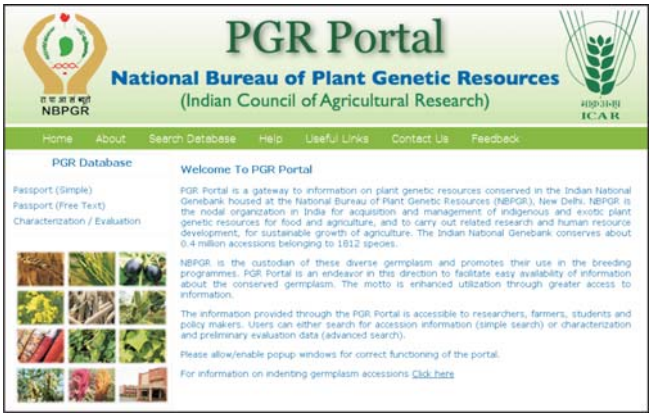
8. AGRICULTURAL KNOWLEDGE MANAGEMENT

Summary: The AKMU (formerly ARIS Cell) at NBPGR is the centre of PGR informatics activities of ICAR. The Unit successfully developed the PGR portal as a completely in-house activity. The access to and use of information contained in the PGR Portal is governed by principles of biodiversity conservation and use as well as relevant clauses of the extant intellectual property instruments. The Unit maintained five independent information systems and hosted ten important URLs on the local servers and carried out service activities including email, LAN, e-circulars and web hosting.

8.1 PGR Portal

The PGR Portal was developed as a completely in-house activity employing the skills, expertise and facilities available at the disposal of AKMU. The Portal was launched on 6th December 2012 by Hon'ble Director General, ICAR and Secretary; DARE, Dr. S Ayyappan at a gathering of PCs and PDs of AICRPs at NBPGR. Users can access the web-based PGR Portal at www.nbpgr.ernet.in/pgrportal. The quality of the interphase, speed of the response and ease of search are comparable to any of the PGR portals developed and maintained by CG genebanks or any national genebanks.

It is pertinent to note that no information is made available on the PGR Portal *de novo*. All the information was already available in the public domain in the form of published catalogues (printed and electronic),



proceedings, presentations, research papers, etc. Furthermore, the information available in the PGR Portal is about only those accessions which are conserved in the National Genebank at NBPGR. This was done to ensure supply of the material in case of requests (through NAGS/MTS). Care has been taken to display only such materials whose data correspond across multiple internal databases. As per the recommendation of the National Advisory Board on Management of Genetic Resources, the passport data to be displayed does not include information on villages and district. The passport data accessible by all include accession number, botanical name, collector number/other ID, variety/cultivar name, biological status, and source (only state in case of indigenous collection and country in case of introduction).

The motto of PGR Portal is enhanced utilization through greater access to information. The information provided through the PGR Portal is meant for researchers, farmers, students and policy makers and can be accessed from anywhere on the globe The access to and use of information contained in the PGR Portal is governed by principles of biodiversity conservation and use as well as relevant clauses of the extant intellectual property instruments.

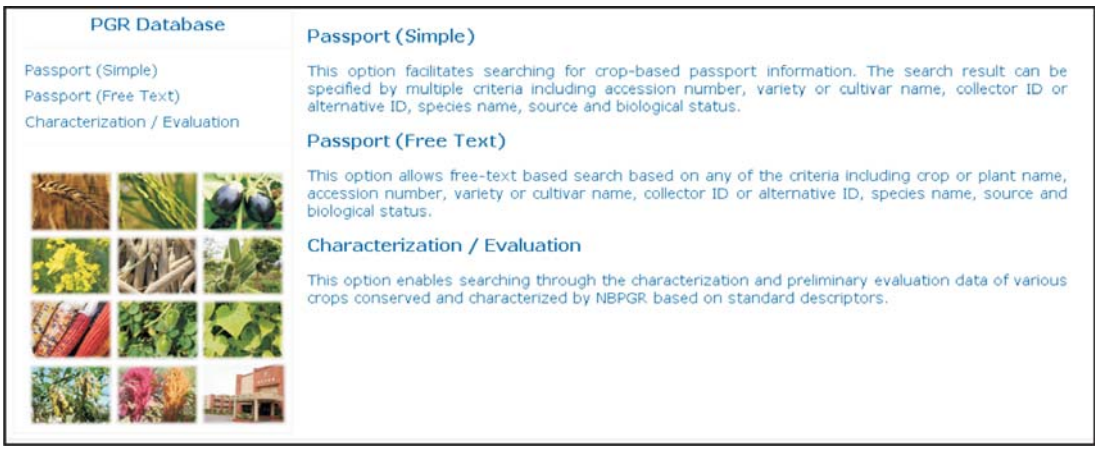
Characterization data include agro-morphological data recorded as per minimum descriptors. Some traits in the characterization data may include preliminary evaluation data such as yield parameters that are useful to the breeders. Evaluation data (displayed in the Portal as an extension of characterization data) is based on trait specific evaluation. As and when characterization activity yields more and more data they will be automatically added to the Portal. Similarly, specific evaluation data will also be added as and when they are available so that breeders can make use of the information.

The information on the germplasm accessions available through the PGR Portal is a result of contributions of scientists of NBPGR since its inception. It also reflects numerous collaborative efforts among organizations of National Agricultural Research System of India.

8.2 Web-mail

NBPGR Webmail facility on RedHat 6.0 platform employing open source software Roundcube with iRedAdmin and LDAP v0.1.9 was developed. The webmail was successfully implemented and hosted at NBPGR mailserver. Email facility is accessible from

The PGR Portal provides flexible search options under three heads.



anywhere at https://www.mail.nbpgr.ernet.in. The facility is extended to all the mail users (>200) of NBPGR including researchers from regional stations.

8.3 Strengthening of PGR Database

The in-house PGR Database Management System comprising of "Passport, Genebank and Evaluation Data" was strengthened by adding new records. This included plugging the gaps by retrieving and complementing missing records and corrections/completions in existing records from available resources to the extent possible. The database is now populated with data on ~460,000 indigenous collections (IC), 7,650,000 exotic collections (EC), 3,75,000 genebank holdings and 90,000 germplasm characterization/evaluation data. The data entry/ editing work on all PGR related tables are being carried upon directly in the database. The major stake holders in the PGR database activities viz; germplasm exploration, evaluation, exchange and conservation divisions have been sensitized about its utilization.

8.4 Maintenance and Service

8.4.1 Infrastructure developed: A high-performance server system (Dell Power Edge R910) with 4TB usable storage for data backup and safety has been procured and installed successfully. In order to boost IT security and connectivity in the office, a user identity-based Unified Threat Management (UTM) System has also been installed. The work was carried out under National Rice Research Database (NRRD) Project. Bureau's mission-critical applications like Website, PGR Web Portal and other Database(s) are being shifted on the

Germplasm Information as on 31-12-2012

Information System	Activity	Entries in 2012	Total entries
PGR management system (only intranet)			
o Indigenous collections (IC)	IC numbers allotted	22,548	4,60419
o Genebank collections	Data ported	7,722	3,75,272
o Evaluation data	Data entered	22,560	22,560
Germplasm Exchange and Quarantine Information System (http://www.nbpgr.ernet.in/geq)	EC numbers alloted	34,453	7,67,064
Plant Germplasm Registration System (http://www.nbpgr.ernet.in/grpvr/login.aspx)	Germplasm registered	19	1,049
ICAR Plant Variety Information System (http://www.nbpgr.ernet.in/pvrs)	Varieties documented	-	2,054
Notified and Released Varieties of India (http://www.nbpgr.ernet.in/norv/index.aspx)	Varieties documented	25	7,418

newly procured hardware.

8.4.2 LAN: Maintenance of two series Lan approx. 490 nodes created to connect computers, printers and servers at NBPGR headquarters was carried out as per the following list: Directorate (15), Administration Section (15), Finance and Audit Section (20), DDO (10), Division of Germplasm Evaluation (50), Germplasm Exchange Unit (20), Division of Germplasm Conservation (50), Tissue Culture and Cryo-preservation Unit (30), Division of Plant Quarantine (50), Division of Exploration and Germplasm Collection (50), NRC on DNA Fingerprinting (50), AKMU (50), PG Computer Lab (10), Library (20) and others (50).

Important URLs maintained on AKMU Servers

AKMU Servers	URL's
NBPGR Homepage	www.nbpgr.ernet.in
Online request for Import Permit and EC data search	http://www.nbpgr.ernet.in/geq/
IC Data Search (only intranet)	http://database_rx/nbpgr/SearchPassport.aspx
Plant Variety Registration System	http://www.nbpgr.ernet.in/pvrs/
In vitro Genebank Management System	http://www.nbpgr.ernet.in/invitro/
Germplasm and Plant Varieties Registration System	http://www.nbpgr.ernet.in/grpvr/login.aspx
Inventory of Registered Crop Germplasm	http://www.nbpgr.ernet.in/IRCG/index.htm
Digital Library on Bruchids	http://202.141.12.150/bruchid-library/
Trait Specific Germplasm Identified through Multi-location Evaluation	http://www.nbpgr.ernet.in/tsgi/index.htm

Research Programme (Programme Code: Title, Leader)

PGR/ARIS-BUR-DEL-01.00: Genetic Resources Information Programme (**Sunil Archak)**

Research Projects (Project Code, Title, Project Leader; Associates

PGR/ ARIS - BUR-DEL-01.01: Molecular Data Analysis Software (**Madhu Bala Priyadarshi)**

PGR/ ARIS - BUR-DEL-01.02: Bioinformatics Software Portal (**Madhu Bala Priyadarshi** and Soma S Marla**)**

Externally funded project

Utilization of *ex situ* collections and climate analogues for enhancing adaptive capacity to climate change (**Sunil Archak**, Sushil Pandey, DP Semwal, BS Phogat)

9. GENOMIC RESOURCES

Summary: Microsatellite based markers were used for genetic diversity analysis of pearl millet (27 accs.), finger millet (35 varieties), maize (143 varieties), flax (94 accs.) pomegranate (45 accs.) and *Luffa* (37 accs.). Twenty one species of *Allium* and two of *Morinda* (31 genotypes) were characterized using RAPD ISSR and SCOT markers respectively. New microsatellite markers were developed through genomic library construction and enrichment in bitter gourd (56 loci) and finger millet (15 loci); through cross species transferability in *Crambe* and bottle gourd and from transcript sequences in *Giloe*. SSR markers were also used for molecular profiling of finger millet minicore (110), wheat (186) and rice (62). DNA fingerprinting services were rendered to various public and private organizations for 46 samples of various crops.

Trait specific markers were generated for specific traits (from the identified germplasm) i.e. for *Tomato leaf curl virus* (from resistant sponge gourd), flowering characteristics (from gynoecious bittergourd lines), alkaline condition responsive genes (from wheat KRL-99), high erucic acid (from *Crambe*), oxidative stress management and zinc transporter genes in cowpea and maize for various biotic (UG99) and abiotic (drought, salt and heat stress) in wheat. To facilitate allele mining for stress tolerance, core collections of *Cucumis*, mothbean and *Lathyrus* were designated and validated using molecular markers. Over 150 candidate genes for moisture stress tolerance were analyzed in reference sets of *Cucumis*, mothbean and *Lathyrus* and so far 394 SNPs each have been shortlisted for SNP genotyping. Transcriptome profiling for generation of genomic resources for moisture stress tolerance and allele mining from the tolerant and susceptible genotypes has resulted in the identification of curated transcripts:12859 and 13448 transcripts in *Cucumis*; 5047 and 5016 transcripts in mothbean and 20,992 and 19,553 transcripts in *Lathyrus.* Expression analysis in moth bean using heat tolerant genotypes indicated that mannose-o-phosphate isomerase, global transcription factor, *prlli*-interacting factor G, and ribulose-bis-phosphate were overexpresed at 30 min treatment in tolerant genotype. Genotyping of mothbean core collection of 250 accessions was completed using 15 SSR and 250 anonymous DNA markers. Analysis indicated presence of moderate sub-structure in the collection and will be used for association analysis along with the phenotype and SNP data. The *Lathyrus* core set of 295 accessions was genotyped with 255 polymorphic markers and estimation of population sub-structure was completed for use in association analysis. Towards QTL localization for improvement of oil quality and yield in sesame, two sesame accessions with high sesamin contents were identified along with associated SNPs and InDels. Thirty SSR markers were used for genotyping the RILs for mapping. Analyses of SNP variation and corresponding differences in fatty acid profiles led to identification of three SNPs in desaturase genes which appear to be responsible for changes in secondary structure of the desaturase proteins. These are being further validated. Sesame recombinants with more than two percent higher linoleic acid (18:2) contents were identified.

Relationships among six species of the genus *Luffa* were studied based on nuclear internal transcribed spacer (ITS) sequences and chloroplast maturase K sequences and studies on intragenomic variation and Haplotypes of ITS region in *L. acutangula* L. (Roxb.). Seed micro-morphology of *Vigna* genus was observed to be helpful in establishing identities of species, and consequently a new species *Vigna indica* was described. Based on molecular phylogeny, the identity and taxonomic status of some taxa like *Vigna trilobata, V. stipulacea, V. hainiana, V. dalzelliana, V. minima; Cucumis callosus, C. melo* var. *agrestis, C. hystrix, C. muriculatus,* and *Abelmoschus manihot* and their subspecies have been assessed and taxonomic confusions have been removed. In *Abelmoschus*, analysis of 16 genomic regions indicated role of at least three species, *moschatus, tetraphyllus* and *tuberculatus* in the origin of okra. The work accomplished included analyses of 101 samples of 10 *Abelmoschus* species for the loci, *ITS-1, ITS-2, trnL-F, trnL exon, rbcL, rpoC1, psbA-trnH, nad B, rps14 –cobr,* trnC-D, atp F-H, trn E-T, matK, rbcL, rpl intron and nad1. *Abelmoschus enbeepeegearense*, a new species from the low elevation Western Ghats of India was described.

In bioinformatics, an in house designed search algorithm was applied and an efficient Degenerate PCR Primer design tool was developed for amplification of orthologs from even distantly related species. The tool is available for free public use at http://192.168.1.5/Dgen/DGEN_tool/index.html.

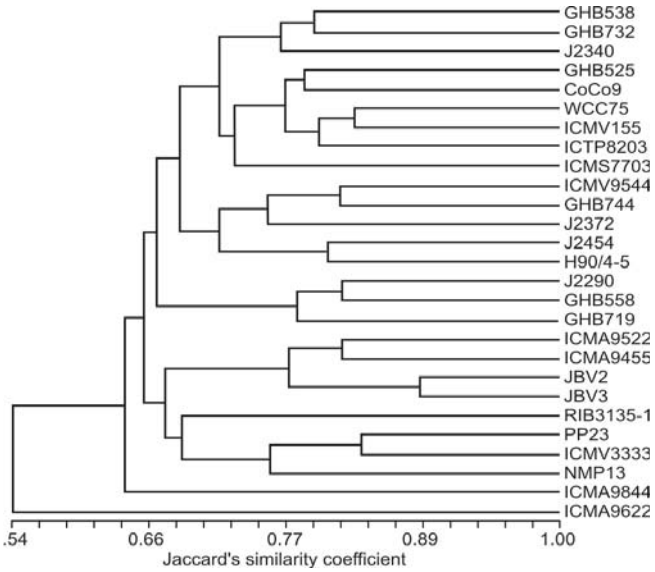
Qualitative and quantitative PCR/real-time PCR assays were developed for detection of *Bt* Brinjal event EE1 and 10 GM maize events. Molecular testing of 1,149 imported transgenic accessions of GM maize, rice, cotton, cabbage and *Arabidopsis* has been completed. Monitoring for adventitious presence of transgenes in *ex situ* cotton collection conserved in National Genebank using PCR based diagnostics was conducted. Under ISO/IEC 17043:2010, GM detection laboratory has successfully executed three proficiency testings for testing the unknown GM contents of different GM maize events in the test samples. The lab has also successfully participated in the ring trial to validate two real-time PCR methods to check contamination of GM rice.

9.1 Development of Molecular Markers for Characterization of Plant Genetic Resources

9.1.1 Application of molecular markers for Genetic Analysis

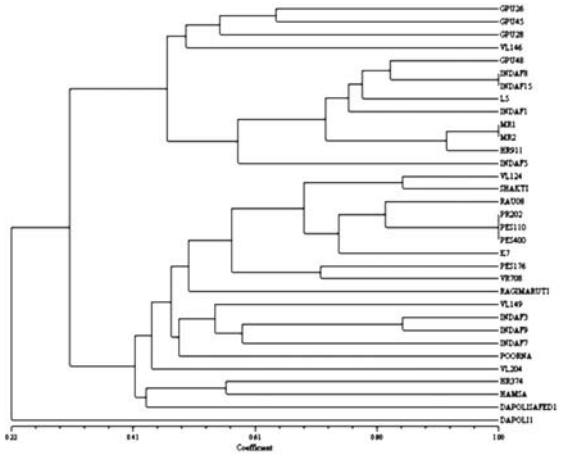
9.1.1.1 Genetic diversity analysis of pearl millet cultivars and parental lines: Genetic diversity among 27 pearl millet genotypes comprising of cultivars and parental lines was analyzed using 18 SSR markers. A total 58

alleles were amplified with an average of 3.2 per locus and ranged from 2 to 5. The maximum genetic similarity was observed between JVB2 and JVB3 whereas minimum was between ICMA96222 and ICMS7703. Moreover, as expected majority of parental lines and their hybrids were clustered together.



Dendrogram showing genetic relationships among pearl millet genotypes based on SSR markers

9.1.1.2 Diversity analysis in finger millet varieties: Thirty three finger millet varieties were profiled with 22 SSR markers and scoring of alleles and data analysis could be completed with 11 SSRs. Number of alleles ranged from two to six with an average of 3.18 alleles per primer. Average Jaccard's similarity index was 0.41 based on these markers. These 33 varieties could be grouped in two clusters as shown in the dendrogram.



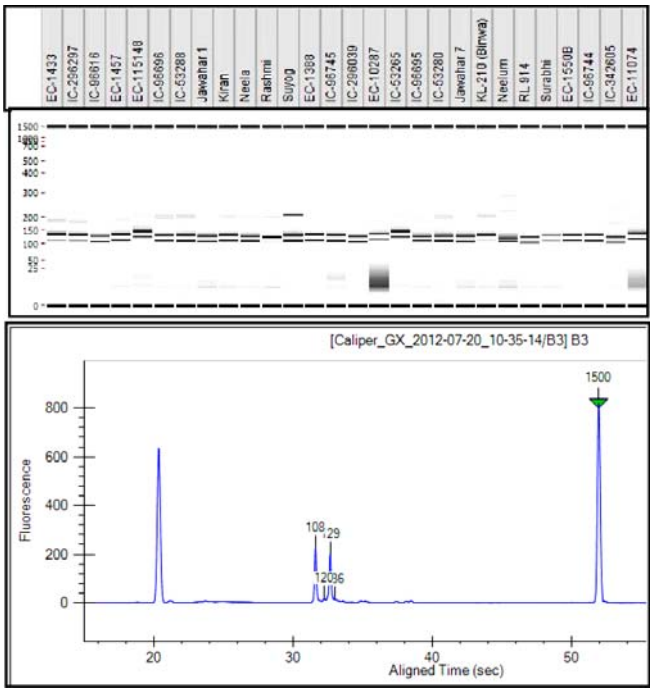
Dendrogram showing genetic relationship among 33 varieties of finger millet

9.1.1.3 Genetic relationships among finger millet genotypes with contrasting responses to blast disease: In order to understand genetic profile and relationships within 69 finger millet germplasm known for contrasting blast disease resistance response, Sequence Related Amplified Polymorphism (SRAP) and Resistance Gene-Analog Polymorphism (RGAP) marker systems were employed. More than 150 SRAP and 40 RGAP-based primer combinations were screened using four contrasting finger millet genotypes. Forty five SRAP and 15 RGAP primer combinations were selected, respectively for profiling a subset of 69 finger millet genotypes known for contrasting blast disease responses under field conditions. Twenty one SRAP and 10 RGAP primer combinations produced satisfactory polymorphic profiles for marker profiling and genetic relationship studies. Few genotype specific bands were identified which can be utilized for developing markers for selection of parents and mapping populations.

9.1.1.4 Diversity analysis in maize (*Zea mays*): Seed material of different varieties, hybrids and their parents were procured from various breeding places of the country. DNA was isolated using CTAB method, further purified and quantified. PCR conditions were standardized for seven microsatellite loci and profiling of all 143 samples was carried out using those seven loci. The samples were electrophoresed using agarose gels, stained with ethidium bromide and photographed. The studied markers were polymorphic and revealed their substantial utility in DNA fingerprinting of maize samples. The study is in progress using additional markers from different chromosomal locations.

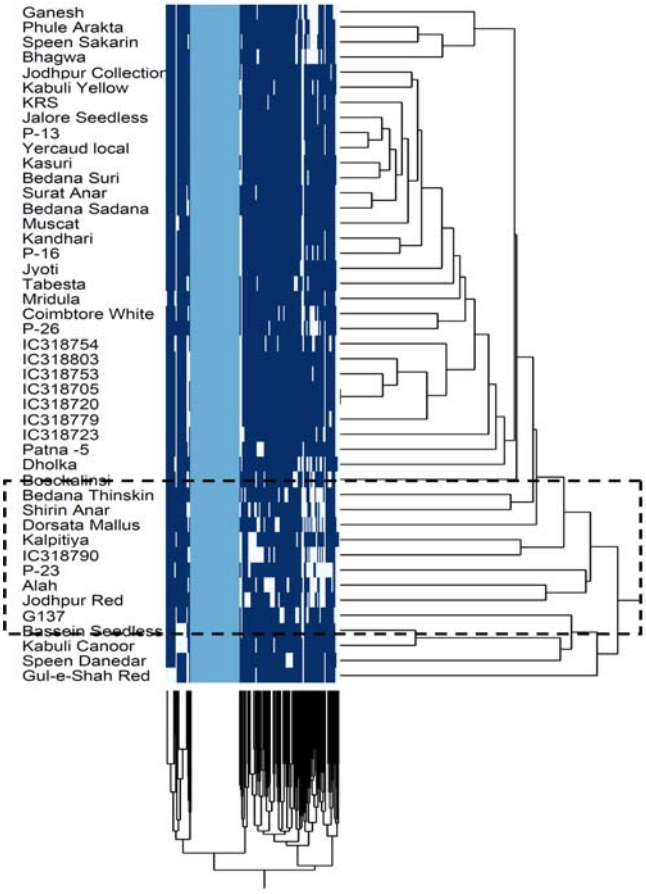
9.1.1.5 Molecular characterization in flax (*Linum usitatissimum* L.): Continuing the work reported last year, additional 10 markers were used to characterize 94 accessions of flax which included 40 extant varieties and 50 germplasm lines. PCR products were resolved in an automated electrophoresis system ($LabChip_{LX}$) from M/S Caliper Life Sciences. The twenty-five SSR primers generated 78 alleles among 94 genotypes. The size of the amplification products varied with each primer and ranged from 134 bp to 388 bp. The number of bands produced also varied with each primer used ranging from 2 to 6 with an average of 3.12 per primer. Out of 78 bands observed, 77 were found to be polymorphic. The number of polymorphic markers per primer ranged from 1 to 6 with an average of 3.08. Cluster analysis revealed

the genotypes, namely, IC342792, IC96748, Shekhar, Shubham, EC1433 and IC342606 to be quite distinct from rest of the material. All the genotypes could be differentiated from one another using combined profile of 25 primers.



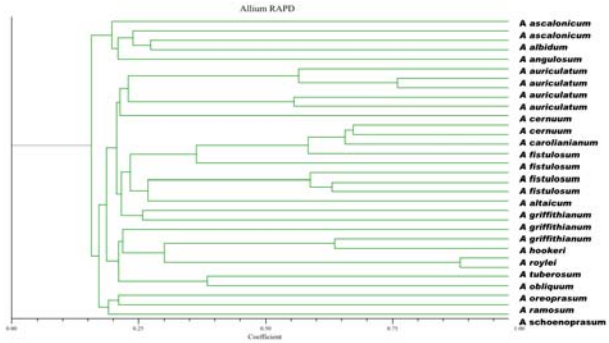
Representative STMS profile of 94 linseed genotypes (left: gel image for 28 genotypes; right: representative one sample depicting allele sizes)

9.1.1.6 Assessment of genetic relationships in Pomegranate: In order to assist the management of germplasm in the field gene banks, assessment of genetic diversity and genetic relationships of 45 accessions of pomegranate (*Punica granatum* L.) that included cultivars and germplasm collections was carried out using nine morphometric, 241 ISSR and six SSR markers. The average genetic distance values based on ANOVA sum of squares (Ward) were 3.94 and 5.10 based on morphometric and DNA markers respectively. Hierarchical clustering based on genetic distances grouped the accessions into at least three distinct clusters; the two-way clustering showing the contribution of individual markers in genetic grouping. Discrete grouping of gene bank accessions (with IC numbers) away from varieties was evident based both on quantitative traits data as well as DNA marker data. The findings suggested the possibility of broadening genetic base of cultivated varieties by augmenting the selection and breeding programmes in India with diverse as well as trait-specific pomegranate germplasm.



Two-way dendrogram of 45 pomegranate accessions based on 247 microsatellite-based markers

9.1.1.7 Molecular characterization of *Allium* spp.: Thirty two accessions of *Allium* representing twenty one species, maintained in the field gene bank at NBPGR regional station Bhowali were characterized using RAPD markers. A total of eighty four primers were screened against representative samples and thirty primers were identified. A total of 728 markers were identified that could differentiate as well as group together accessions of all the species under study as per the traditional classification of *Allium* indicating that selected RAPD markers can be used for this purpose.



Dendrogram based on Jaccards similarity coefficient of RAPD markers in *Allium*

9.1.1.8 Comparative analysis of three popular Indian mango hybrid cultivars and their parents: In mango**,** Amrapali, Mallika and Ratna are the three popular hybrids developed using Dashehari, Neelum and Alphonso as parents. In an effort to provide cues to the breeders about these hybrids, band sharing information at 1,022 Amplified Fragment Length Polymorphism (AFLP) loci and 125 Inter Simple Sequence Repeat (ISSR) loci was generated. AFLP and ISSR profiles revealed substantial differences in band sharing pattern. Number of ISSR markers shared between pairs of parents and their hybrid was nearly 20% more than that of AFLP markers, endorsing the relatively conserved nature of ISSR profiles. Dashehari, both as male and female parent, contributed significantly higher number of ISSR markers to the hybrids. On the other hand, Ratna shared a greater number of AFLP bands with its female parent Neelum. Notably, Amrapali produced an unusually higher number of novel AFLP bands (20.5%) in relation to parents' profiles.

9.1.1.9 Development of markers for early sex determination in kiwifruit: Male and female genotypes of kiwifruit procured from NBPGR regional station Bhowali were screened to identify molecular markers suitable for early sex determination in kiwifruit .One putative RAPD marker has been identified which is being validated on male and female accessions procured from Shimla.

9.1.1.10 Genetic diversity in *Luffa* species: Genetic diversity of 37 accessions comprising of *L. acutangula, L. aegyptiaca, L. hermaphrodita, L. graveolens* and *L. echinata* from distinct geographical regions of India was evaluated using ISSR markers. Thirty ISSR primers amplified 438 fragments, of which 426 were polymorphic. The number of polymorphic fragments detected per primer ranged from 3 to 27 bands with an average of 14.6. Average Resolving Power value was 8.0362 over all primers. Cluster analysis using UPGMA method grouped the genotypes into three main clusters according to species. The domesticated species; *L. acutangula*, *L. hermaphrodita*, *L. acutangula* var. *amara* and *L. aegyptiaca* formed two different clusters, respectively and the two wild taxa *L. graveolens* and *L. echinata* formed a single cluster. Population structure analysis differentiated the two domesticated species (*L. acutangula* and *L. aegyptiaca*) into two populations with the wild taxa accessions showing representation in both the populations. The obtained Nei's Gene Diversity 0.35 and Shannon's Information Index 0.52 revealed moderate level of diversity amongst different accessions used in the study. The results revealed the efficacy of the ISSR markers for species differentiation and genetic diversity and relationship studies in *Luffa* germplasm in India.

9.1.1.11 Genetic diversity analysis in *Morinda spp.*: RAPD markers were used to evaluate genetic variability in *Morinda tomentosa* (Rubiaceae), collected from different villages of Gujarat. Using 12 random primers, 79 bands were amplified of which, 73 were polymorphic in all the 31 genotypes. All the genotypes could be distinguished. The numbers of RAPD bands generated per primer varied from 5 to 10 with an average of 6.6 bands per primer. The Jaccard's similarity coefficients ranged from 0.32 to 0.92 with an average of 0.65. In another study, a total of 31 genotypes belonging to *M. tomentosa* and *M. citrifolia* were profiled with 15 ISSR primers. One hundred and seventy six bands were obtained with an average of 11.7 bands per primer. UPGMA based cluster analysis could clearly group the genotypes belonging to two species in separate clusters. Similar results were obtained using 177 Start Codon Targeted (SCoT) markers generated by twenty-seven SCoT primers.

9.1.2 Development of molecular markers

9.1.2.1 Development of STMS markers in bitter gourd (*Momordica charantia*): Fifty six new primer pairs were synthesized from sequences of positive clones obtained from a microsatellite enriched partial genomic library of Pusa Vishesh. These were validated on 62 genotypes of bitter gourd. A total of 70 novel STMS markers have been identified with an average of 1.3 alleles per locus. These primer pairs were tested for cross-species transferability on a panel of eight different *Momordica* species. Forty of the primers-pairs amplified alleles in other species. The sequences of repeat containing clones have been submitted to the public database (NCBI).

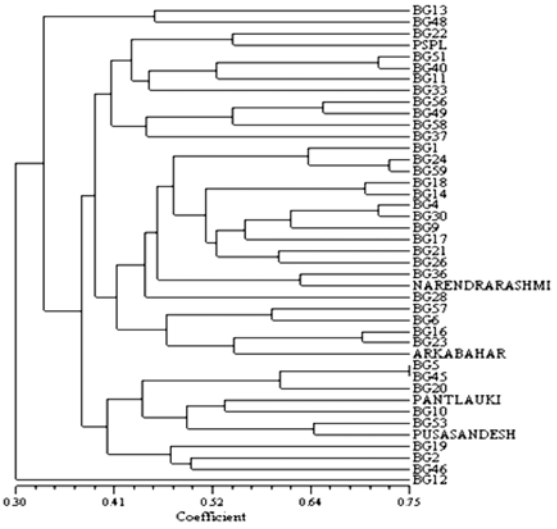
9.1.2.2 Development of genomic SSR markers in finger millet (*Eleusine coracana* L. Gaertn.): Fifty one new primer pairs were designed from genomic library sequences after Vec screening, SSR finding, designing and redundancy check for SSR marker development in finger millet. These were tested in three germplasm lines of finger millet for amplification and the primers showing amplification were validated in 24 germplasm lines and varieties of finger millet. Fifteen SSR markers could be developed and five were found polymorphic (Table 1).

Table 1 Characteristics of gSSR markers developed in finger millet

Name	Repeat Type	Expected size	Polymo-rphism
FMgSSR17	(GA)8/(GTA)4	300 bp	P
FMgSSR20	(AG)30	177 bp	P
FMgSSR24	(CT)8	218 bp	P
FMgSSR27	(TGGTT)2	109 bp	P
FMgSSR30	(TAC)4	134 bp	P

9.1.2.3 Transferability of Brassica's genic-SSR markers in genus *Crambe*: A total of thirty two SSR markers, representing different functional alleles, were tested for their transferability in diverse accessions of *Crambe*. Approximately 30% of each of di-nucleotide repeat SSRs and tri-nucleotide repeat SSRs were transferable across randomly selected different *Crambe* accessions belonging to five different species. Further identification of markers is underway. The markers showing robust and reproducible results may be useful for candidate genes determination, genetic mapping, diversity analysis etc.

9.1.2.4 Marker development and validation in bottle gourd: In continuation with previous year work of SSR marker development through transferability in bottle gourd, 12 additional polymorphic markers were validated in 48 genotypes of bottle gourd. So a total of 19 SSRs (7 SSRs developed earlier) were used to construct UPGMA based dendrogram of 42 genotypes of bottle gourd.



Dendrogram based on 19 polymorphic SSR markers developed through cross species transferability in bottle gourd

9.1.2.5 Development of EST-SSR makers in *Andrographis* (Kalmegh): Four hundred and twenty four EST-SSR makers have been developed from *Andrographis paniculata* (Kalmegh) transcriptome. Fifty EST-SSR primers were synthesized for validation on 18 accessions of *Andrographis*. Twenty-five EST-SSR primers showed good amplification and polymorphism in all accessions. These EST-SSR markers can be used for DNA fingerprinting as well as diversity analysis of *Andrographis*.

9.1.3 Molecular profiling

9.1.3.1 Genotyping of finger millet minicore using microsatellite markers: Finger millet minicore obtained from AICSMIP, Bangalore was characterized using additional 29gSSR markers. Scoring of alleles and data analysis is in progress to estimate the level of polymorphism and genetic diversity in this set of finger millet germplasm.

9.1.3.2 Genotyping of wheat germplasm lines: A total of 186 germplasm lines including six released varieties were profiled with 10 SSR markers for its molecular characterization. These lines were also evaluated for traits related to terminal heat tolerance.

9.1.3.3 SNP genotyping in wheat: The prediction of SNPs using wheat germplasm available and screened at NBPGR is in progress. Towards this end the prescreening of genes using *in silico* methods is highly desirable. With this objective, the development of prediction tool to predict genes involved in thermo tolerance was undertaken. The biochemical-biophysical properties were analyzed using bioinformatics tools Statistical tests were performed to look for significant differences in the properties studied. As a next step the parameters showing significant differences between proteins involved in heat stress and not involved in stress are being mined for novel rules using sophisticated data mining tools as VEKA. The data obtained was mined using sophisticated data mining tools. The "rules" for classifying proteins into heat stress and non-stress classes could be deduced. Our prediction algorithm is showing more than 80% accuracy for proteins involved in heat stress in wheat. The wet lab validation of the results is in progress.

9.1.3.4 SNP genotyping in pigeonpea: DNA was extracted from 37 genotypes of pigeonpea including genotypes resistant and sensitive to *Fusarium* wilt and

Yellow Mosaic virus. Twenty four primer sets designed from domains important in disease resistance were used for PCR amplification. The sequencing of amplicons is in progress.

9.1.3.5 Giloe (*Tinospora cordifolia*) fingerprinting with SCOT marker: Thirty-two SCoT markers were used for diversity analysis of twenty-five accessions of Giloe. Out of which twenty primers could get amplified and were used for diversity analysis. Jaccard's similarity coefficient was used to generate similarity matrix and similarity ranged from 0.68-0.93. Dendrogram was constructed for amplicons generated using the SCoT markers using the UPGMA method. All the accessions could be differentiated except IC281960 and IC281963.

9.1.3.6 Molecular profiling of rice: Fingerprinting of 62 rice cultivars was done using SSR primers viz., RM1, RM162, RM271, RM215, and RM307. In addition, SSR markers with high PIC value and based on their chromosomal location were identified from the published reports and a total of 105 markers were custom synthesized. Thirty one primers were screened to check their amplification and polymorphism pattern with four diverse lines Pusa Basmati 1460; Pusa Sugandh 2, IR24 and V L Dhan 286.

Another set of sixty rice accessions was fingerprinted with 18 HvSSR makers using fragment analyzer for accurate allele sizing. Number of allele generated varied from 2-7. Initial cluster analysis shows that all sixty accessions are grouping together into two groups.

9.1.3.7 DNA fingerprinting Services: DNA fingerprinting service was rendered to various public and private organizations and resources worth Rs. 48,000 were generated. Forty-six samples were fingerprinted using mostly STMS markers. However, techniques like RAPD, ISSR, and SRAP were also used in some crops where STMS markers were not available.

9.2. Development and Utilization of Genomic Resources and Bioinformatics Tools

9.2.1 Trait specific markers

9.2.1.1 Cloning and identification of resistance gene candidate (RGC) sequences from ToLCNDV resistant sponge gourd genotype: Yellow mosaic and leaf curl disease caused by *Tomato leaf curl New Delhi virus* (ToLCNDV) is one of the serious field diseases of many cucurbitaceous crops. A sponge gourd genotype, DSG-6 known for resistance to ToLCNDV both at field and green house conditions was used to isolate resistance gene candidates as genomic resources. Degenerate primers were employed to Amplify Nucleotide-binding Site (NBS) domain of RGCs. Sixteen non-redundant sequences of RGCs were identified with un-interrupted open reading frames (ORFs) and high amino acid sequence homologies (60-98%) to various nucleotide NBS-LRR proteins from Genbank database. These sgRGCs belong to the TIR and non-TIR group of NBS-LRR genes and consisted of conserved NB-ARC domain from resistant (R)-gene family with characteristic P-loop, Kinase-2, RNBS-A, Kinase-3A and GLPL motifs. The analysis of expression profiles of sgRGCs in asymptomatic and field-driven symptomatic leaf tissues of ToLCNDV resistant and susceptible genotypes identified one, RGCLc28 is expressed differentially in tolerant genotypes and is suggested to have association with the resistance trait against the leaf curl and mosaic disease in sponge gourd.

9.2.1.2 Identification of marker associated with gynoecious lines in bitter gourd: An ISSR marker associated with gynoecious trait in bitter gourd has been identified. Subsequent to screening gynoecious and monoecious plants with 200 RAPD and 28 ISSR primers a ~ 1000bp ISSR fragment was identified that was amplified only in gynoecious plants. Further analysis of this 1kb fragment is underway for its conversion into a SCAR marker and its utilization in gynoecious sex expression.

9.2.1.3 Construction of SSH library in wheat for isolating alkaline condition responsive genes: SSH libraries (forward and reverse subtracted) of wheat (KRL-99) were constructed using PCR-Select™ cDNA kit (Clontech). The KRL-99 was selected because it has been reported as one of the most saline and alkaline conditions tolerant genotype of wheat. The root tissues of wheat seedling subjected to salt stress and alkaline condition (pH-8.5) in micro plots (at CSSRI, Karnal) and from control were used for the construction of the library. The differentially expressed cDNAs were cloned in pGEMTeasy vector and will be sequenced to identify novel genes.

9.2.1.4 Cloning and characterization of cowpea (*Vigna unguiculata (L.)* Walp) genes: Cowpea is an important legume which is used as food and fodder. While calcium exchanger gene (JQ731678) is responsible for accumulation of high calcium in plant which is important

for nutritional quality, genes such as glutamine synthase (KC462885), dehydrin are responsible for oxidative stress management in plant cell. Therefore, the full length of these genes was isolated from the young leaf of cowpea plant. *In silico* analysis deduced amino acid sequence, characteristics conserve domain, secondary structure which showed high degree of homology with other similar genes of angiosperm. Further, cloning of genomic sequence of carbonic anhydrase (CA) (JQ429799) as well as full length cDNA by RACE-PCR revealed that while the genomic sequence was 1470 bp long with four introns yet, the Open Reading Frame (ORF) was 990 bp in length with 5'UTR and 3'UTR is 73 bp and 250 bp long, respectively. The deduced amino acid sequence (329 amino acids) contained two characteristic conserved domain of CA i.e. CSDSRV and EYAVLHLKVSNIVVIGHSACG, which showed high degree of homology with other CA genes of angiosperms. Further, in order to find out the allelic variations of CA gene, the ORF was cloned from a set of 10 diverse cowpea accessions (JX840169 to JX840177) and some novel SNP were found which may be potential molecular markers in cowpea breeding program.

9.2.1.5 Identification of Zn transporter (ZIP) family genes in maize (*Zea mays*): ZRT-IRT-like proteins (ZIP) are an important zinc transporter family in plants with the characteristic ZIP domain (Pfam: PF02535). Although individual genes belongs to ZIP family have been discovered from various plants, yet genome-wide analysis of the paralouges (*ZmZIP*) and their relationships among the other related genera have not been conducted so far. Thus, a genome-wide analysis was carried out which identified 12 members of the *ZIP* gene family in maize. Based on phylogenic relationship, 12 ZIP genes were classified into three major classes (Class A, B, and C) according to their structural characteristics and phylogenetic comparisons. Further tissue specific expression of those genes were determined by real-time PCR in the flag leaf as well as in 10 day-old-baby kernel among the high and low kernel zinc containing maize inbreds under field grown conditions. It has been found that overall transcript abundance is higher in flag leaf in both the inbreds but two members namely *ZmZIP5* and *ZmZIP11* are highly expressed in flag leaf of high zinc kernel containing inbred. Therefore, these results provide a basis for further functional characterization of specific *ZmZIP* genes in future.

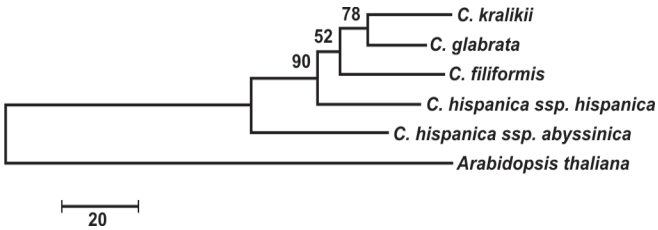
9.2.1.6 Screening for DNA markers to tag stress tolerance in wheat germplasm: Thirteen wheat germplasm accessions known to be tolerant to moisture stress/ heat were screened using 55 gene-based markers known to be involved in abiotic stress tolerance in plants. Similarly, 87 wheat germplasm accessions putatively resistant/ tolerant to UG99 race of stem rust were screened using 20 markers. Preliminary results showed amplicon length polymorphism in a few cases prompting need for identification of sequence differences.

9.2.1.7 Development and validation of MYB and NAC transcription factor based markers in Wheat for characterization of wheat germplasm: The MYB TFs (Transcription factors) comprise one of the largest gene families. Keeping in view, the various functions of MYB proteins, especially their important role in response to abiotic stresses in plants, wheat MYB TFs based EST sequences have been downloaded from NCBI database for the development of EST-SSR markers in wheat. A total of 124 EST-SSR primer pairs based on MYB TF factors have been designed. Similarly NAC TF based EST sequences have been downloaded and eight primer pairs have been designed. Initially, 29 MYB based and eight NAC based primer pairs have been tested for amplification in four drought tolerant and sensitive varieties of wheat. Out of 29, twelve MYB and five NAC based primer pairs showed amplification and validation of the markers developed is in progress in a set 24 drought, salt and heat stress tolerant and sensitive varieties of wheat.

9.2.1.8 Cloning of fatty acid elongase 1 (*FAE1*) gene from *Crambe* germplasm: To augment our understanding regarding genomic basis of biosynthesis of erucic acid, the complete coding sequence (CDS) of *FAE1* gene from geographically diverse *Crambe* accessions belonging to five different species were isolated .The *FAE1* genomic fragments were cloned in T/A vector for downstream processing and application. The genomic clones of *FAE1* gene lacks intron, a feature typically associated with *FAE1* gene of plant kingdom. The sequence verified clones of *FAE1* gene revealed an ORF of either 1521 bp (in five *C. abyssinica* accessions, in three *C. hispanica* accessions and two *C. filiformis* accessions), or 1515 bp in one *C. karalikii* accession and 1524 bp in one *C. glabrata* accession. The functional characterization of genomic tools i.e. complete CDS of *FAE1* gene isolated from diverse

accessions will provide vital information regarding biosynthesis of erucic acids and may provide insight into modulation of erucic acids content through biotechnological approaches.

The evolutionary relationship among *Crambe* species, based on *FAE1* gene was inferred using the Maximum Parsimony method. The bootstrap consensus tree inferred from 1000 replicates is taken to represent the evolutionary history of the *Crambe* species with *Arabidopsis* as outgroup. The Maximum Parsimonious tree was obtained using the Close-Neighbor-Interchange algorithm with search level 3 in which the initial trees were obtained with the random addition of sequences (10 replicates). The tree is drawn to scale, with branch lengths calculated using the average pathway method and are in the units of the number of changes over the whole sequence. The *C. hispanica* along with the subsp. *abyssinica* were outgrouped with *C. kralikii* and *C. glabrata* clade and *C. filiformis* as intermediate. The evolutionary rate test also showed that except *C. kralikii* and *C. glabrata* all other species have equal rate of evolutionary lineages.



Evolutionary relationship of different species of *Crambe*.

9.2.1.9 Bioprospecting of genes and allele mining for stress tolerance in selected crop germplasm: In order to facilitate allele mining, core collections of *Cucumis*, mothbean and *Lathyrus* were designated and validated using molecular markers. The size of core collections was: *L. sativus* - 295 acc.; *Cucumis* - 225 accessions including *melo* and *sativus; V. aconitifolia* 223 accessions. The core collection of cucumber, muskmelon, long melon and snap melon (both wild cultivated species) were morphologically characterized. STMS genotyping of core collections of cucumis (45 markers), mothbean (30 markers) and lathyrus (20 markers) were completed using the selected markers as indicated. Phenotyping and classification of 225 cucumis core for moisture stress tolerance was performed for relative water content, Soil moisture (%), osmotic potential, wilting recovery, flower drop, chlorophyll content, seed yield/ plant. The accessions identified as a reference set for moisture stress tolerance studies included: highly tolerant – 9; moderately tolerant – 5; susceptible – 4. SNP discovery using candidate gene approach for stress tolerance in *Cucumis*, mothbean and *Lathyrus* was done after analyzing over 150 candidate genes in reference sets of *Cucumis, Lathyrus* and mothbean. So far 394 SNPs each in the three target species have been short-listed for SNP haplotyping. Two accessions each of *C. sativus* and *C. melo* with considerable tolerance to moisture stress identified and crosses between tolerant and susceptible were made and F1analyses indicated presence of considerable tolerance to moisture stress in comparison to susceptible parents.

Studies on allele mining for drought related antioxidant genes in *Cucumis* spp. were undertaken in 44 genotypes of ten *Cucumis* spp. Among these genotypes 11.3% were found tolerant whereas 20.4% were susceptible. There was a general reduction in root- shoot length, and root - shoot weight in most of the genotypes under drought conditions. The CAT and GPOX activities increased but APX activity decreased under drought in most of the genotypes. Allelic variations in the form of SNPs were observed between and within various *Cucumis* spp. studied. Transition, transversion and indels were obtained at different positions in the sequences. Variation between genotypes was observed at various sequence positions while between the species variations were observed for *C. melo* and *C. sativus* and *C. callosus*. This variation could be important for the dissimilarity of catalase enzyme activity in different genotypes of *Cucumis* spp. under water stress.

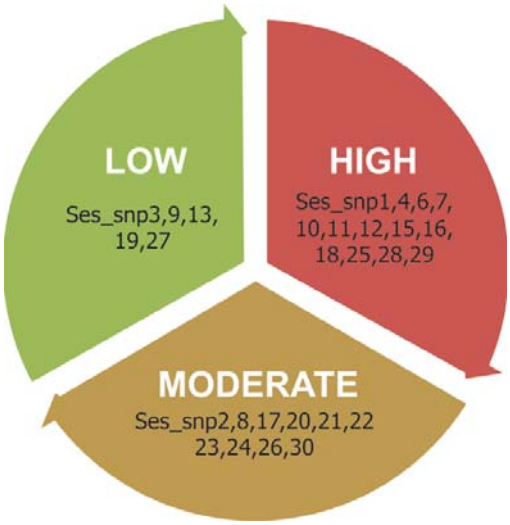
For generation of genomic resources for prospecting of genes for moisture stress tolerance and allele mining in *Cucumis* and mothbean, moisture stress tolerant and susceptible genotypes were selected for transcriptome profiling in *Cucumis, Lathyrus* and mothbean. Analysis resulted in 145 million reads each for transcriptomes in the target genera. Further processing resulted in identification of curated transcripts in the three species: 12,859 and 13,448 transcripts in *Cucumis*; 5,047 and 5,016 transcripts in mothbean and 20,922 and 19,553 annotated transcripts in *Lathyrus.*

Further, 204 genotypes of mothbean (*Vigna aconitifolia* Jacque Marcheal) were screened for heat stress tolerance. In total 22 genotypes were found to be heat tolerant whereas 35 genotypes were found heat susceptible. Rest of the genotypes were found to be moderately tolerant or susceptible. The genotypes

studied indicate that this crop's genepool has a skewed distribution towards tolerant type. Expression analysis using heat tolerant genotypes indicated that mannose-o phosphate isomerase, global transcription factor, *prlli*-interacting factor G, and ribulose bis phosphate were over expressed at 30 min treatment in tolerant genotype. Expression of jumongi box was of almost same intensity in the genotypes under control and heat treated condition. Gigentia expressed better in CZM -105 at 30 min treatment. Genotyping of mothbean core collection of 250 accessions was completed using 15 SSR and 250 anonymous DNA markers. Analysis indicated presence of moderate sub-structure in the collection and will be used for association analysis along with the phenotype and SNP data. The *Lathyrus* core set of 295 accessions was genotyped with 255 polymorphic markers and estimation of population sub-structure was completed for use in association analysis.

9.2.1.11 QTL localization for improvement of oil quality and yield in sesame: Fatty acid and lignan profiles of 150 selected sesame germplasm including released varieties, landraces, introgression lines and wild species were generated and this led to identification of genotypes with higher linoleic acid contents that could be of use in breeding programmes. Two sesame accessions with high sesamin contents were identified along with associated SNPs and InDels. The lignans are of value in improving keeping quality of oil and also as antioxidants. Over 34,000 new SSRs were identified in sesame to facilitate molecular mapping and localization of QTLs. 178 new SSRs polymorphic between the parental lines of the mapping population were identified from the 1,023 new SSRs generated in the project. Thirty of these were used for genotyping the RILs for mapping. Twelve QTLs for nine important traits, namely, number of branches per plant, date of 50% flowering, seed weight per capsule, seed yield per plant, internode length L_1, stem girth, capsules per node, days to maturity and node with capsule were localized on to the two linkage groups identified in sesame. F8 segregants with high yield and yield components were identified and multiplied for commercialization

Analyses of SNP variation and corresponding differences in fatty acid profiles led to identification of three SNPs in desaturase genes which appear to be responsible for changes in secondary structure of the desaturase proteins. These are being further validated. Sesame recombinants with more than two per cent higher linoleic



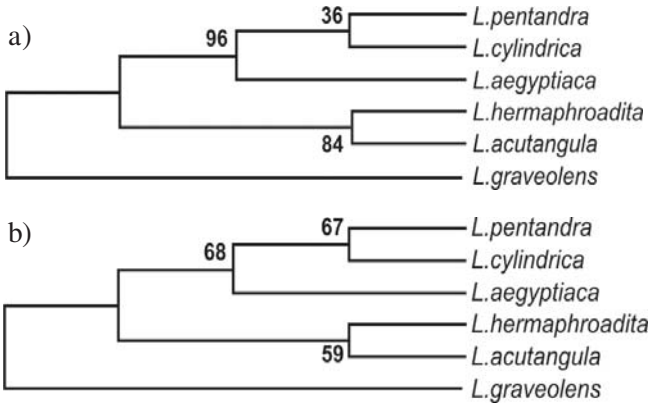
Graphical presentation of SNPs involved in the increase/ decrease or moderation of that particular fatty acid with which it is associated

acid (18:2) contents were identified. These were derivatives of crosses between *S. indicum* cultivars and *S. mulayanum* accessions with higher linoleic acid contents. Sesame accessions with more than 50 % linoleic acid were identified, while the released varieties generally have linoleic acid content of 31.39 to 45.28 %.

9.2.2 Species relationship and phylogeny

9.2.2.1 Species relationship of genus *Luffa* based on nuclear internal transcribed spacer (ITS) sequences and chloroplast maturase K sequences: Six recognised species of genus *Luffa* were used to study the species relationship and species phylogeny using nuclear ITS sequences. Universal primers were used to amplify the ITS1 -5.8S-ITS2 regions from genomic DNA and the same were sequenced for futher phylogenetic analysis. The ITS1 and ITS2 sequences were separatley analysed for the species relationship and phylogeny baed on pairwise multiple alignment method and hierarchial cluster were made based on UPGMA with 1000 bootstrap replicates. The average nucleotide length of ITS1 were 202 bases and ITS2 were 256 bases. Three distinct cluster were formed with *L. aegyptiaca* complex which includes *L. cylindrica* and *L. acutangula* complex which includes *L. hermaphrodita* and *L. graveolens* form in a distinct branch. The *L. pentandra* and *L. cylindrica* were considered morpho-taxonomically similar to *L.*

aegyptiaca and *L. hermaphrodita* was considered closer to *L. acutangula*.



Dendrograms showing phylogenetic relationship between *Luffa* species using a) ITS1 b) ITS2 sequences

For analysing the maturase K locus, six species of *Luffa* were used to generate partial chlorplast sequences using universal primers. Species relationship and phylogeny were analysed using pairwise multiple alignment method and hierarchial clusters were made based on UPGMA with 1000 bootstrap replicates. The average nucleotide length was 760 bases. The dendrogram displayed morpho-taxonomical conlcusion of L. *hermaphrodita* and *L. echinata* with *L. acutangula* and *L. pentandra* with *L. aegyptiaca*. The species *L. graveolens* was outgrouped from all other species. Total number of mutation comparing all the sequences were five with two indels. The total nucleotide diversity between the sequence was (Pi) 0.0028.

Dendrogram showing phylogenetic relationship between *Luffa* species using *mat*K sequences

9.2.2.2 Intragenomic variation and haplotypes of Internal Transcribed Spacer region (ITS) in *L. acutangula* L. (Roxb.) Cucurbitaceae: Total six accessions of *L. acutangula* nuclear ITS regions were amplified and sequenced to identify sequence polymorphism between the accessions. The ITS1 region did not show any variation between the accessions. However, ITS2 regions showed 248 monomorphic sites and 10 polymorphic sites with eight singleton variable site and two parsimony informative sites. Out of six sequences five haplotypes were observed with nucleotide diversity of 0.015. For intrageneomic variation the ITS regions were cloned in pGEMT and randomly selected five clones were sequenced to identify polymorphism between sequences. The ITS1 region did not show any variation. However, ITS two region showed seven mutations with no indel events. In order to ascertain, more clones are to be sequenced and analyzed.

9.2.2.3 Biosystematics and molecular phylogeny of *Vigna, Cucumis* and *Abelmoschus*: In order to establish a firm basis for taxonomic delineation of species under the genera *Vigna, Cucumis* and *Abelmoschus* basic data on morphological, anatomical and cytological features were collected. The distribution and dispersion pattern of *Cucumis, Abelmoschus* and *Vigna* species was mapped for all major zones of occurrence in India. The total work accomplished now spans the species distribution, variation, eco-geographic specificity and identity described for 22 *Vigna,* 12 *Cucumis* and 11 *Abelmoschus* species from Indian sub-continent. A total of 380 accessions were collected and assembled. The correct species identities were enumerated with essential illustrations for the key taxonomic traits for the *Vigna, Cucumis* and *Abelmoschus* species from India. Seed micromorphology of *Abelmoschus* and *Vigna* species was found useful for identification and classification of target species. The work was conducted with funding from the NAIP to the consortium comprising NBPGR, New Delhi including Thrissur Station; Shivaji University, Kolhapur and North Eastern Hill University, Shillong.

Seed micro-morphology of *Vigna* genus was observed to be helpful in establishing identities of species, and consequently a new species was described, viz. *Vigna indica* T. M. Dixit, K. V. Bhat & S. R. Yadav. Correct identity of *V. trivervia* var *trinervia* was established and described from Odisha, which is a new report. In order to establish molecular basis for taxonomic delineations of *Vigna, Cucumis* and *Abelmoschus* species, survey of cpDNA and mtDNA regions helped in identification of organelle regions useful for classification and delimitation of Asiatic *Vigna, Cucumis* and *Abelmoschus* species. Molecular phylogeny in *Vigna, Cucumis* and *Abelmoschus* genera were analyzed using *matK* and *rbcL* in addition to rpoC1, trnC-D, psbA-trnH, ITS1, ITS2 sequences in 380 samples for all species occurring in India. The detail description for each one of the species and workable keys for

identification have been prepared. The identity and taxonomic status of some taxa like *Vigna trilobata, V. stipulacea, V. hainiana, V. dalzelliana, V. minima; Cucumis callosus, C. melo* var. *agrestis, C. hystrix, C. muriculatus,* and *Abelmoschus manihot* and their subspecies have been assessed and taxonomic confusions are removed. The nomenclature problems have been resolved for Indian species of all the three genera. For *Vigna*, the analysis indicated existence of wider differentiation of the African species from Asiatic species. Further, within the Asiatic species, members of the major groups such as *V. mungo var. silvestris, V. radiata var. sublobata, V. aconitifolia, V. umbellata* etc were differentiated to a greater extent than reported earlier. Phylogenetic analyses of resistance gene analogues were conducted in relation to *Yellow mosaic virus* occurrence in different *Vigna* species. The wild species accessions with considerable tolerance to MYMV were identified (one accession of *Vigna radiata* var. *sublobata*, four accessions of *V. hainiana,* two accessions of *V. trilobata,* two accessions of *V. khandalensis,* one accession of *V. dalzelliana,* three accessions of *V. mungo* var. *silvestris).* Analysis of the resistance gene analogue, G8540 in the *Vigna* species indicated substantial differences between the susceptible and tolerant accessions.

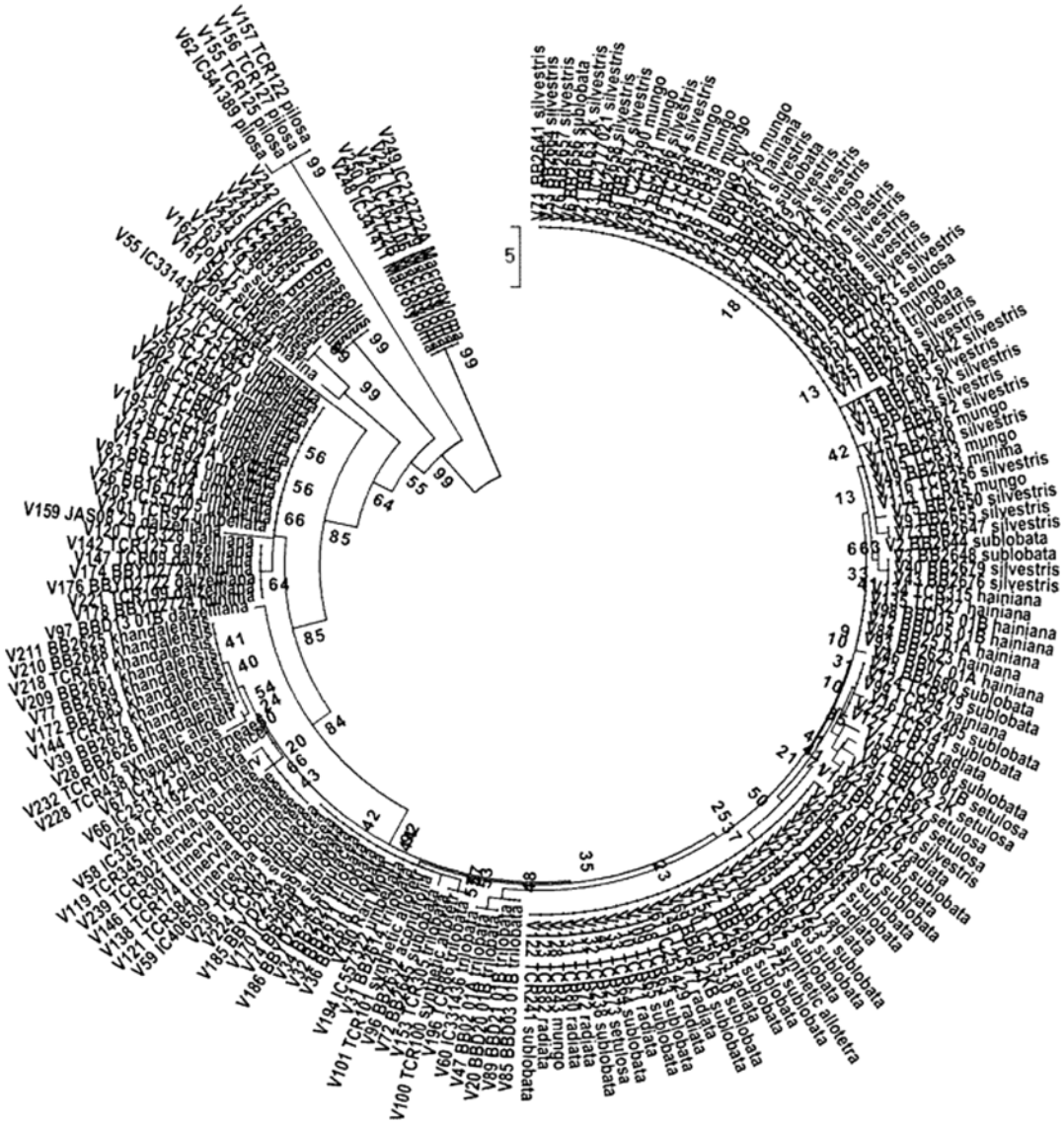
Morphotaxonomical investigations have been made to assess the generic status of *Cucumis, Cucumella, Mukia* and *Dicaelospermum*. *Cucumis dipsaceus* Ehrenb. Ex Spach. reported was a new record for India. Recollection of diverse accessions of *C. hystrix* was made since its first description in 1952 from Garo Hills. The generic delimitations between *Dicaelospermum* C. B. Clarke, Mukia Arn. and *Cucumis* L was described. Cytological and morphological analysis of the target species helped in establishing correct identity of the species, *Cucumis callosus, C. indicus, C. silentvalleyii, C. prophetarum* and *C. setosus;* all 2n=24, and their basic genomic differences vis-à-vis *C. sativus, C. sativus C. hardwikii* (2n=14) and *C. melo* (2n=24). The ambiguity existing in literature regarding species identities in the genera *Cucumis* is now resolved. Based on the surveys undertaken, a new species, *Cucumis dipsaceus* Ehrenb. ex Spach was recorded for India. In *Cucumis*, 145 accessions of *Cucumis* species collected from diverse ecologies were analysed. The accessions represented *C. sativus* var. *hardwickii, C. sativus, C. callosus, C. utillissimus, C. melo* var. *melo, C. melo* var. *momordica, C. cantaloupensis, C. trigonus, C. agrestis, C. setosus, C. melo* var. *conomon* and *C. prophetarum*. The regions sequenced were - *ITS1 & 2* region of nuclear DNA, *psbA-trnH, trn L-F* and *trn E-F* inter-genic spacer region of chloroplast DNA. The taxa under the four major groups of *Cucumis*, namely, *C. sativus, C. melo, C. prophetarum* and *C. setosus* were observed to be well differentiated for the genomic regions analysed. Three collections for *Cucumis sativus* from Tripura, Andaman and Nicobar Islands and Cherthala, Kerala were found to be field resistant to *Alternaria* fruit rot. Further, F_2 derivatives of a cross; *Cucumis melo* x *C. callosus* were found field resistant to *Alternaria* fruit rot and leaf blight. Seven collections of Cucumber from North East were found to be carotenoid rich.

Wide variations in chromosome numbers were detected within the cultivated *Abelmoschus esculentus*, and its wild relatives indicated highly complex nature of evolution of cultivated okra. The seed surface micro morphology appears to be a more stable trait for species delineation in this genus. In *Abelmoschus*, analysis of 16 genomic regions indicated role of at least three species, *moschatus, tetraphyllus* and *tuberculatus* in the origin of okra. The work accomplished included analyses of 101 samples of 10 *Abelmoschus* species for the loci, *ITS-1, ITS-2, trnL-F, trnL exon, rbcL, rpoC1, psbA-trnH, nad B, rps14 –cobr,* trnC-D, atp F-H, trn E-T, matK, rbcL, rpl intron and nad1. The F_1 hybrids between *A. crinitus* x *A. moschatus* subsp. t*uberosus* with bright red double flowers had good ornamental value and could be propagated through cuttings and perennating tubers. *Abelmoschus enbeepeegearense* J John, Scariah, Nissar, KV Bhat et Yadav, a new species from the low elevation Western Ghats of India comprising Kerala, Karnataka and Tamil Nadu was described. Quality meotic studies were conducted for the first time in the genus *Abelmoschus*, a very difficult genus for cytology due to high polyploidy and very small chromosome sizes. The cross combinations analysed were *A. esculentus* x *A. tuberculatus; A. esculentus* x *A. caillei; A. sagittifolius* x *A. moschatus and A. moschatus* x *A. sagittifolius.*

9.3 Bioinformatics

9.3.1 Development of bioinformatics tools: The following tools were developed

- An in-house designed search algorithm was applied and an efficient Degenerate PCR Primer design



Phyologenetic tree based on rbcL sequences of Indian *Vigna* species collections depicting the relationships among the species

tool was developed for amplification of orthologs from even distantly related species. The tool is available for free public use at: http://192.168.1.5/Dgen/DGEN_tool/index.html.

- A Laboratory repository management tool "LABCOMPANION" was designed and made accessible for free use and distributed among seven ICAR institutes.
- A new and open source operating system Ubuntu, V.12.0, gene prediction tool Augustas and an online NGS data cleaning, sorting & preparation tool-NGSQC Tool kit was downloaded and installed. The tool is being utilized for analysis of pigeonpea raw sequence data sets.
- Two genome sequence assemblers- Velvet and EDena installed in both Windows and UNIX operating systems, are being utilized in pigeonpea data analysis.
- A Genome Data Alignment Tool-MUMmer, was installed and being used for alignment of pigeonpea data and also for detection of SNPs referencing *Glycine max* genome.

9.3.2 Documentation and maintenance of database for NGRC: Online data submission, storage & retrieval forms facilitating user web interface was designed using PHP, .NET and Perl language scripts. Database was populated with g enomic resources of rice, pigeonpea and *Sorghum bicolor*.

9.3.3 Crop Genome data analysis: Pigeonpea data (51,000 contigs of total 191,000 contigs) of sequenced cultivar Asha was downloaded from online public repositories. Data was cleaned, sorted, prepared as per PHRED QC norms for analysis, reassembled employing Next Generation Bioinformatics Software Tools. Putative coding gens were predicted. Comparative genomic analysis with *Glycine max, Medicago trancatulum* and *Phaselous vulgaris* enabled prediction of 104 othologous disease resistance genes. Forty genotypes of Pigeon pea were collected and genomic DNA extracted. Twenty three Primers were designed for predicted putative RGAs. Five predicted disease resistant analogues were PCR amplified in seven pigeon pea genotypes. Cleaning, analysis and assembly of *Phytophthora* raw genome employing Next Generation Bioinformatics tools resulted in prediction of nearly 14,000 effector genes.

9.4 Marker Development for Transgene Detection

9.4.1 Technology for detection of *Bt* brinjal event EE1: Event-specific conventional and real-time PCR assays to characterize the *Bt* brinjal event EE-1 with *cry1Ac* gene, imparting resistance against lepidopteran insects *viz.,* brinjal fruit and shoot borer *Leucinodes orbonalis* and fruit borer *Helicoverpa armigera,* have been developed with a sensitivity of 0.01%. Pentaplex PCR assay targeting amplification of five elements (*cry1Ac* gene/*CaMV* 35S promoter/*nos* terminator/*aadA* marker gene and endogenous *â-fructosidase*) has also been developed.

9.4.2 Molecular testing of imported transgenic planting materials: One thousand one hundred and forty-nine (1149) samples of imported transgenic lines of maize, rice, cotton, cabbage and *Arabidopsis,* were received and tested for the absence of embryogenesis deactivator gene employing primers specific for *cre* recombinase gene. None of these lines showed the presence of terminator gene technology. All of these imported lines were also tested for specific transgene/ promoter/terminator/marker gene using qualitative/ quantitative PCR assays.

9.4.3 Technology for PCR/Real-time PCR based qualitative and quantitative analysis of GM crops:

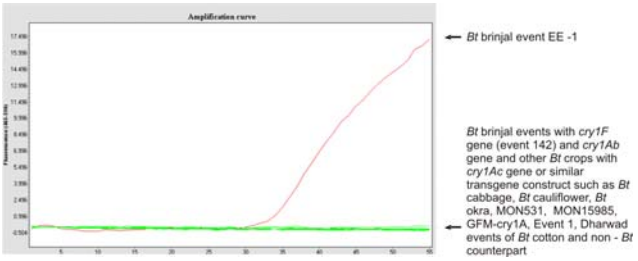
(a) Simplex gene-specific PCR assays were standardized for *2mepsps* gene in ten GM cotton events and *vip3A* gene in five GM maize lines. Event-specific PCR assays were standardized for eight GM maize events.

(b) Multiplex PCR assays have been optimized for the following single and stacked imported GM maize events:
- Pentaplex PCR assay for GM maize event TC1507 (*cry1F, pat* marker gene, *CaMV* 35S promoter, *nos* terminator)
- Triplex event-specific PCR assay for stacked GM maize event MON89034 x NK603 x TC1507
- Triplex event-specific PCR assay for stacked GM maize event MON810 x TC1507

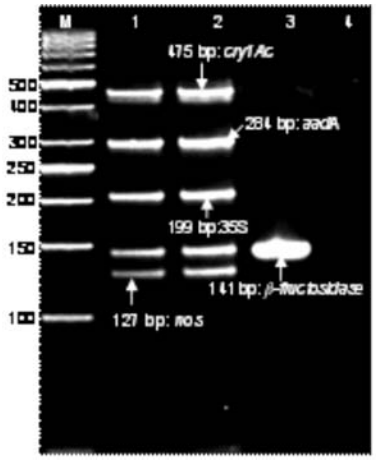
(ii) Quantitative PCR assays

(a) Real-time simplex event-specific PCR assays based on *Taq*Man and SYBR® Green I-chemistry were developed for four (4) GM maize events, *viz.,* GA21, *Bt*11, MIR162 and MON89034

(b) TaqMan-based real-time multiplex PCR protocols have been developed for four (4) GM



Amplification plots to confirm the specificity of event-specific real-time PCR for *Bt* brinjal event EE-1



Pentaplex PCR detection of *Bt* brinjal event EE-1, M: 50 bp ladder; Lanes 1, 2: Samples of *Bt* brinjal; Lane 3: Sample of non-*Bt* brinjal; Lane 4: Water control

maize events, *viz.*, TC1507, NK603, *Bt*176, MON810

(c) **SYBR® Green** based multiplex real-time PCR protocols have been developed for three GM maize events, MON89034, *Bt*176 and *Bt*11

9.4.4 Monitoring of adventitious presence of transgenes in 151 *ex-situ* cotton accessions/ samples: Sixty-nine accessions were collected from National Genebank and 82 samples from different cotton growing regions of Maharashtra were tested for adventitious presence using nonaplex (9-plex) and simplex PCR assays, respectively.

None of the 69 accessions of cotton, conserved *ex-situ* at National Genebank, showed the presence of transgenes of five commercialized *Bt* cotton events. The study of 82 cotton samples is under progress.

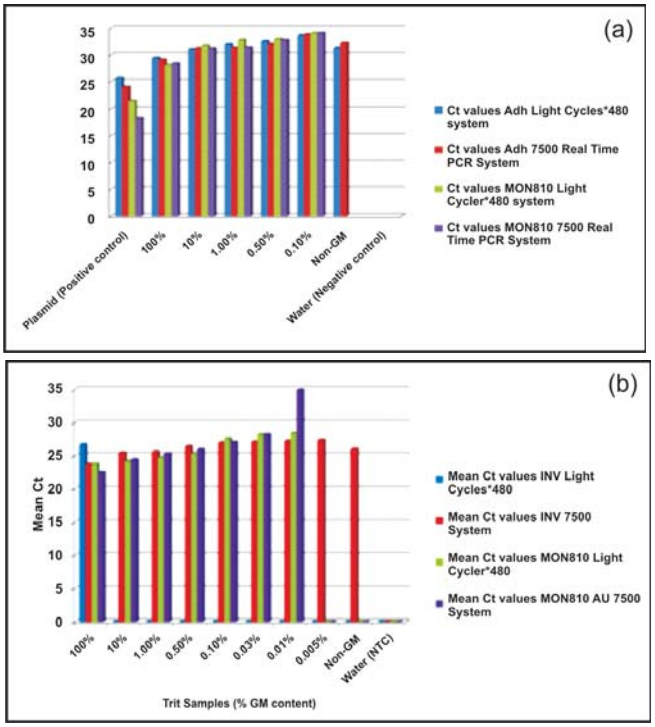
9.4.5 Real-time PCR-based multi-target analytical system for GMO detection: Multi-target real-time PCR system is a high-throughput analytical approach, which can be employed as an efficient screening tool for the unequivocal simultaneous identification of authorized and unauthorized GM events. The system consists of pre-spotted plates containing lyophilized primers and probes for the specific targets allowing the simultaneous detection of a range of GM crops/events. Screening elements, *viz.*, commonly used promoters/ terminators/ markers/ transgenes and specific events of GM maize, rice and cotton along with their species-specific reference genes were selected for designing of two multi-target real-time plates. Primers and probes for these targets were synthesized and PCR protocols for most of these were optimized on real-time PCR.

9.4.6 Comparison of real-time PCR based GM detection assays in different real-time systems: Real-time PCR assays for detection of GM maize event MON810 were performed in the two different real-time systems, *viz.*, Light Cycler®480 and 7500 Real-time PCR systems and the Ct (threshold) values were compared to check the consistency of the GM detection assays. Singleplex PCR using endogenous *Adh1* gene and MON810 event specific primers showed consistent results in both of the real-time systems. In duplex real-time PCR simultaneously targeting MON810 event and endogenous *invertase* gene, the sensitivity of the duplex assay was found higher in 7500 real-time system as per the sensitivity experiments so conducted, whereas individually these targets were amplified with same efficiency in both systems.

9.4.7 Comparative/ proficiency testings and collaborative trial validation studies, at international level:

(a) Proficiency Testings: For international visibility, quality assurance and global harmonization of GM detection, under ISO/IEC 17043:2010, GM detection lab in NBPGR has successfully executed three proficiency testings, for testing the unknown GM contents in the powdered samples of different GM events of maize using Real-time PCR assays organized by:

(i) European Commission Reference Laboratory, Joint Research Centre, Italy (1), under ISO/IEC 17043:2010 accreditation in April 2012, to check the unknown content of GM maize event 59122, in the DNA sample



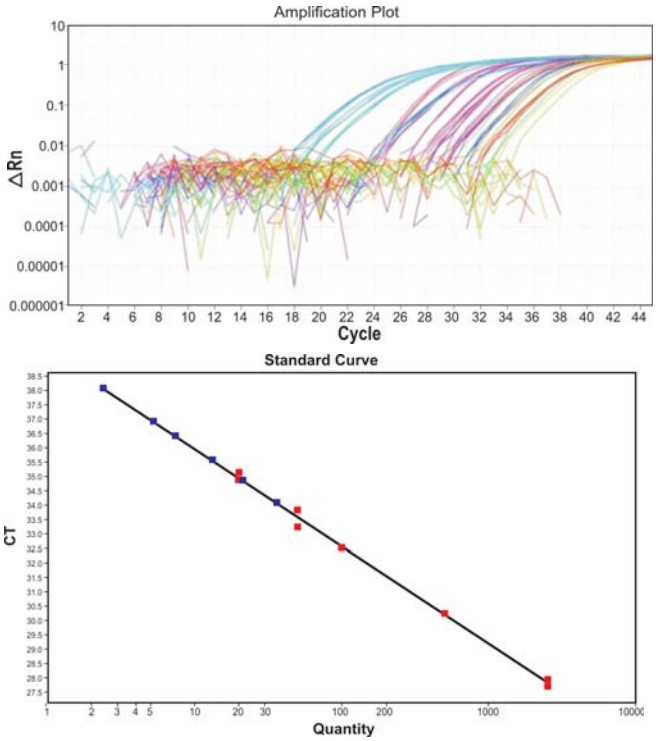
Plot of mean Ct values for real-time PCR performed in two different systems for (a) singleplex PCR assays for *Adh1* and MON810 event; (b) duplex PCR assay simultaneously targeting *invertase* gene and MON810 event

(ii) Grain Inspection, Packers Stockyards Administration (GIPSA), United States, Department of Agriculture (2) in June and November, 2012, to check qualitatively and quantitatively the presence of GM maize events MON810, T25, CBH351, GA21, NK603, *Bt*176, *Bt*11, MON863, TC1507, 3272, MIR604, MON89034, MIR162, MON88017, in six blind samples

All the values obtained in quantitative tests were within the z-score of +2 and -2 (statistical criteria for correct values of unknown sample).

(b) Collaborative trial validation study on GM rice organized by Federal Office of consumer Protection and Food Safety, Germany:

GM Detection Laboratory at NBPGR successfully participated in real- time PCR based validation study on GM rice organized by Federal Office of consumer Protection and Food Safety, Genetic Engineering Department, Mauerstrasse, Berlin, Germany to validate two real-time PCR methods to detect specific DNA sequences, frequently present in insect resistant GM lines.



Amplification curves and standard curves obtained from the *Taq*Man based Real-time PCR assay of positive controls of GM rice and to know the unknown content in test samples, their values were intrapolated on the standard curve

Research Projects under programmes (Code: Title, PI, CoPIs and Associates)

Programme I

PGR/DFP-BUR-DEL-01.00: Development of genomic tools for the enhanced utilization of PGRs (KV Bhat)

PGR/DFP-BUR-DEL-01.01: Development of genomic tools for discovery and validation of genes of economic importance for enhancing the use of plant genetic resources of pulses and oilseeds. **(KV Bhat,** MK Rana, Yasin Jeshima, Rajesh Kumar; J Radhamani; M Latha; MA Nizar; Ranbir Singh and Mohar Singh)

PGR/DFP-BUR-DEL-01.02: Development of genomic tools for enhanced utilization of fiber and forage crops. (**MK Rana**, Amit Kumar Singh, TK Mondal; JC Rana)

PGR/DFP-BUR-DEL-01.03: Development of genomic tools for enhanced utilization of cereal and millets. **(L Arya**, M. Verma, Chet Ram, M Yadav, Sundeep Kumar, D Saha, TK Mondal, Amit Kumar Singh; BS Phogat, Sangita Yadav; NK Dwivedi, JC Rana; S Pandrawada and Firoze Hussain)

PGR/DFP-BUR-DEL-01.04: Development of genomic tools for enhanced utilization of cucurbitaceous crops. **(M Verma**, L Arya, Chet Ram, D Saha, Monendra Grover; Rakesh Bharadwaj)

PGR/DFP-BUR-DEL-01.05: Development of genomic tools for enhanced utilization of medicinal and aromatic plants. **(R Singh**, Amit Kumar Singh, S Marla, Sundeep Kumar; NS Pawar, A Raina, and Ashok Kumar)

PGR/DFP-BUR-DEL-01.06: Development of genomic tools for enhanced utilization of under-utilized crops. **(S Archak**, A B Gaikwad; AK Trivedi(Bhowali); JC Rana(Shimla); and NK Dwevedi upto 08.02.2012) and Om Vir Singh (wef 09.02.2012))

PGR/DFP-BUR-DEL-01.07: Development of genomic tools for enhanced utilization of horticultural crops. (**AB Gaikwad,** S Archak; KS Negi; and Joseph John)

Programme II

PGR/DFP-BUR-DEL-02.00: Establishment and maintenance of National Genomic Resources Repository.(Sunil Archak)

PGR/DFP-BUR-DEL-02.01: Establishment and maintenance of National Genomic Resources Repository.(**S Archak,** KV Bhat, GJ Randhawa, M Yadav, AB Gaikwad, MK Rana, Rakesh Singh, M Verma, Lalit Arya, Sundeep Kumar, TK Mandal, D Saha, Rajkumar, Rajesh Kumar, Amit Kumar Singh, R Parimalan, Chet Ram, Yasin Jeshima and R Chaudhury)

PGR/DFP-BUR-DEL-02.02: Documentation and maintenance of data base for National Genomic Resources Repository. **(Soma S Marla,** Madhu Bala, Monendra Grover, and Dayashankar)

Programme III

PGR/DFP-BUR-DEL-03.00: Development of diagnostics for transgene detection and biosafety assessment in crop plants. (GJ Randhawa)

PGR/DFP-BUR-DEL-03.01: Molecular diagnosis of GM crops. (**GJ Randhawa,** S Archak and R Parimalan).

PGR/DFP-BUR-DEL-03.02: Screening ex-situ germplasm collections for adventitious presence of transgenes. (**GJ Randhawa,** S Archak and R Parimalan)

Programme IV

PGR/DFP-BUR-DEL-04.00: Exploitation of molecular genetic tools for species delineation and genetic erosion studies in agri-horticultural crops (MC Yadav)

PGR/DFP-BUR-DEL-04.01: Development of DNA bar-codes for identification of wild relatives and molecular phylogeny in important crops. **(MC Yadav**, Rakesh Singh, S Rajkumar, K Yasin Jeshima, and D R Pani)

PGR/DFP-BUR-DEL-04.02: Monitoring temporal variation in genetic diversity for devising effective PGR management strategies in safflower. **(S Rajkumar,** MC Yadav, K Yasin Jeshima; J Radhamani and M A Nizar)

Externally funded Projects

020-ICAR-DFC-KVB-06 Application of microorganisms in agriculture and allied sectors (AMAAS) (**KV Bhat**)

027-TMC-MMI-DFC-MR-07 Molecular characterization of cotton germplasm Technology Mission on Cotton – Mini Mission I (**MK Rana**)

033-NOVODB-DFC-KVB-07 DNA fingerprinting and molecular characterization of *Jatropha* germplasm collected from diverse agroclimatic zones of India (**KV Bhat**)

038-NAIP-DFC-KVB-08 Molecular tools for exploitation of heterosis, yield and oil quality in *Sesame* (**KV Bhat**)

044-NAIP-DFC-KVB-08 Biosystematics of the Genera *Vigna, Cucumis* and *Abelmoschus* (**KV Bhat)**

055-NAIP-DFC-KVB-09 Prospecting of genes and allele mining for abiotic stress tolerance (**KV Bhat**)

056-ICAR(NPTC)-NRCF-RS-09 Rationalisation of selected set of rice collections originating from major areas of diversity and allele mining for biotic, abiotic and quality traits using molecular markers. (**R Singh**)

057-DBT-GCD-KS-09 Establishment of National Rice Resource Database. (**R Singh** (Co-PI)

063-NAIP-DFC-SM-10 Establishment of National Agricultural Bioinformatics Grid (**S Marla**; M Grover; S Archak (CO-PIs))

067-DBT-DFC-GJR-011 Multi-target System for GM detection and quantification in GM food crops (**GJ Randhawa**)

070-DST-DFC-GJR-011 Novel cost-effective methods for GMO detection Indo–Slovenian Inter-Governmental Programme of Cooperation in Science and Technology (**GJ Randhawa**)

10. REGIONAL STATION, AKOLA

Summary: Two exploration and collection missions were undertaken, one from the Melghat regions of Maharashtra for collection of millets, small millets and their wild relatives and another from Eastern Ghats of Andhra Pradesh for *Cucumis* and *Abelmoschus* species. Collected a total of 111 accessions of germplasm belonging to ten genera and 17 species. A total of 3,615 accessions of germplasm were characterized during 2012, out of which 388 accessions during *Kharif* 2011, 1,041 accessions during *Rabi* 2011-12 and 2,186 accessions during *Kharif* 2012. Regenerated and multiplied 2,366 accessions of germplasm for LTS / MTS during *Kharif* 2012. These include sesame (1,175) and horse gram (1,191) accessions. A total of 1,542 accessions of germplasm comprising 49 accessions of finger millet, 801 accessions of Sesame and 692 accessions of pigeonpea were multiplied and sent for long term storage in the National Genebank at NBPGR, New Delhi. In addition, 65 accessions of collected germplasm comprising 45 accessions of rice, 11 accessions of *Oryza nivara* and nine accessions of *O. rufipogon* were also conserved in the LTS of the National Genebank. A total of 594 accessions of germplasm of various crops/ species were supplied to 26 indenters from various R & D organizations within the country for their research and crop improvement programmes. A total of 19,849 accessions of germplasm comprising millets (1,094), pulses (4,844), vegetables (2,120), oilseeds (10,002), wild relatives of crop plants (630), underutilized crops (1,155) and others (4) are being maintained in the medium term storage module under controlled conditions at 7° C.

10.1 Plant Exploration and Germplasm Collection

10.1.1 Exploration and collection of millets and their wild relatives from Melghat areas: Millet and small millet species are grown by the primitive aboriginal tribes mainly by Korku and Gond in the Melghat region. Melghat constitute the south-western Satpura mountain ranges and is located on the northern portion of the Amravati district of Maharashtra. An exploration was undertaken from October-November, 2010 to capture the variability exist in the millets, small millet and their wild relatives. 73 accessions of millet and small millet representing twelve species of Poaceae were collected from 26 collection sites. During the exploration, cultivated millet species collected were barnyard millet (15), little millet (13), kodo millet (9), finger millet (7), sorgum (5), pearl millet (5) and foxtail millet (4). The wild relatives includes *Echinochloa colona* (7), *Eleusine indica* (3), *Setaria verticillata* (2), *Setaria glauca* (2) and *Echinochloa crus-galli* (1). Inter and intra-specific variation was observed among the collected species.

10.1.2 Exploration and germplasm collection of wild species of *Abelmoschus* and *Cucumis* from Eastern Ghats of Andhra Pradesh: As per the National Exploration plan for the year 2012-13, a seven day's exploration programme was undertaken in December 2012 to the Eastern Ghats of Andhra Pradesh in collaboration with the IIHR, Bengaluru for the collection of wild species of *Abelmoschus* and *Cucumis*. A total of 38 accessions of germplasm comprising 22 accessions in three species of *Cucumis,* 13 accessions of *Abelmoschus ficulneus* and three accessions in two species of *Sesamum* were collected during the mission.

10.2 Characterization of Germplasm

A total of 3,615 accessions of germplasm were characterized during 2012, out of which 388 accessions during *Kharif* 2011, 1,041 accessions during *Rabi* 2011-12 and 2,186 accessions during *Kharif* 2012.

Ear head variability in traditional sorghum landraces collected from Melghat Biosphere Reserve areas of Maharashtra

Fruit variability in *Cucumis* spp. germplasm collected from Eastern Ghats of Andhra Pradesh

Panicle variability in barnyard millet germplasm (*Kharif* 2012

Table - 1: Crop-wise accessions characterized during 2012

Season/ crop	No of Accns./ Design	Checks	Traits studied
***Kharif* 2011-12**			
Castor	288 (ABD)	48-1 and DCS-9	Five qualitative and six quantitative
Winged bean	100 (ABD)	AKWB-1	Ten qualitative and nine quantitative
***Rabi* 2011-12**			
Linseed	835 (ABD)	Kiran, Garima, H-local	Eight qualitative and six quantitative
Linseed trial	51 (RBD)	Kiran, Garima, H-local	Eight qualitative and six quantitative
Safflower	55 (RBD)	Bhima, A-1, AKS-207	Nine qualitative and seven quantitative traits
Grain Amaranth	100 (ABD)	Suvarna, GA-2, BGA-2	Nine qualitative and 11 quantitative traits
***Kharif* 2012**			
Foxtail millet	50 (RBD)	Lepakshi, Krisnadevaraya, Narasimharaya, Prasad	Ten qualitative and twelve quantitative
Finger millet	50 (RBD)	BR-708,VL-149, HR-374,GPU-28	Eight qualitative and ten quantitative
Barnyard millet	50 (RBD)	KL-1, TNAU-101, VL-29	Eight qualitative and eleven quantitative
Little millet	50 (RBD)	JK-8	Eight qualitative and ten quantitative
Niger	100 (RBD)	JNC-6, CHH-1, CHH-2	Seven qualitative and eleven quantitative
Pigeonpea	1786 (ABD)	AKT 8811, PKV-Tara, ICPL 87119	14 qualitative and five quantitative
Winged bean	100 (ABD)	AKWB-1	10 qualitative and nine quantitative traits
Total	**3615**		

10.2.1 Characterization of castor germplasm (*Kharif* 2011-12): A total of 288 accessions of castor germplasm were grown in an augmented design in 3.0 metre row length and two numbers of rows per accession. Checks used were 48-1 and DCS-9. The qualitative and quantitative traits recorded were stem length, number of nodes on main stem, stem colour, effective raceme length, days to 50% flowering (primary raceme), days to maturity (secondary raceme), seed colour, seed length, seed width and 100 seed weight.

Traditional landraces of sorghum and pearl millet grown together by tribals in backyards at Melghat Biosphere Reserve areas of Maharashtra

ICP 11986- A tall less branching, late flowering accession of pigeonpea with purple stem and broad leaves

ICP 15175 - Pigeonpea accession with broad leaves and dark purple pods

10.2.2 Linseed germplasm and linseed trial *(Rabi* 2011-12): A total of 835 accessions of linseed germplasm were grown in a randomized block design in 3.0 metre row length with two rows each per accession and a row gap of 60 cm. Checks used were Kiran, Garima and H-local. Eight qualitative and six quantitative traits were recorded.

Fifty one accessions of linseed germplasm were grown in a randomized block design in 3 m row length with two rows each per accession and a row gap of 60 cm. Checks used were Kiran, Garima and H-local. Eight qualitative and six quantitative traits were recorded (Table 1,2) and promising accessions recorded.

Table - 2: Range, mean and promising accessions identified in Linseed germplasm

Traits	Range	Mean	Value of superior accessions	Check value
Linseed germplasm (835 accns.)				
Number of capsules/plant	88-107	97.14	EC541222 (92.60) IC53296 (89.40) EC41687 (81.40)	Garima (67.80)
Yield per plant (g)	1.0-6.7	2.78	NC60434 (7.65) IC345490 (6.70) IC424872 (6.42)	Garima (2.29)
Linseed trial (51 accns.)				
	Minimum	**Maximum**	**Mean**	**CV (%)**
Plant height (cm)	41.56	61.01	51.93	8.16
Days to 50 % flowering	56.0	65.5	59.75	3.79
Days to 80 % maturity	89	102	94.76	3.02
Number of capsules/plant	21.65	41.7	29.86	15.16
100 seed weight (g)	0.330	0.635	0.48	18.89
Yield per plant (g)	1.20	7.79	3.15	39.94

10.2.3 Grain Amaranth: A total of 100 accessions of grain amaranth germplasm were grown in *Rabi* 2011-12 in augmented design using Suvarna, GA-2 and BGA-2 as check material. Nine qualitative and 11 quantitative traits were recorded. The qualitative traits studied include early plant vigour, plant growth habit, leaf colour, inflorescence colour, inflorescence compactness, stem colour, stem surface, inflorescence shape and inflorescence spininess. The quantitative traits include plant height (cm), leaf length (cm), petiole length (cm), stem thickness (mm), number of branches per plant, inflorescence length (cm), lateral spikelet length (cm), days to 50% flowering, days to maturity, 1,000-seed weight (g) and seed yield per plant (g).

ICP 15180 - A promising accession of pigeon pea for more number of pods

Leaf variability in pigeon pea germplasm (*Kharif* 2012)

Pod variability in pigeon pea germplasm (*Kharif* 2012)

10.2.4 *Kharif* 2012: A total of 300 accessions of germplasm comprising 50 accessions each of foxtail millet, little millet, finger millet and barnyard millet and 100 accessions of niger germplasm were characterized during *Kharif* 2012. Standard checks were used. Crop-wise range, mean, superior accessions identified are mentioned (Table-3).

Table - 3: Range, mean and promising accessions identified in *Kharif* 2012

Traits	Range	Mean	Value of superior accessions	Check value
Foxtail millet				
Inflorescence length (cm)	11.0-23.04	16.40	IC22178 (23.04) IC97103 (21.80)	Lepakshi (19.14)
100 seed weight (g)	0.18-0.32	0.27	IC97188 (0.32) IC28444 (0.31)	Krishnadevaraya (0.28) Narasimharaya (0.28)
Yield per plant (g)	4.13-8.48	6.03	IC97185 (8.48) IC97298 (8.10) IC97104 (8.03)	Krishnadevaraya (7.93) Narasimharaya (6.28)
Finger millet				
Finger length (cm)	5.41-10.71	7.29	IC340180 (10.71) IC340116 (10.22) IC340127(9.69)	VL-149 (6.96) HR-374 (6.53)
Productive tillers	4.73-9.66	6.76	IC340127 (9.66) IC50002 (9.63) IC43276A (9.27)	HR-374 (8.4) GPU-28 (7.8)
Yield per plant (g)	2.37-12.17	5.79	IC49974A (12.17)	GPU 28 (10.34)
Barnyard millet				
Basal tillers	2.93-7.87	4.60	IC24848 ((7.87) IC52701 (7.4) IC338896 (7.07)	VL-29 (5.33)
Inflorescence length	10.74-19.19	15.49	IC97034 ((19.19) IC97031 (19.04)	VL-29 (15.49)
100 seed weight (g)	0.17-0.37	0.29	IC326725 (0.37)	KL-I (0.32)
Yield per plant (g)	1.82-6.71	3.80	IC97034 (6.71) IC338960 (6.10) IC97031 (6.010	VL-29 (5.08)
Niger				
Number of primary branches	4.3-8.0	6.0	IC210957 (8.0) IC210945 (7.6) IC210940 (7.47)	CHH-1 (6.17) JNC-6 ((5.77)
100 seed weight (g)	0.29-0.47	0.39	IC210971 ((0.47) IC210970 (0.46)	JNC-6 (0.40) CHH-2 (0.39)
Yield per plant (g)	1.18-5.57	3.59	IC210955 (5.57) IC274631 (5.53) IC210947 (5.47)	JNC-6 (3.71) CHH-2 (3.59)

10.2.5 Screening of okra germplasm: 570 accessions of okra germplasm were screened for jassids and YVMV during *Kharif* 2012 under field condition in the experimental farm of NBPGR Regional Station. The severity of incidence was recorded as per the Minimal Descriptors of Agri-Horticultural Crops (Part-1) published by the NBPGR (2000). Out of 570 accessions 109 accessions exhibited low, 270 accessions intermediate, 183 accessions high and eight accessions very high sign of susceptibility for jassids whereas 209 accessions shown very low or no sign of susceptibility for YVMV (*Yellow vein mosaic virus*).

10.3 Regeneration and Multiplication

Regenerated and multiplied 2,366 accessions of germplasm for LTS / MTS. These include Sesame (1,175) and horse gram (1,191) accessions during *Kharif* 2012.

10.4 Germplasm Conservation

A total of 1,542 accessions of germplasm comprising 49 accessions of finger millet, 801 accessions of sesame and 692 accessions of pigeon pea were multiplied and sent for Long Term Storage in the National Gene Bank at NBPGR, New Delhi. In addition, 65 accessions of collected germplasm comprising 45 accessions of rice, 11 accessions of *Oryza nivara* and nine accessions of *O. rufipogon* were also conserved in the LTS of the National Genebank.

10.5 Germplasm Supply

A total of 594 accessions of germplasm of various crops/ species were supplied to 26 indenters from various R & D organizations within the country for their research and crop improvement programmes.

10.6 Medium Term Storage of Germplasm in the Regional Genebank

A total of 19,849 accessions of germplasm comprising millets (1,094), pulses (4,844), vegetables (2,120), oilseeds (10,002), wild relatives of crop plants (630), underutilized crops (1,155) and others (4) are being maintained in the medium term storage module under controlled conditions at 7^0C.

Research Programme (Code, Title and Programme Leader)

PGR/GEV-BUR-AKO-01.00 Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources in the Central Indian Plains (M Abdul Nizar)

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 pulses (pigeonpea and chickpea), vegetables (okra) and underutilized crops (winged bean and amaranth) (**M Abdul Nizar**, N Dikshit)

PGR/GEV-BUR-AKO-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of oil seeds (sesame, niger, castor, ground nut, safflower, soybean and linseed), millets and small millets (**N Dikshit**, M Abdul Nizar)

11. REGIONAL STATION, BHOWALI

Summary: Three crop-specific explorations and one plant specific tour were undertaken and 124 accessions were collected which include landraces and primitive cultivars of cereals (33), fruits (26), wild relative of crops (51) and *Swertia* spp.(14) from remote areas of Uttarakhand hills and four districts of Sikkim including subdivision of Darjeeling, West Bengal under National Exploration Programme. A total of 61 accessions were received for regeneration, characterization and maintenance. Some of the elite seed samples and live rooted plant material *viz.*horticultural Crops: kiwi (2,516), kagazi nimbu (304), hill lemon (105), malta (203), M. & AP. and WEUPS (Wild Economically Useful Plant Species): rosemary (50,462), sweet basil (25,465), geranium (2,884), lavender (203) were supplied to different farmers/ indentors. A total of 437 accessions were supplied to user scientists in the country and 573 accessions were deposited in National Genebank for conservation.

11.1 Plant Germplasm Exploration and Collection

Total four explorations were undertaken, three from Uttarakhand and one from Sikkim, NEH region of India and a total of 124 different germplasm of peach and pear, wheat and barley, *Allium* spp. and *Swertia* spp. were collected.

11.1.1 Field crops: During June, 2012 crop specific exploration for wheat and barley from districts Champawat and Almora was undertaken. A total of 33 accessions comprising of wheat (26) and barley (07) were collected.

11.1.2 Horticultural crops: During February, 2012, crop specific exploration for peach and pear under NEP from districts Champawat (Lohaghat) and Pithoragarh (Ghat) of Uttarakhand were undertaken. A total of 26 trait specific accessions of peach (12) and pear (14) were collected.

11.1.3 M&AP and wild economically useful plants: During September, 2012, crop specific exploration was carried out in collaboration with NRC Onion and Garlic, Pune (Maharashtra) and ICAR, RC, Sikkim, for *Allium* spp. from four districts of Sikkim including sub Division of Darjeeling, West Bengal. A total of 51 acc. comprising *Allium cepa* (4), *A. sativum* (21), *A. ampeloprasum* (3), *A. ascalonicum* (11), *A. hookerii* (7), *A. tuberosum* (3) and *Allium* spp. (9) - wild (2) were collected.

During October - November, 2012 collection for *Swertia* spp from districts Pithoragarh, Bageshwar, Chamoli and Rudraprayag of Uttarakhand was undertaken. A total of 14 accessions comprising *Swertia alata* (3), *S. chirayita* (1), *S. ciliata* (5), *S. cordata* (2), *S. nervosa* (1), *S. paniculata* (1), *S. tetragona* (1) were collected in collaboration with NBPGR Regional Station, Shimla.

11.1.4 Germplasm enrichment: A total of 61 accessions of different crops were received in including- Ricebean (25) from NBPGR, R/S Umiam, Meghalaya; Ricebean (03) from CSK, HPKV, Department of Organic Agriculture; Ricebean (05) from GBPUA&T, College of Forestry and Hill Agriculture, Hill Campus, Ranichauri, Tehri, Garhwal; Ricebean (02) from NBPGR, R/S Shimla; Chilli - (20) from NBPGR, Pusa Campus, New Delhi and *Allium* spp. (Wild 06) (RS-21, RS-20, KCB-Dunna, AP-Dunna, *A. chinensis*, AKP agrigatum) from Head Exploration Division, NBPGR, Pusa Campus, New Delhi.

11.2 Germplasm Characterization and Evaluation

11.2.1 Germplasm characterization, regeneration and seed multiplication of field crops: The germplasm accessions collected from Kumaon and Garhwal regions of Uttarakhand were grown at Bhowali for characterization, regeneration and multiplication during *Kharif* 2012 and *Rabi* 2011-2012 (Tables 1).

Table 1. Germplasm characterization during *Kharif* 2012

Crop	No. of Acc.	Checks Used
***Kharif* 2012**		
Paddy	65	VL-206, VL-207, VL-208, VL-209, Majehra -7
Finger millet	104	VL-146, VL-149, Pithoragarh local, Almora local

Foxtail	20	KJ-550, Rudraprayag local, DARL/PK 2338, Pithoragarh local
Soybean	173	VLS-02, VLS-21, VLS-47, VLS-54
Rice bean	25	PRR-1, PRR-2, VRS-1, LRB-460
Rice bean trial	15	PRR-1, PRR-2, RBL-6
Total	**402**	
***Rabi* 2011-12**		
Wheat - material received from gene bank (Exotic)	200	VL- 616, VL-738, VL-832, VL-892, VL-907
Wheat – indigenous	41	VL- 616, VL-738, VL-832, VL-892, VL-907
Barley - indigenous	33	VLB-56, VLB-64, VLB-1 & VLB-85
Fenugreek	203	Pant early, C-74, Champawat Local, PEB, Bageshwar Local
Pea (powdery mildew nursery)	50	Harbhajan, Rachana, Selection -18, VL-8, Lincan, Bhowali Local-B
Pea (Kalon) (*Pisum arvense*)	50	Champawat Local, Pithoragarh local, Rudraprayag Local , Uttarkashi Local
Coriander (*Coriandrum sativum*) – Delhi	324	ACR-41, Panipat Mulakot, Kashipur Block-44, Pant Harit-01, Bhowali local
Coriander (*Coriandrum sativum*) – Bhowali	152	Kashipur local, Panipat Mulakot, Kashipur Block-44, Pant Harit- 01
Rapeseed mustard	30	Itallian Rai, PT-303, Kranti, T-9, Pusa Jai kishan, Rajat
Total	**1,083**	

Table 2. Multiplication for Long Term Storage (LTS) in National Genebank during *Kharif* 2012 and *Rabi* 2012-13

Crop	No. of acc.
***Kharif* 2012**	
French bean	12
Paddy	48
***Rabi* 2012-13**	
Pea (*Pisum sativum* var. *sativum*)	32
Kayon (*Pisum sativum* var. *arvense*)	39
Garlic	121
Total	**252**

11.2.2 Evaluation under All India Co-ordinated Trial: All India Co-ordinated trial of Initial Varietal Trial, Advance Varietal Trial I & II–Hills of rice bean consisting of 15 varieties was conducted. Seeds (200 g) of IC563980, IC141077 and LRB-460 was supplied to NBPGR, R/S Phagli, Shimla; NBPGR, R/S Umiam, Shillong, Meghalaya; Head, Crop Improvement Division, VPKAS, Almora, 263601, Uttarakhand; Department of Organic Agriculture, CSK, HPKV, Palampur,H.P.; College of Forestry & Hill Agriculture, Department of Plant Breeding, GBPUA&T, Hill Campus, Ranichauri, Tehri Garhwal, Uttarakhand for IVT – II.

Table 3. Germplasm evaluation and characterization during *Rabi* 2012-13

Crop	No. of Acc.	Date of Sowing	Checks Used
Wheat	229	05.11.2012	VL- 616, VL-892, VL-738, VL-832 & VL-907
Barley	22	05.11.2012	VLB-1, VLB-56, VLB-64 & VLB-85
Coriander	345	08.11.2012	ACR-41, Pant Harit – 01, Panipat, Mulakot, Kashipur Block – 44 & Kashipur Local
Mustard	30	19.11.2012	RH-30, Kranti, PT-303, T-09, Pusa Kisan & Rajat
Fenugreek	167	18.11.2012	PEB, Pant Early, C-74, Pant Ragini & Bageshwar Local
Garlic	39	18.10.2012	—-
Total	**832**		

11.3 Germplasm Characterization, Regeneration and Seed Multiplication of Horticultural Crops

11.3.1 Fruit crops germplasm characterization and evaluation: Six fruit crops viz., *kagazi nimbu, malta,* kiwi, peach, pear and plum were evaluated with different descriptors. Range of variation and promising accessions were identified.

11.3.2 Multiplication of vegetable for Long Term Storage (LTS) in National Genebank during *Kharif* 2012: A total of 30 acc. of chilli were multiplied for submission to LTS.

11.3.3 Germplasm characterization, regeneration and seed multiplication of the M&AP and wild economically useful plants

11.3.3.1 Preliminary evaluation of *Allium* spp.: A total of 41 acc. of *Allium* spp. (wild only) and garlic 123 acc. with the checks Lohit, Bhowali local & VGP-S/ VLG-1(C) are being maintained and evaluated in Field Genebank.

11.3.2 M&AP characterization and evaluation: *Ocimum* spp. were evaluated with different descriptors. Range of variation and promising accessions were identified.

11.4. Germplasm Conservation

11.4.1 Conservation of field crops germplasm: A total of 12,617 accessions of germplasm have been maintained in MTS of NBPGR, R/S Bhowali. The details are as follows cereals (4,250), pseudocereals (604), millets and minor millets (554), pulses (3,938), oil seeds (578), vegetables (398), spices and condiments (1,662), medicinal and aromatic plants (268), wild relatives of crops (356), ornamental crops (22).

11.4.2 Conservation of horticultural crops: fruits- 338 acc. [(*Prunus amygdalus* (03, *Emblica officinalis* (04), *Pyrus malus* (23), *Pyrus armeniaca* (14), *Aegle marmelos* (01), *Prunus avium* (03), *Citrus* spp. (89) – {*C.jambhiri* (06), *C. pseudolemon* (04), *C. decumana* (02), *C. sinensis* (29), *Poncirus trifoliata* (01), *C. aurantifolia* (23), *C. medica* (14), *C. reticulata* (06), *C. regulosa* (01), *C. limetta* (01), *C. grandis* (02)}, *Cotoneaster microphylla* (01), *Ficus carica* (04), *Elaegnus latifolia* (02), *Vitis vinifera* (04), *Vitis jacquomontii* (01), *Corylus avellana* (01), *Diospyrus kaki* (03), *Averrhoa carambola* (01), *Myrica esculenta* (01), *Carissa carandus* (02), *Actinidia chinensis* (07), *Cordia mixa* (01), *Eriobotrya japonica* (01), *Morus serrata* (01), *Passiflora edulis* (01), *Prunus persica* (18), *Pyrus communis* (18), *Prunus domestica* (06), *Punica granatum* (10), *Rubus ellipticus* (18), *Fragaria vesca* (79) & *Juglans regia* (21)]; vegetables 1225 acc. (*Capsicum annuum*-1225 acc.); ornamental crops 109 acc. (*Aralia elegantissima* (01), *Calendula officinalis* (01), *Camellia japonica* (01), *Centaurea cyanus* (02), *Cinnamonum* sp. (01), *Codonopsis convolvulacea* (01), *Dahlia sp.* (19), *Delphinium ajacis* (02), *Delphinium stapliosum* (01), *Gladiolus sp.* (31), *Glardia sp.* (02), *Gompherina sp.* (01), *Helichrysum bracteatum* (01), *Hydrangea paniculata* (01), *Juniperus* sp. (01), *Lagerstroemia indica* (01), *Narcissus sp.* (01), *Petunia hybrida* (01), *Phlox paniculata* (02), *Phlox sp.* (01), *Polienthes tuberose* (01), *Spiraea arcuata* (01), *Spiraea canescens* (01), *Tagetes minuta* (01), *Tagetes spp.* (29), *Trapaeolum majus* (01), *Viola tricolor* (02), *Wisteria sinensis* (01)) are maintained in MTS, greenhouse (plants in 2,500 pots and 7,000 polythene packets); /Field Genebank/MTS at R/S Bhowali.

11.4.3 Conservation of medicinal and aromatic Plants: A total of 445 accessions (indigenous -304 acc. + exotic-141 acc.: vegetatively propagated - 125; seed producing- 320) comprising of 260 species belonging to 153 genera of 37 families have been conserved in the MTS/ Field Genebank/ herbal garden of the station.

11.4.3.1 Maintenance of arborescent plants: A total of 190 accessions of arborescent plants belonging to 150 species (92 genera of 50 families of both exotic and indigenous origin) have been maintained in the station's Biodiversity Botanical Garden.

11.4.3.2 Maintenance of bamboosetum: A total of 41 accessions comprising of 18 species belonging to seven genera are maintained in Field Genebank.

11.4.3.3 Maintenance of temperate forage grasses: A total of 54 accessions of temperate forage grasses have been maintained in the MTS/ Field Genebank.

11.5. Germplasm Supply

11.5.1. LTS supply: A total of 573 accessions were multiplied and send to Long Term Storage at Headquarters.

11.5.2. Supplied under MTA: A total of 437 accessions of different crops viz., finger millet (15) to Gene Campaign, Regional Station Orakhan, Post. Natuakhan, Distt. Nainital, Uttarakhand; Strawberry (66 acc.) to IIHR, Bangalore, Karnataka; *Allium spp.* (24 acc.) to Department of Vegetable Crop, PAU, Ludhiana, Punjab; Leaf material of *Allium* spp. (08), Seed material of *Allium* spp. (03) and Live material of *Allium* spp. (04) to Department of Molecular Laboratory, NBRI, Lucknow; Pomegranate germplasm (07) to National Research Centre on Pomegranate, Solapur, *Hedychium spicatum* (100), *Viola serpense* (10), *Origanum vulgare* (100), *Valeriana jatamansi* (100) to Department of Chemistry, Kumaun University, Uttarakhand.

11.6. Externally Funded Projects

11.6.1. Management and Multiplication of Plant Genetic Resources of Kiwi and *Kagazi Nimbu* under Horticultural Mission for North East and Himalayan States, Mini Mission I (08/ICAR/BHW-SKV-04)

Regeneration/multiplication/nursery management: Kiwi (EC64093, EC24672, EC64094, EC64090, EC137263, EC64092) and *Uttaranchali Kagzi Nimbu* (*Citrus aurantifolia*) IC319045 were regenerated through cuttings, grafting and other vegetative means and through seeds for onward supply to different indenters.

Distribution of quality planting material: Quality planting material of grafted Kiwi plants was distributed in the ratio of 1:4 male and female plants respectively. A total of 304 plants of *Kagazi nimbu* and 2,516 plants of kiwi fruit were supplied to VPKAS Almora and among farmers of Uttarakhand.

Distribution of quality planting material from adopted farmer's field: Technical know-how for propagating kiwi fruits (grafting and cuttings) was provided from time-to-time to selected farmers under HMNEH MM-I project at different places in Uttarakhand. The plants raised under technical guidance of HMNEH MM-I project of NBPGR Regional Station, Bhowali and distributed at their own level were 21,700 viz., Hill lemon (2,025), kiwi (5,425), *Malta* (3,720), Peach (4,400), Plum (500), Walnut (700) and Uttaranchali *Kagazi Nimbu* (4,930).

11.6.2. Establishment of Mother Block for Bud wood Production of Citrus and Kiwi fruit under Horticultural Mission for North East and Himalayan States, Mini Mission I

Five plants each of five species of citrus (viz., *C. aurantifolia* – IC319045, *C. jambhiri*-IC319047, *C. medica*-IC318908, *C. reticulata* – IC319065 and *C. sinensis*-IC319043) and Kiwi fruit (Female varieties: Abbott-EC64094, Allison-EC24672, Bruno-EC64090, Monty-EC137263 and Hayward-EC64093 Male variety: Tomuri-EC264092) were planted in new block to established mother block for bud wood production of citrus and kiwi fruit.

11.6.3. Studies on relationship between ecogeography of the chemotypic variation of nine important but highly threatened medicinal plant species and prospects of their cultivation (041/NAIP/BHD/KSN/08)

Studies on relationship between ecogeography of the chemotypic variation of nine important but highly threatened medicinal plant species and prospects of their cultivation" under NAIP-IV was successfully completed on June 30, 2012. Under this project following four proposals were submitted for plant germplasm registration:

11.6.4. Biosystematics of the genera *Vigna, Cucumis* and *Abelmoschus* (044/NAIP/KVB/08)

Biosystematics of the genera *Vigna, Cucumis* and *Abelmoschus* (044/NAIP/KVB/08) ended on March 31, 2012. Seeds of crosses F_2 *Cucumis sativus* var. *hardwickii* (female) X male (*C. sativus*) – 4 acc.; Cross F_1 female (*C. sativus* var. *hardwickii*) X male (*C. sativus*) – 03 acc. and crosses – Self, female (Cultivated) X Wild Cucumber – 03 acc. submitted to CPI, of the said project.

11.6.5. Popularization of Geranium, Lavender and Rosemary among Local Farming Communities of Uttarakhand under Horticultural Mission for North East and Himalayan States, Mini Mission I

Crop Name/ Botanical Name and Indentor No.	Criteria for Registration
Spiked ginger Lily, *Hedychium spicatum* Buch. Ham ex. J.E. Smith, Zingiberaceae, NKSK – 07/ IC573208 submitted on November 03, 2011	High content of 1, 8 Cineole: 58-15%
Indian Valerian, *Valeriana jatamansi* Jones Valerianaceae, NKSK-03/ IC573206 submitted on March 01, 2012	High content of Maaliol : 55.77%
Oregano, *Origanum vulgare* L., NKO-68/ IC589087 submitted on June 13, 2012	High percentage of phenolic compound: Thymol 85.87% and high yield of essential 2.07%
Oregano, *Origanum vulgare* L., MMBO-3055/ IC589079 submitted on December 04, 2012	High percentage of Carcacrol (63.06%)

(I) Regeneration/Multiplication/Nursery management: Geranium (IC236494 cv Kelkar/ Egyptian, NIC23413 cv Almoria, cv Cimpawan); Lavender (IC212822 cv Carlova, IC273870, cv Sher-E-Kashmir, IC449508, IC449514, IC449512); Rosemary (NIC23416 cv French, IC449513 cv Italian, IC334572) were regenerated through cuttings and other vegetative means for onward supply to different indenters.

(II) Distribution of elite planting material/ germplasm

i. From NBPGR Regional Station, Bhowali, Nainital, Uttarakhand: A total of 53,549 rooted plants/ cuttings of Geranium–2,884, Lavender–203 nos., Rosemary–50,462 nos. were distributed to different indentors and farmers.

ii. From farmer's field: Two progressive farmers were selected and identified for nucleus nursery of Geranium, Lavender and Rosemary. Another three had already started producing the nucleus planting material of three crops Gernaium, Rosmary and Lavender and distributed 45,000 rooted plants to nearby areas. Technical know-how for regeneration/multiplication/nursery management was provided time-to-time to selected farmer's under HMNEH MM-I at different places in district Almora and Nainital, Uttarakhand.

Programme (Code, Title and Programme Leader)

PGR/PGC-BHO-01.00- Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation and Documentation of Genetic Resources of the Northern Himalayas and Adjoining Plains (**SK Verma**).

Projects (PI, Co-PIs and Associates)

PGR/PGC-BHO-01.01- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of field crops with emphasis on ethno botanical aspects (**KS Negi**, SK Verma, A K Trivedi, P S Mehta)

PGR/PGC-BHO-01.02- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of temperate horticultural crops (**SK Verma**, KS Negi, and Sandhya Gupta).

PGR/PGC-BHO-01.03- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species (**KS Negi**, AK Trivedi, SK Verma and Archana Raina.

12. BASE CENTRE, CUTTACK

Summary: Three explorations were undertaken and a total of 174 accessions comprising cultivated rice (submergence tolerant-124); wild *Oryza* species (34); cotton (14); *Ocimum citriodorum* (1) and *Coix-lacryma-jobi* (1) were collected from 95 collection sites covering Odisha, Jharkhand and Tripura. The significant collections among rice germplasm include submergence tolerant land races (*Baliadadha*, *Khoda, Kakudimanji, Khadara, Champeisali, Putia, Bhutia*), *Oryza rufipogon* and *O. nivara* from higher altitude region (360m) of Jharkhand, coloured cotton (*Gossypium arboreum*) and perennial cotton (*G. barbadense*) from Tripura.

Out of 3,197 accession of various crops grown for characterization, a set of 2,123 accession comprising cultivated rice (1,832), green gram (21), black gram (23), *Ocimum* species (47), *Mucuna pruriens* (12), wild *Oryza* species (168) and other wild relatives of crops (20) were characterized for various agro-morphological traits. Under germplasm evaluation activity, a set of 20 accessions of cultivated rice viz. IC46918, 53724, 49673, 46852, 51976, 5911, 49676, 67764, 49419, 46935, 9996, 46502, 62496, 75428, 49724, 46793, 49776, 46696, 46510, 46488 were identified as highly tolerant against leaf blast. Another set of 14 accessions of rice germplasm was identified as tolerant both for survival elongation percentage in deep water condition as compared with best check genotypes (Swarna *sub*-1 and Jalamagna).

A total 3,265 accession comprising cultivated rice, wild *Oryza* species, black gram, green gram, sesame, *Trichosanthes*, tubers, *Ocimum* spp., *Mucuna pruriens* and other medicinal plants were multiplied for conservation in LTS. A total of 3,405 accession comprising cultivated rice, wild *Oryza* species, medicinal and aromatic plants, wild cucurbits, wild relatives of other vegetable crops, tuber/aroid crops, economic plants of agro-forestry and horticultural crops are being maintained in the experimental field and FGB of the centre. 170 herbarium specimens collected from Mizoram, Similipal and coastal districts of Odisha were added to the herbarium of the centre. Besides, the PGR of Similipal Biosphere Reserve comprising a total of 1,254 species have been documented.

12.1 Exploration and Germplasm Collection

During the reporting period three exploration missions were undertaken and a total of 174 acc comprising submergence tolerant rice landraces (124), wild *Oryza* species (34), cotton (14), *Ocimum citriodorum* (01) and *Coix lacryma-jobi* (01) was collected from Odisha, Jharkhand and Tripura. The exploration wise details are given in table-1

Table-1: Details of exploration and germplasm collection during 2012.

Crops/Species	Areas	Collaboration	Collection sites	Period of collection	No. of spp.	No. of acc
Wild *Oryza* species	Lohardaga, Latehar, Palamu & Garhwa (Jharkhand)	CRRI, Cuttack	29	November 1 -10 2012	2	34
Cotton	West Tripura, Gomati, Khowai & Dhalai (Tripura)	CICR, Nagpur	14	November 26 to December 5, 2012	3	15
Submergence tolerant rice landraces & *Coix*	Balasore, Bhadrak, Jajpur, Puri, Kendrapara, Jagatsinghpur & Cuttack (Odisha)	CRRI, Cuttack	52	December., 28 2012 to January., 5, 2013	2	125
		TOTAL	**95**		**6**	**174**

12.1.1 Collection of wild *Oryza* species from Jharkhand: The exploration for collection of wild *Oryza* species from Lohardaga, Latehar, Palamu and Garhwa districts of Jharkhand was undertaken in collaboration with CRRI, Cuttack during November, 2012. A total of 34 acc comprising *O. rufipogon* (23) and *O. nivara* (11) was collected from 29 collection sites covering 21 blocks. The district wise collections include 6 acc from Lohardaga (4 blocks), 7 acc from Latehar (4 blocks), 11 acc from Palamu (7 blocks) and 10 acc from Garhwa (6 blocks). It was observed that wild *Oryza* species were available up to an elevation range of 400m above mean sea level. In Jharkhand, frequency of occurrence of *O. rufipogon* was more than that of *O. nivara* and the districts like Palamu and Garhwa are rich in wild rice genetic resources than Lohardaga and Latehar. Variability with respect to habitat, maturity duration, spikelet, panicle type and awn characteristics was recorded during the exploration.

12.1.2 Collection of submergence tolerant rice germplasm from Odisha: The exploration programme for collection of known landraces of submergence tolerant rice germplasm was undertaken in collaboration with CRRI, Cuttack during 28.12.12 to 05.01.13. In all, 125 acc comprising rice (124) and coix (1) were collected from 52 collection sites covering 22 blocks in seven districts of Odisha. The district wise collections made include Balasore-30, Cuttack-17, Jagatsinghpur-4, Jajpur-13, Kendarpara-19, Nayagarh-9, Puri-33. Random and bulk sampling method was followed for the collection of rice germplasm mainly from farmer's field, threshing yards and farm stores representing named landraces for submergence/flood tolerance. Emphasis was given to explore and collect each named landrace from diverse agro climatic conditions, rainfed lowlaying and flood prone areas. Information was collected about the germplasm with respect to nature and extent of submergence tolerance. The collected samples along with the passport data, GPS information and photographs were recorded and deposited for LTS at NBPGR (H.Q), New Delhi.

12.1.3 Collection of cotton germplasm from Tripura: The exploration mission was undertaken for collection of cotton germplasm in NEH regions from Tripura in collaboration with CICR, Nagpur during 26th Nov. to 5th Dec., 2012. A total of 15 acc comprising landraces of *Gossypium arboreum* (10) & perennial types of *G. barbadense* (4) and *Ocimum citriodorum* (1) was collected from 14 collection sites of 4 districts such as west Tripura, Gomati, Khowai and Dhalai.

Specific traits/morphological variability observed:

(i) ***Gossypium arboreum:*** Two accessions of (RCM/PM-MS/08 and /09) collected from jhum areas of Tripura represented coloured cotton (with brown and light brown lints). Wide range of variability with respect to boll length, boll weight, seed number/locule/boll, seed/lint etc was recorded, representing derivatives of race 'cernuum' and 'burmanicum'. The range of boll size reaches up to 13 - 15 cm in length (RCM/PM-MS/03 and /12). The flowers were yellow with purple centre and the fibres were short and coarse in nature. The brown linted types are rarely seen.

(ii) ***G. barbadense:*** Perennial cotton germplasm of 3-6 years old were collected from homesteads, village yards and valleys. The plant varies from 5-12 ft height; deeply palmi-parted leaves with oblong lobes; petals yellow, 6-8 cm long without purple centre; capsules beaked; long and fine fibres and naked separate seeded (not fused).

12.2 Germplasm Characterization and Evaluation

A total of 3,197 accessions comprising cultivated rice (2,906), green gram (21), black gram (23), medicinal and aromatic plants (59), wild *Oryza* species (184), and wild relatives of crops (20) were grown for characterization, evaluation and seed multiplication during 2012. Wide range of variability was recorded and promising accessions for various attributes have been identified in the germplasm of different crops.

12.2.1 Cultivated rice: Out of 2,906 accessions of rice germplasm grown during 2012, 1832 accessions were characterized along with six checks (*Panidhan, Ketakijoha, Tulsi, Kalajira, Jyoti, Geetanjali*) for 28 agro-morphological traits. Each accession was maintained in four rows in non replicated augmented

Collecting submergence tolerant rice landrace (*Khoda*) from threshing floor at Khandapada, Nayagarh

Collecting *Coix lacryma-jobi* from Chandanpur, Kendrapara

***Gossypium barbadense* (perennial cotton), flower without purple centre collected from South Joying, Tripura**

Longest boll (length 13.5 cm) of *Gossypium arboreum* (RCM/PM/MS/03) collected from Toibaklai, Tripura

design with 20X15 cm spacing between rows and plants. Observations on various traits were recorded as per the minimal descriptor. The range of variability was observed and promising accessions were identified for various agronomic traits are given in Table 2 & 3.

12.2.2 Green gram: A set of 21 accessions of green gram germplasm received from NBPGR RS, Hyderabad along with five standard checks (ML-267, K-851, Pusa Vishal, LGG-460, PDM-54) were grown in RBD with three replications during *Rabi*, 2012 for characterization. PU-35, PU-19) were grown in RBD with three replications during *Rabi*, 2012 for characterization. Observations on various agro-morphological traits were recorded as per the minimal descriptor. Wide range of variability was recorded for various agro-morphological characters viz., no. of pods/cluster, no. of pods/ plant, no. of seeds/ pod, pod length (cm) and 100 seed wt. (mg). On the basis of best check value of different attributes the promising accessions were identified and given in Table-4.

Table-2: Range of variation in quantitative traits among cultivated rice germplasm (*Kharif*-2012)

Traits	Range		Mean	Promising lines	Best check
	Minimum	Maximum			
Plant height	38.70 (cm)	200.76 (EC591255)	122.3 (EC491262)	EC491293, 491253, 491262	Kalajira (146.06)
EBT	2.0 (EC491240)	22.60 (EC718230)	11.9	EC721041, 491294, 718230	Geetanjali (9.04)
Leaf length (cm)	1.20 (EC519975)	77.46 (EC491274)	37.33	EC491263, 491472, 491274	Kalajira (56.92)
Leaf width (cm)	0.44 (EC718230)	3.42 (EC491265)	2.11	EC491229, 491250, 491435, 491265	Panidhan (1.06)
Panicle length (cm)	11.98 (EC721056)	35.90 (EC491250)	24.4	EC491228, 519872, 491250	Kalajira (28.44)
Panicle wt. (g)	1.74 (EC518853)	48.11 (EC491228)	26.9	EC491242, 491477 491228	Panidhan (21.56)
100 grain wt. (g)	1.10 (EC0586815A)	4.64 (EC491447)	2.65	EC491447	Jyoti (3.30)

Observations on various agro-morphological traits were recorded as per the minimal descriptors. The range of variability and promising accessions for different quantitative traits are given in Table-3.

12.2.3 Black gram: A set of 23 accessions of black gram germplasm received from NBPGR RS, Hyderabad along with six checks (T-9, LBG-20, PDU-1, PU-30,

12.2.4 Wild *Oryza* species: A set of 184 accessions of wild *Oryza* species received from NBPGR, New Delhi was grown for characterization and seed multiplication. Out of which 168 acc were characterized for morphological and quantitative traits.

12.2.5 Wild relatives of cucurbitaceous plants: A total of 20 accessions of cucurbitaceous vegetables and

Table-3: Range of variation in quantitative traits among green gram germplasm (*Rabi*-2012)

Traits	Range		Mean	Promising lines	Best check
	Minimum	Maximum			
Days to 50% flowering	35.0 IC343860	49.0l C519683	43.8	IC519607, 519683	PDM-54 (43.0)
Plant height (cm)	10.30 IC343907	42.60 IC519682	24.95	IC519607, 343870, 519682	Pusa Vishal (31.0)
No. of cluster/plant	1.25 IC343907	6.2 IC343904	4.16	IC519604, 426771, 343904	Pusa Vishal (4.3)
No. of pods/cluster	1.5l C343907	3.2l C519796	2.62	IC426772, 343843, 519796	Pusa Vishal (4.0)
No. of seeds/Pod	4.8 IC343907	11.8 IC343870, 382812	7.83	IC519796, 519607, 343870, 382812	K-851 (10.33)
Pod length (cm)	3.38 IC343893	7.50 IC519607	4.64	IC343870, 519796, 519607	Pusa Vishal (7.0)
100 seed wt. (g)	1.83 IC343860	3.74 IC343870	3.53	IC519607, 343907, 343870	K-851(3.46)

their wild relatives comprising *Cucumis melo* (3) *Luffa aegyptica* (1), *L. hermaphrodita* (2), *Momordica charantia* (2), *Trichosanthes anguina* (9), *T. cucumerina* (2) and *T. lobata* (1) were in RBD with three replications for characterization and seed multiplication. One acc. of *L. hermaphrodita* (DPP-10/46) is identified with unique trait of bunch type fruits with 10-11 fruits/ bunch.

12.2.5.1 *Ocimum* species: A total of 47 acc of *Ocimum* spp. comprising *O. sanctum* (24), *O. basilicum* (9), *O. canum* (9), *O. citriodorum* (2) and *O. gratissimum* (3) are being multiplied and characterized in three replications for 30 agro-morphological characters. A good variation in the colour, shape and size of leaves, length of spike, colour of flowers and number of leaves per primary branch has been observed and recorded. The post flowering characters

Table-4: Range of variation in quantitative traits among black gram germplasm (*Rabi*-2012)

Traits	Range		Mean	Promising lines	Best check
	Min.	Max.			
Days to 50% flowering	43.0l C426768	49.0l C519811	44.6	IC519801, 519684, 519714, 519811	PU-35 (43.67)
Plant height (cm)	8.92 IC519705	22.58 IC426768	16.57	IC426495, 541882, 426768	PDU-1 (16.73)
No. of clusters/ plant	1.0l C426768, 726769, 519619	7.2 IC519678	4.86	IC519620, 426495, 519678	T-9 (3.35)
No. of pods/ cluster	1.0 IC519721	2.8 IC426495	1.6	IC519684, 519714, 343942, 426495	PU-35, PU-30(2.20)
Pod length (cm)	2.63 IC519684	3.96 IC343942	4.02	IC519684, 519711, 343942	PU-30 (3.78)
No. of pods/ plant	2.0l C426768	19.2 IC519620	12.6	IC519833, 426495, 519620	PDU-1 (15.87)
No. of seeds/ pod	3.6 IC426768	21.12 IC541882	14.36	IC343942, 519619, 541882	PU-30, PDU-1(6.07)
100 seed wt. (g)	2.66 IC519711	4.77 IC382811	3.48	IC519684, 541882, 382811	T-9 (4.45)

such as herbage yield, essential oil content (%), oil yield/ plant are being characterized in collaboration with P.G. Deptt. of Pharmaceutical Sciences, Utkal University, Bhubaneswar. Variability on vegetative, flowering and fruiting and oil yield parameters were recorded. In *O. basilicum* high herbage yield/ plant (597.3 g) and essential oil yield/ plant of 1.5 ml were recorded for IC589189 and IC589199 respectively. *O. canum* recorded high herbage yield (718.07 g) for IC589198 and essential oil yield/ plant (2.1ml) for IC589198.

12.2.5.2 *Mucuna pruriens*: Twelve accessions of *Mucuna pruriens* grown during 2012 for multiplication and simultaneously characterized in respect of 28 agro-morphological characters. Observations on range of variation for different traits were recorded.

12.3 Germplasm Evaluation

12.3.1 Cultivated rice:

12.3.1.1 *Evaluation for leaf blast tolerance:* A set of 1264 accessions of cultivated rice germplasm were grown at CRRI, Cuttack for screening against leaf blast caused by *Pyricularia grisea* along with susceptible checks viz. *HR-12* and *B-40*. A set of 20 accessions viz. IRGC- 46918, 53724, 49673, 46852, 51976, 5911, 49676, 67764, 49419, 46935, 9996, 46502, 62496, 75428, 49724, 46793, 49776, 46696, 46510, 46488 were identified as highly tolerant genotypes with 0-1 score as compared with susceptible checks (score-9).

12.3.1.2 *Evaluation for deep water condition:* A set of 64 acc of deep water rice germplasm collected from Assam by NBPGR Regional Station, Thrissur in collaboration with CRRI, RS, Gerua and Regional Agricultural Research Station, Assam Agril University, Garimoria, North Laxmipur was evaluated during *Kharif*, 2012 in controlled condition (cemented tanks of 1.5m depth) with five checks viz., Dinesh, Swarna *sub*-1, Jalamagna (tolerant) and IR-42, IR-64 (susceptible). A total of seven accessions viz. (ZA&NB/2011-6, 9, 17 and ZA&DC/2011- 36, 42, 53, 60) was identified as promising for deep water condition as compared with best check *Jalamagna* (internode elongation -56.55%) and Swarna *sub-1* (survival percentage - 70.4 %). The result revealed highest internode elongation in case of ZA&DC/2011-60 (83.3%) and highest survival % in case of ZA&NB/2011-6 (77.77%) & 2018 (80.2%).

12.3.1.3 *Evaluation for drought tolerance:* A set of 59 accessions of rice germplasm collected from drought affected areas of Odisha were evaluated for vegetative period drought tolerance with five checks viz. N-22, *Vandana*, APO, *Salempiket* and IR-36 in collaboration with CRRI, Cuttack. Direct sowing was undertaken in randomized block design with three replications both for stress and controlled condition. Each entry was maintained in five rows of 4m length with spacing of 15 cm between rows and 10 cm between hills. Irrigation was suspended after 35 days of germination till complete wilting of the checks. Then irrigation was given to the crop and after a period of one week, drought scoring was recorded. On the basis of drought score, yield and yield attributing traits of best check *Vandana*, 12 accessions viz., IC591346, 591348, 591349, 591353, 591354, 591357, DP/HNS-13, 18, 19, 25, 38, 57 were identified as donor for drought tolerance.

12.3.1.4 Evaluation for salt tolerance: A set of 35 accessions of rice germplasm collected from Sundarvan Biosphere Region (WB) were evaluated for salt tolerance in controlled condition with checks (CSR-1, CSR-2, Lunishree, Pokkali) in collaboration with CSSRI, Regional Station, Canning Town, WB. Based on the performance of the best check the genotypes such as *Talmugur, Getu, Nonabokra, Kalonunia, Darsal* were identified as donor for salt tolerance.

12.3.*2* *Mucuna pruriens*: The seed samples of 11 acc of *Mucuna pruriens* collected from Ganjam and Gajapati districts of Odisha were analyzed for estimation of L-Dopa content (%) at NBPGR, New Delhi. The range of L-Dopa content varies from 4.20 (IC589230) to 6.11 (IC589220). The genotypes such as IC589220 and IC589208 were identified for high L-Dopa content (%) i.e.6.11 and 6.04, respectively, against normal range of 2.2 to 5.3 in Indian conditions.

12.3.3 Validation of medicinal plants: Phytochemical screening of leaves of *Ocimum basilicum, O. canum, O. sanctum, O. gratissimum* and seeds of three species of *Mucuna* such as *M. pruriens* (3 acc), *M. monosperma* and *M. nigricans* to detect the active compounds for validation of ethno-medicinal properties was under progress. Studies were also made to establish correlation between bioactive compounds and ethno-medicinal properties in respect of *Celastrus paniculata* (*Jyotismati*), a vulnerable medicinal plant of Odisha.

12.4 Seed Multiplication

A total of 3265 accessions comprising cultivated rice (2906), sesame (77), green gram (21), black gram (23), medicinal and aromatic plants (59), wild *Oryza* species (184), *Solanum* spp. (16), *Canavalia* (6) and wild relatives of crops (20) were grown for seed multiplication during 2012.

12.5 Germplasm Supply

A total of 88 acc comprising *Mucuna* (11), saline tolerant rice (63) and cotton (14) were supplied to three institutes for research purposes and 246 accessions comprising wild *Oryza* spp.(15), deep water rice (61), pulses(100) and sesame (70) were received from NBPGR, New Delhi, RS, Thrissur, Hyderabad and Akola respectively.

12.6 Germplasm Conservation

A total of 2,008 accessions comprising cultivated rice (1,862), cold tolerant rice (43), salinity tolerant rice (60), cotton (29), *Crotalaria* (10), M&AP (02), Chilli (01) and Sesame (01) were deposited for long term conservation in NGB, NBPGR, New Delhi.

12.7 Germplasm Maintenance

A total of 3,674 acc comprising cultivated rice (2,906), wild *Oryza* species (184), medicinal and aromatic plants (469), wild cucurbits (20) and other wild relatives of crops (27), tuber/aroid crops (38), economic plants of agro-forestry importance (24) and horticultural crops (06) were maintained in the experimental field and field genebank of the centre.

12.7.1 Herbarium preservation: The herbarium of the Base Centre has been enriched with 827 herbarium specimens comprising wild relatives (89), minor fruits (124), vegetables including leafy types (74), tuber crops (36), ornamentals (67), rare/ endangered (12), high valued medicinal and aromatic plants (340), beverages/ additives (37), fibres (26) and other economically useful plants (22) collected during different exploration missions from Odisha, Mizoram and Tripura.

12.7.2 Documentation and new reports of plant genetic resources: Fifty five species of wild tuberous plants were documented as supplementary/ famine food from Similipal biosphere reserve, Odisha out of which 17 species were reported first time as new records of food plants for India. Besides, the floristic diversity of Similipal Biosphere Reserve comprising a total of 1254 species have been documented which includes 118 vascular plant species as new additional reports to the biodiversity of Similipal comprising 92 species of dicotyledons, 21 species of monocotyledons and 5 species of pteridophytes.

12.7.3 Maintenance of wild rice germplasm : A total of 164 accessions of 19 species of wild rice are being maintained

12.7.4 Maintenance of medicinal and aromatic plants: A total of 469 acc of medicinal and aromatic plants have been conserved in the field genebank of the centre including some potential and high value species viz., *Argyreia nervosa, Asparagus racemosus, Bacopa monnieri, Baliospermum montanum, Celastrus paniculatus, Centella asiatica, Gardenia gummifera, Hedychium coronarium, Hemidesmus indicus, Litsea glutinosa, Mallotus philippensis, Nyctanthes arbortristis, Ocimum basilicum, O. canum, O. sanctum, Oroxylum indicum, Piper longum, Plumbago rosea, Pterocarpus santalinus, Rauvolfia serpentina, Saraca asoca, Scindapsus officinalis, Stevea rebaudiana, Strychnos potatorum, Tinospora cordifolia, Watakaka volubilis.*

Programme (Code, Title and Programmes 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 and Associates)

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

13. REGIONAL STATION, HYDERABAD

Summary: A total of 24,500 samples consisting of 16, 921 import and 7, 579 export samples were processed for quarantine clearance and a total of 59 Phytosanitary Certificates were issued. Several pathogens of quarantine importance were intercepted, of these, downy mildew (*Peronospora manshurica*) of soybean from USA, *Peanut stripe virus* and bacterial wilt of groundnut (*Ralstonia solanacearum*) from Senegal are quarantine pests for India. The import samples (5,253) that were found infested/ infected with pests/ pathogens could be salvaged and released to the consignees except 43 detained/ rejected samples (groundnut-38; soybean-3 and chickpea-2). In exports, 89 samples were rejected due to the association of quarantine pests/ pathogens. Quarantine service was extended to 44 organizations in South India. Post-entry quarantine inspection was conducted on 2,480 samples of different crops grown at PEQIA of ICRISAT (2,080), private industry (139 including 1 transgenic sample), and NBPGR greenhouse (261). Three explorations were undertaken for collection of diversity in sorghum, small millets, vegetable cowpeas and leafy vegetables from different parts of Andhra Pradesh and the NEH region. In addition, as collaborator also associated in an exploration for collection for palmyrah palm from Nellore district of Andhra Pradesh. A total of 198 collections were made. In addition, under NAIP-Biodiversity, project two explorations were undertaken in Adilabad district of Andhra Pradesh surveying 64 villages of 21 mandals resulting in the collection of 158 accessions of agri-horticultural crops. A total of 3,118 accessions of sorghum, horsegram, linseed, dolichos bean, tomato, french bean, millet, finger millet, little millet, greengram, cowpea, chillies and brinjal were grown in the field along with appropriate checks for characterization/ evaluation/ multiplication. In addition, wild legumes including *Canavalia ensiformis, Mucuna pruriens and Vigna trilobata* were also raised for seed multiplication and initial characterization. Further, 559 accessions of diverse crops were characterized, evaluated and multiplied under the NAIP Biodiversity Project. A total of 47 accessions including paddy and amaranth were multiplied at the station and sent for long term conservation in the National Genebank (NGB). Voucher samples of 107 accessions of diverse germplasm collected during the different explorations were submitted to Germplasm Handling Unit for national accessioning and medium term storage. A total of 122 accessions of germplasm collected during explorations were shared with the NAGS. A total of 326 accessions including French bean, Lima bean, *Phaseolus* spp., tomato, sorrel, brinjal, cowpea, pearl millet, small millets, sorghum and chillies germplasm along with wild species of tomato viz. *Solanum peruvianum*, *S. esculentum* var. *ceresiforme*, *S. incanum* and *S.chilense* were supplied against indents from ICAR institutes/ SAUs for research purposes.

13.1 Quarantine Activities

During the year 2012, a total number of 24,500 samples [16, 921-imports & 7, 579-exports] were received for quarantine processing during the period under report, the details of which are given hereunder.

Out of the 24,500 samples processed for quarantine clearance, 14,901 samples (paddy- 10,488; wheat- 07; barley- 10; maize- 2821; sorghum- 359; pearl millet- 28; grasses (*Pennisetum* spp) - 35; finger millet- 727; *Setaria* sp- 1; chickpea- 303; cowpea- 116; soybean- 09; sunflower- 733; safflower- 70; groundnut- 78; castor- 01; chilli- 334; tomato- 282; okra- 15; *Arabidopsis* sp- 99; *Chenopodium*- 9; Acacia- 8; mustard- 20; *Eucalyptus* spp- 120; tobacco- 3; *Casuarina* sp- 129; and *Corymbia* sp-116) were imported from different countries and the remaining 7,579 (sorghum- 1,788; pearl millet- 1,050; chickpea- 803; pigeonpea- 294; groundnut- 296 and small millets-50 and maize-3,298) were meant for export to different countries. In addition, a total of 11,200 samples of ICRISAT mandate crop germplasm including sorghum-1,112; kodo millet- 48; proso millet- 93; barnyard millet- 117; finger millet- 1,378; foxtail millet- 342; little millet- 39; pigeonpea- 875; pearl millet- 815; chickpea- 2,801 and groundnut- 3,580 were processed and released for conservation in the SVALBARD Gene Vault, Norway.

13.1.1 Import quarantine interceptions: All the import samples were subjected to various seed health tests like visual examination, blotter test, X-ray radiography, Enzyme Linked Immunosorbent Assay (ELISA), centrifugation and microscopic examination. The following pathogens were intercepted during the reporting period.

Pests and Pathogens	Crop	Country
Alternaria helianthi	Sunflower	Argentina
Ascochyta pinodes, Rhizoctonia bataticola and *Colletotrichum dematium*	Chickpea	Nepal
C. cereale and *Drechslera sativus*	Barley	USA
C. graminicola and *R. bataticola*	Sorghum	Uganda

Diplodia maydis	Maize	USA
Drechslera maydis	Maize	Vietnam
D. nodulosa, Sclerophthora macrospora, Rhizoctonia solani and *Myrothecium rorridum*	Finger millet	Uganda
D. setariae and *Rhizoctonia solani*	Pearl millet	Tanzania, Uganda
D. sorghicola	Sorghum	Argentina, Bulgaria, Sudan, Tanzania, Uganda, and USA
Fusarium oxysporum	Chilli	Taiwan
Peanut stripe virus, Peanut mottle virus, Ralstonia solanacearum	Groundnut	Senegal
Periconia lateralis	Mungbean	Taiwan
Peronospora manshurica	Soybean	USA
Pestalotia sp	*Eucalyptus* sp.	South Africa
R. bataticola	Maize	Thailand
Rhizoctonia bataticola, Sporisorium cruentum	Sorghum	Argentina
R. solani	Sorghum	Bulgaria
R. solani	Sunflower	Australia, Belgium, USA
R. solani and *Puccinia carthami*	Safflower	USA
R. solani, Sitophilus oryzae	Maize	Australia, Thailand, USA
Rhyzopertha dominica	Paddy	Philippines
T. castaneum and *Corcyra cephalonica*	Sunflower	Argentina
Tribolium castaneum, R. dominica and *Lasioderma serricorne*	Sunflower	France

The healthy accessions were released after giving the necessary salvaging treatments

Barley seedlings (USA) infected with *Colletotrichum cereale* (Left) along with healthy seedlings (Right)

Barley seedling (USA) showing infection of *Drechslera sativus* during grow-out in the green-house

Blast symptoms on wild pearl millet accession from Uganda, grown in PEQIA of ICRISAT

13.1.2 Imports processed and released: Released 16,181 samples consisting of paddy (9,591), maize (2,589), sorghum (1,007), barley (10), pearl millet (63), finger millet (730), *Setaria viridis* (01), chickpea (301), sunflower (650), safflower (70), groundnut (40), mustard (20), castor (1), *Eucalyptus* spp (92), chilli (318), tomato (205), *Arabidopsis* sp (99), *Acacia crassicarpa* (8), *Corymbia* sp (116), *Casuarina* spp (129), *Aloe ferox* (1), okra (15), tobacco (3), soybean (6), and cowpea (116) after necessary mandatory treatments. Forty-three

(43) accessions consisting of soybean (3) from USA, chickpea (2) and groundnut (38) from Senegal were rejected due to the infection of *Peronospora manshurica*, *Ascochyta pinodes,* and bacterial wilt and *Peanut stripe virus*, respectively.

Import germplasm salvaging details

Total number of samples infected/infested	: 5,253*
Number of samples salvaged	: 5,210
Number of samples detained	: Nil
Number of samples rejected	: 43

(*Fungi: 5,211; Bacteria: 144; Viruses: 5; Nematode:1 ; Insects:16)

13.1.3 Post-entry quarantine observations: Post-entry quarantine inspection was conducted on 2,480 samples of different crops grown at PEQIA of ICRISAT (2,080), private industry (139 including 1 transgenic sample), and NBPGR greenhouse (261) and the details are given below.

13.1.3.1 ICRISAT-PEQIA: Post-entry quarantine inspection was conducted on wild pearlmillet accessions (101 samples) from Uganda, grown in the post-entry quarantine isolation area of ICRISAT. Leaf samples (EC702781; EC702799) suspected with blast symptoms were collected to check the infection.

Maize accessions (7) from Vietnam belonging to CIMMYT, ICRISAT Campus, Hyderabad were also inspected and found healthy.

Inspection was carried out to check the health status of six imported consignments (776 samples) consisting of sorghum (28) from Brazil, pearl millet (5) from Niger, foxtail millet (16) from China, finger millet from Tanzania (25), Uganda (437) and Nepal (265) in the Post-entry quarantine isolation area, ICRISAT. Shoot borer damage was noticed in few lines of sorghum from Brazil, while one accession was showing anthracnose (*Colletotrichum graminicola*) suspected spots. Finger millet accessions from Tanzania and Uganda and foxtail millet accessions from China showed poor germination.

Inspection was carried out to check the health status of imported consignments of sorghum (932 accessions) from Sudan (648), Bulgaria (122), Tanzania (103) and Uganda (59), being grown in the Post-entry quarantine isolation area, ICRISAT. Downy mildew infected plants were uprooted and incinerated. It was advised to give spray of metalaxyl (Ridomil) to prevent the spread of infection.

Inspection of 70 accessions of safflower from USA, belonging to the Directorate of Oilseeds Research, Hyderabad, being grown at ICRISAT were inspected from time to time and all accessions were found free from exotic pests.

13.1.3.2 ICRISAT - glasshouse: Regular inspections are being carried out on groundnut accessions (78) from Senegal, grown in the glasshouse and incidence of *Peanut mottle virus* and *Groundnut bud necrosis virus*, and bacterial wilt due to *Ralstonia solanacearum* (EC733896; EC733898) were recorded.

Inspection of released groundnut samples (39) from Senegal, being grown for multiplication in the glasshouse at ICRISAT was done. Since some of the seedlings were showing viral suspected symptoms, leaf samples were drawn from all samples for conducting ELISA against *Peanut stripe virus* and *Peanut mottle virus.* ELISA test revealed that all plants were free from the suspected viruses. However, mite damage was seen in all accessions. In the second phase, leaf samples suspected with *Peanut mottle virus* were ELISA tested and one out of 26 accessions was found positive to PeMoV.

Cowpea accessions from USA (110) and Taiwan (06), grown in the glasshouse, ICRISAT were inspected and found healthy.

13.1.3.3 Private industry: Inspection of maize accessions (37) from Thailand, being grown at PEQIA, ICRISAT by Hitech Seeds Pvt Ltd was done and two accessions were showed zonate leaf spot (*Gloeocercospora sorghi*) symptoms.

Post-entry quarantine inspection was conducted on 48 paddy accessions from Philippines, grown in the farm of Bayer Crop Sciences, Khanapur village, Rangareddy Dt, Andhra Pradesh. All were found healthy.

Inspection of maize accessions (11) from France, being grown in the polyhouse of Atash Seeds Pvt Ltd was conducted all were found healthy.

Inspection of 42 accs. of cotton germplasm from USA, released by NBPGR, New Delhi, grown in the glasshouse at Bayer Biosciences Pvt Ltd., Hyderabad. All accessions were found healthy.

13.1.3.4 NBPGR-greenhouse: One consignment of Cowpea (256) imported from Nigeria and received from NBPGR New Delhi was grown in isolation in Plant Quarantine Green House and are being observed for exotic pests. Incidence of powdery mildew was recorded. Collected leaf samples suspected with viral infection on random basis were tested at NBPGR, New Delhi.

Cowpea from CIAT grown in PEQ glasshouse

13.2 Export Quarantine

Pre-export crop inspection: Pre-export crop inspection was carried out at ICRISAT on chickpea (7,211 accns) covering 6.99 ha. Incidence of upto 10% Sclerotial and Fusarial wilts was noticed and the infected plants were uprooted and destroyed.

Export germplasm processed: A total of 7, 579 export samples consisting of sorghum (1,788), pearl millet (1,050); small millets (50); chickpea (803); pigeonpea (294); groundnut (296) and maize (3,298) samples were processed for export to different countries.

In addition, a total of 11,200 samples of ICRISAT mandate crop germplasm including sorghum-1,112; kodo millet-48; proso millet-93; barnyard millet-117; finger millet-1,378; foxtail millet-342; littile millet-39; pigeonpea-875; pearl millet-815; chickpea-2801 and groundnut-3,580 were processed and released for conservation in the SVALBARD Gene Vault, Norway.

A total of 88 seed samples (sorghum-9, pearlmillet-15, chickpea-53, and pigeonpea-11) was rejected due to pathological reasons. The remaining 7,491 healthy samples were exported to different countries. In all, 59 Phytosanitary Certificates were issued.

13.3 Supportive Research

13.3.1 NAIP-Virology: As part of antiserum validation, groundnut (1,216), sunflower (2), tobacco (14) leaf samples from the fields of ICRISAT and CRIDA, Hyderabad, and import consignment of groundnut from Senegal, grown in the glasshouse at ICRISAT (229) and NBPGR were ELISA tested against *Groundnut bud necrosis virus* (GBNV *Peanut mottle virus* (PMV), *Peanut stripe virus* (PStV) and *Tobacco streak virus* (TSV). In addition, 2,428 leaf samples consisting of tomato (597), chilli (186), canavalia (86), mucuna (20), papaya (27), roselle (4), colocasia (27), miscellaneous crop samples (12), onion (45), French bean (88), dolichos bean (84), field bean (5), bittergourd (62), cucumber (22), watermelon (120), bottlegourd (4), horsegram (200), okra (2), brinjal (5), pillipesara (67), spinach (1), black gram (239), green gram (169), *Coccinia* (71), ridge gourd (119), golden durantha (139), *Muraya* sp (1), jasmine (7), cowpea (2), cotton(2), wild legumes (7) and medicinal plants (06) from the fields of Chilkur village, Moinabad Mandal, Ranga Reddy distrit of Andhra Pradesh, and NBPGR RS, Hyderabad, were ELISA tested against GBNV, *Cucumber mosaic virus* (CMV), *Papaya ring spot virus* (PRSV), and *Tomato leafcurl virus* (ToLCV).

13.3.2 Studies on traits of resistance to thrips and mites in chilli: Field screening of 126 chilli germplasm was done for the resistance against the thrips, *Scirtothrips dorsalis* Hood and mite, *Polyphagotarsonemus latus* Banks during *Kharif* 2012 in an augmented block design with three check varieties (CA-960 – resistant, LCA-334- susceptible and Pusa Jwala- resistant check). Chilli accessions IC565169 and EC739328 were found to be resistant against thrips and mites.

Morphological traits like leaf colour, leaf thickness and leaf trichome density in selected chilli germplasm were analysed in the fully opened 5th leaf from top collected from the field trial at 45 DAT. The leaf colour of 20 accessions was recorded from using RHS colour chart. No correlation was observed between leaf colour and

Chilli accession IC565169 resistant to thrips and mites

Chilli accession EC739328 resistant to thrips and mites

resistance traits. Leaf thickness and trichome density had positive significant correlation with the resistance traits. The leaf thickness varied from 0.236 mm (IC572504) to 0.319 mm (EC391087) and the accn. with thicker leaves are resistant to thrips and mites. Trichome density is maximum in the resistant accession EC599994 (427/cm^2) and minimum in the susceptible EC596952 (62/cm^2)

13.3.3 Evaluation against *Groundnut bud necrosis virus:* Green gram accessions (168) that are being evaluated in the field of NBPGR Regional Station, Hyderabad were inspected and incidence of GBNV was recorded based on the apparent symptoms. To confirm these results, ELISA was conducted by drawing leaf samples from all the accessions. Forty samples were found positive to GBNV.

Black gram accessions (239) being evaluated at this station, were also evaluated for resistance against virus diseases. Two observations on the incidence of GBNV were recorded based on apparent symptoms and ELISA was conducted for confirmation. Eighty-seven of the tested samples were found positive for GBNV incidence.

13.3.4 Seed health testing: Seed health testing of four samples of paddy, meant for export to Philippines, submitted by Bayer Bioscience Pvt Ltd was done and both the samples were found free from target pests. One paddy sample (JKRH-1220) received from JK Agri Genetics Pvt Ltd., Hyderabad meant for export to Mozambique was tested and found free from all the target pests.

13. 4 Plant Genetic Resources Activities

13.4.1 Plant Exploration and Germplasm Collection: A total of three explorations were undertaken during the year for collection of diversity; one in Andhra Pradesh (sorghum and millets) and two in NEH region (small millets; vegetable cowpea and leafy vegetables). In addition, an exploration for collection for palmyrah palm was undertaken as collaborator in Nellore district of Andhra Pradesh. A total of 198 collections were made as detailed below:

Sorghum and millets: The exploration was undertaken in parts of Khammam district of Andhra Pradesh for collection of sorghum and millets during the first fortnight of October, in association with Directorate of Sorghum Research (DSR), Hyderabad. A total of 64 samples consisting sorghum (40), pearl millet (2), finger millet(5), fox-tail millet (11), barnyard millet (4), prosomillet(1) and little millet (1) was collected during the survey. Landraces collected include: Sorghum (*Pachcha jonna, Konda jonna, Dubba jonna/erra jonna*); Fox-tail millet (*Korra, punasa korra, tella korra*); Barnyard millet (*Bontha sama, Gattukallu*); Finger millet (*Chollu, Thaithalu*).

Vegetable cowpea, landraces of pigeonpea, leafy amaranthus and perilla: A collaborative survey involving IIHR, Bangalore, ICAR-NEH Mizoram centre and NBPGR, RS, Hyderabad was undertaken in parts of Mamit, Aizawal, Serchhip and Champhai districts of Mizoram. A total of 42 accessions were collected comprising of cowpea (26), *Perilla* (11), pigeonpea (4) and amaranthus (1). Good diversity was observed in

Variability in finger millet germplasm collected from West Siang and Upper Siang Districts of Arunachal Pradesh

Variability in Italian millet germplasm collected from West Siang and Upper Siang Districts of Arunachal Pradesh

A finger millet landrace (*Merung*/ SC-13674) with semi-compact to compact panicles being cultivated by the Adi groups in Jengging region, Upper Siang District of Arunachal Pradesh.

cowpea in pod length, pod colour, seed size, seed shape and colour. Some of the landraces of cowpea collected were *Hlawite, Behlawilaihawl, Furbehlawi, Behlawinanei, Behlawisenthau, Hlawivapual*.

Small millets: A special mission was undertaken in West Siang and Upper Siang districts of Arunachal Pradesh for collection and conservation of small millets germplasm in collaboration with AIC Small Millets Improvement Project. In all, 83 accessions consisting of 64 of finger millet, 16 of Italian millet and three of Adlay were collected from 28 villages and 11 Sub-Divisions belonging to West Siang and Upper Siang districts of Arunachal Pradesh in the above survey. The tribal groups from whom the germplasm was sampled from were *Adi, Galo* and *Memba* from the targeted region. The landraces collected in Finger millet include *Bomdilla tami, Chaptang tami, Grunjun, Khungpo kalangtang, Kongpu, Mebber, Meepo, Meeru, Mepeng, Mero, Merung, Miber, Mikeer, Mipak, Mipang, Mirek, Mirung, Misor, Mitum, Rube, Rumuk, Tami* and *Tawang tami* and in Italian millet include *Ayak, Chong* and *Tayek* etc.

In finger millet significant diversity was observed for plant height (medium/ tall/ very tall), tillers (sparse/ medium/ high/ very high), panicle shape (compact/ discontinuous nature of spikelets/ incurved/ tips curved/ semi-compact/ open/ lax), size (small/ medium/ large), no. of fingers (5 - 12), finger length (branched/ medium/ long and thin), finger width(short/ medium), seed colour (light brown/ brown/ copper brown/ purple-brown), seed size (small/ medium/ bold) and maturity (early/ medium/ late) and yield potential (5 - 10 q/ acre). The quantitative trait finger length seems to be more diverse when compared to others. In Italian millet variability was observed for panicle shape and size (small/ medium/ compact/ long); spikelets/ lobes (more/ conspicuous/ absent); bristles (nil/ short/ medium/ very long), seed size (small/ medium) and seed colour (light yellow) etc.

Palmyrah palm (*Borassus flabellifer*): The exploration was undertaken in association with AICRP on Palms, Agricultural College & Research Institute, Tamil Nadu Agricultural University, Killikulam, Vallanadu. Dr. Y S R Horticultural University, Horticultural Research Station, Pandirimamidi, Rampachodavaram, East Godavari District, Andhra Pradesh collaborated in the exploration. Areas surveyed included Nellore district of South coastal

Italian millet diversity collected from a tribal group (*Konda reddy)* of farmers in Khammam district of Andhra Pradesh

A highly compact finger millet landrace (Mirung/ SC-13691) being cultivated by the Adi groups in Upper Siang District of Arunachal Pradesh

A finger millet landrace (Tami/ SC-13707) characterized by large semi-compact panicles with long fingers being cultivated by the Galo groups in Rumgong region, West Siang District of Arunachal Pradesh

region of Andhra Pradesh. A total of 9 accessions were collected. Significant variability was observed in palm height (short/ medium tall/ tall/ very tall), leaf colour (shades of yellow/ green), fruit colour (Black/ Black with orange-red blotch at bottom/ orange with light purple markings on the side and bottom/ yellow-orange characterized by small faint diffused markings on the side and a blotch at bottom), fruit shape (Round/ Round-oblong/ Ob-ovate), fruit size (small/ medium/ large), yield (sparse/ medium/ heavy), bearing (seasonal/ over-lapped); tree height (m) (5.0 - 8.8); girth of trunk at 1 m height (m) (1.1 - 2.2); total leaves (no.) (24 - 60); petiole length (m) (0.4 - 1.7); leaf length (m) (0.5 - 1.5); bunches/ tree (no.) (9 - 15); fruits/ bunch (no.) (12 - 30); fruit length (cm) (10.0 - 17.0); fruit circumference (cm) (30.0 - 46.0).

13.4.2 Germplasm characterization and evaluation

Rabi, 2011-2012: A total of 573 accessions of sorghum, horse gram, linseed, dolichos bean, tomato, French bean, were grown in the field along with appropriate checks for characterization/evaluation/ multiplication. In addition wild legumes including *Vigna trilobata, Canavalia ensiformis, Mucuna pruriens,* were also raised for seed multiplication and initial

***Kharif 2012*:** A total of **1187** accessions of barnyard millet, finger millet, little millet, greengram, cowpea, chillies, brinjal, *Vigna trilobata*, *Canavalia ensiformis* and *Mucuna pruriens* were grown in the field along with checks for characterization/evaluation/ multiplication.

Rabi 2012-2013: A total of 358 accessions of greengram, horsegram, linseed, french bean and chillies were grown in the field along with checks for characterization/evaluation/multiplication. Promising accessions in comparison to check varieties in different crops were identified.

Canavalia ensiformis: Twelve accessions of *Canavalia ensiformis* (Jack bean) were analyzed for total oil content and fatty acid composition. Total oil content varied from 0.5% to 1.8% in the germplasm accessions while the Omega-3 content ranged from 39.7% to 58.6%.

13.4.5 Explorations and evaluation under the NAIP Biodiversity project: Under NAIP-Biodiversity project, a total of two explorations were undertaken in Adilabad district surveying 64 villages belonging to 21 Mandals covering 79 farmers resulting in the collection of 158 accessions of Agri-horticultural crops. The wild relatives collected include *Canavalia ensiformis, Cucumis hardwickii, Luffa acutangula* var.*amara, Lycopersicon pimpinellifolium* and *Solanum surattense*. A total of 559 accessions were characterized and evaluated during the *Kharif* 2012 and *Rabi* 2012-2013 under the project. These included sorghum (56), amaranths (11), barnyard millet (23), black gram (67), rice bean (10), mothbean (7), safflower (13), chickling pea (2), cowpea (72), green gram (109), chickpea (45), Italian millet (88), little millet (12), maize (38), field bean (25), dolichos bean (21), *Clitoria* (8), proso millet (2), pearl millet (7) and kodo millet (2).

PSR-12226, A promising *Canavalia ensiformis*

IC345054 Inflorescence width 11.6cm

NSJ-263 – Ear width 7.1cm

NSJ-348 – Basal tillers 22

13.5 Germplasm Conservation

A total of 65 accessions of germplasm (sorghum-40; other millets-25) collected during a survey undertaken in parts of Khammam district, Andhra Pradesh sent to the Germplasm Handling Unit for national accessioning and conservation.

Forty two accessions including cowpea (26), pigeonpea (4), amaranth (1) and *Perilla* (11), collected in a survey undertaken in Mizoram from 14.11.2012 to 26.11.2012, were sent to GHU, NBPGR, New Delhi along with tour report, passport data, route map for accessioning and conservation in the genebank.

Fifty-six accessions of cold tolerant paddy germplasm collected from parts of Western Ghats (Nilgiris, Wayanad and Kodaikkanal) were shared with collaborating institute Tamil Nadu Agricultural University (Ramaiah Genebank).

Forty sorghum landraces collected during the collaborative exploration programme in parts of Khammam district of Andhra Pradesh shared with Directorate of Sorghum Research, Hyderabad for further characterization and multiplication.

Twenty six accessions of cowpea germplasm collected from of Mamit, Aizawl, Serchhip and Champhai districts of Mizoram in a collaborative survey were shared with IIHR, Bangalore.

Thirty accessions of paddy collected and multiplied under the NAIP Project of Harmonizing Biodiversity were sent for long-term conservation to NGB, New Delhi. Seventeen (17) accessions of amaranth germplasm lines, which were not represented the national gene bank were sent to NGB for conservation.

13.6 Germplasm Distribution

A total of 326 accessions in crops namely French bean (64), tomato (107), sorrel (15), brinjal (32), chilli (50), cowpea (19) sorghum (14), pearl millet (3), small millet (22) were supplied to different universities in Hyderabad, Tamil Nadu and Rajasthan.

Variety Release

Coriander germplasm accession SH-3466 (LCC-170/ NIC-18231/ IC574503) was released by Dr.YSR Horticultural University as APHU Dhania-1 based on Mass selection breeding methodology. Recommended for cultivation in Andhra Pradesh, Bihar, Haryana and Tamil Nadu. Average yield 1 tonne/ ha under irrigated condition. The variety was notified in 2010 by the Central Sub Committee on release of varieties. Dr SR Pandravada, NBPGR Regional Station, Hyderabad was associated with the collection and release of the above variety.

Research Programmes (Programme Code: Title, Leader)

PGR/PQR- BUR-HYD-01.00- Quarantine Processing of Plant Germplasm under Exchange and Supportive Research (**SK Chaktabarty**)

PGR/PQR- BUR-HYD-02.00- Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Genetic Resources of South East Coastal Zone (**SK Chaktabarty**)

Research Projects (Project Code, Title, Project Leader; Project Associates)

PGR/PQR-BUR-HYD-01.01 Detection, Identification and Control of Pests Associated With Import and Export of Seed/ Plant Material (**K Anitha,** SK Chakrabarty, B Sarath Babu, N Somasekhar, N Sivaraj, K Rameash and Babu Abraham)

PGR/PQR-BUR-HYD-01.02 Developing a Database on Pests and Pathogens of Quarantine Significance (**B Sarath Babu,** and K Anitha)

PGR/PQR-BUR-HYD-01.03 Quarantine Treatments for Germplasm under Exchange and Developing Detection Techniques and Treatment Schedules for Seed Borne Pathogens (**SK Chakrabarty** and K Anitha)

PGR/PQR-BUR-HYD-01.04 Post-entry Quarantine Processing of Imported Germplasm (**SK Chakrabarty**, B Sarath Babu, K Anitha, K Rameash and Babu Abraham)

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. (**K Venkateswaran,** SR Pandravada, N Sivaraj, N Sunil 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, Species, Medicinal and Aromatic Plants etc.) and their Wild Relatives. (**SR Pandravada,** K Venkateswaran, N Sivaraj, N Sunil and Babu Abraham)

PGR/PQR-BUR-HYD-02.03 Characterization and Evaluation of Wild edible Crops of Leguminosae (**N Sivaraj**, ER Nayar, SR Pandravada, K Venkateswaran, N Sunil and Babu Abraham)

PGR/PQR-BUR-HYD-02.04 Studies on traits of resistance to thrips and mites in chilli (**K Rameash**, B Sarath Babu, Someswara Rao Pandravada)

Externally Funded Projects

- Harmonizing biodiversity conservation and agricultural intensification through integration of plant, animal and fish genetic resources for livelihood security in fragile ecosystem (**NAIP**) **SK Chakrabarty**, SR Pandravada, N Sivaraj, N Sunil
- Novel strategies for molecular diagnosis of plant viruses **(NAIP) K Anitha**

14.6 Seed Multiplication

The seeds of 850 accessions of pearlmillet were multiplied by sib mating following the newly developed technique of sowing accession in ring method and then covering the panicle of all plants at the time of flowering using butter paper bag and muslin cloth bag.

Table 2. Germplasm being maintained in the field Genebank

Crop/ taxa group	Number	
	Crop/ taxa	Accession
Fruit crops	26	263
Ornamental plants/ trees/shrubs	10	53
Oil yielding plants	6	212
Medicinal & Aromatic plants	38	147
Trees of Economic Importance	17	44
Fibre plants	1	8
Fodder Trees	5	14
Others	9	10
Total	**112**	**751**

14.7 Germplasm Conservation

The 34,995 accessions of agri-horticultural crops are being conserved at the station either being maintained as live plants in the field or seed being conserved in the MTS facilities.

In MTS, a total of 34,995 accessions-cereal & millets (8,022), legumes (13,855),oil seeds (6,005), plants of economic importance (1,017), medicinal plants (572), horticultural crops (2,855), fibre / fodder plants (504) & others (2,165) are being consumed in the MTS.

14.8 Germplasm Supplied

A total of 1,357 accessions of various crop species viz. cluster bean (436), cowpea (317), moth bean (208), jojoba (10), pearl millet (224), sesame (100), mustard (32), and cucumber (30) were supplied to indenters under MTA.

Research Programme (Code, Title, 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 Projects (Code, Title, PI, Co-PI and Associate)

PGR/GEV-BUR-JOD-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of cereals, pearl millet, minor millets and horticultural crops (**AK Singh,** Om Vir Singh)

PGR/GEV-BUR-JOD-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of legumes and oilseeds (**AK Singh,** Om Vir Singh)

PGR/GEV-BUR-JOD-01.03: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of fodder, fuel, medicinal and aromatic and other economic plants (**Om Vir Singh**, AK Singh).

15. REGIONAL STATION, RANCHI

Summary: Two explorations, one in which 100 accessions of the pigeonpea and the second to collect the diversity of upland rice (drought tolerant) and minor millets was undertaken in Ramgarh, Hazaribagh, Giridih and Ranchi districts of Jharkhand and a total of 60 accessions viz. rice (22), ragi (31), sorghum (5) and gundali (2) were collected. Germplasm accessions evaluated include *Kulthi* (362), *Mucuna* (39), pigeonpea (113*), Andrographis* (10), *Costus* (9), *Chlorophytum* (17), *Asparagus* (21), *Dioscorea* (17), *Curculigo* (18) and *Tinospora* (18). Germplasm maintenance in field Genebank includes jackfruit (154), tamarind (51), barhal (14), aonla (19) *Mangifera* sp. (19) *Musa* sp. (34) & *Moringa oleifera* (14).

15.1 Exploration and Collection of Germplasm

During 2012, two explorations were undertaken. First exploration was undertaken to tap the genetic diversity in the *Cajanus cajan* (pigeonpea) in the eastern Jharkhand. The districts explored included Kodarma, Giridih, Deoghar, Godda, Sahibganj, Pakur, Dumka, Jamtara, Dhanbad and Bokaro. A total of 100 accessions of the pigeonpea representing high amount of diversity were collected. Second exploration to collect the diversity of upland rice (drought tolerant) and minor millets was undertaken in Ramgarh, Hazaribagh, Giridih and Ranchi districts of Jharkhand and a total of 60 accessions viz. rice (22), ragi (31), sorghum (5) and gundali (2) were collected.

15.2 Evaluation of Germplasm

15.2.1 *Kulthi*: A total of 362 accessions of *Kulthi* germplasm were sown for evaluation in augmented design. No. of rows per accession was kept two with a row length of 3.0 meter. The space between two accessions was kept 80 cm and space between two rows of same accession was kept 40 cm. Two checks Madhu and Birsa Kulthi-1 (BK1) were used in the experiment. The observations on 10 plants of each accession were recorded. The observations on primary branches per plants, days to 50% flowering, pods / plant, pod length (cm), plant height (cm), no. of seeds / pod, yield / plant (g), 100 seed weight (g), growth habit, growth pattern, leaf color, leaf surface, pod shape, pod surface and seed color were recorded. The data recording is in progress.

15.2.2 *Mucuna*: A total of 39 accessions of *Mucuna* germplasm were evaluated in RBD with two replications. Spacing between two accessions was kept one meter and spacing between two rows of same accession was kept 50 cm. A row length of six meter was maintained. Number of rows in each accession was kept two. The observations were recorded on plant height, leaflet shape, odd leaflet length, odd leaflet width, days to flower initiation, inflorescence length, no. of inflorescence/ plant, flower inflorescence, flower color, no. of pods/ cluster, no. of pod cluster/ plant, pod pubescence intensity, pod pubescence color, pod shape, pod length, pod width. The data recording is in progress.

15.2.3 Pigeonpea- A total of 113 accessions of *Cajanus cajan* collected from Jharkhand were sown for multiplication and preliminary characterization in augmented design with a national check (NDA-1) and a local check (Bahar) with three number of rows per accession. The lengths of rows were kept at three meters. The distance between rows was kept 50 cm and between accessions 75 cm. A basal dose of N:P:K in the ratio of 25:50:30 Kg/ha was also applied at the time of sowing. The data recording is in progress.

15.2.4 *Andrographis paniculata* (Kalmegh) – A total of 10 accessions were characterized. These accessions were collected during various exploration trips carried out in Jharkhand. These were characterized for 13 different traits of economic importance. The observations were recorded on 10 plants of each accession and averaged. The branching pattern in fifty percent of the plants was profuse while in the remaining fifty percent, it was of normal kind. The mean value of primary branches/ plant was found to be 24.9. The observations on leaf lamina length and width were taken from the leaf present nearest to the 6th primary branch from the base. The minimum leaf lamina length was 7.6 cm (IC331510, 551525) while the maximum length was 10.6 cm (IC376209) with a mean length of 8.87 cm. The leaf lamina width ranged from 2.1 cm (439110) to 3.5 cm (376209) with a mean width of 2.68 cm. The days to flowering ranged from 69 (IC331510) to 96 (IC439112) with an average of 85.5 days. Days to the maturity of the capsule were recorded when 50% of the total capsules born on the plant turned yellowish and ranged from 93 (IC331510) to 165 (IC336863) days with an average of 121.1 days. Plant height was measured in centimeters from the base of the plant up to the tip of the main stem at maturity and it varied from 49 cm (IC439110) to 65 cm (IC336863) with an average of

57.9 cm. The capsule length varied from 1.6 cm (IC331510) to 1.95 cm (IC376210) with a mean value of 1.77 cm. The minimum capsule width was recorded 0.3 cm (IC439111, 439110, 376209, VKG23/129, 439112, 376210) and maximum as 0.32 (IC336863, 331510, 399612, 551525) cm. The mean capsule width came out to be 0.308 cm. The number of seeds capsule was computed by taking an average of 10 capsules taken randomly. The value for the number of seeds per capsule ranged from 8.6 (IC376209) to 11.2 (IC336863) with a mean value of 9.7 seeds/ capsule. The fresh weight/ plant was recorded on the plants harvested at 50% flowering stage and ranged from 21.7 g (IC439110) to 157.6 g (VKG23/129) with a mean value of 79.09 g. The plants were shadow dried for 14 days to record dry weight per plant and the value ranged from 9.01 g (IC439110) to 68.81 g (VKG23/129) with a mean value of 32.36 g/ plant.

Multiplication and preliminary characterization of pigeonpea germplasm

Multiplication of *Sesbania* seeds for green manuring

15.2.6 *Costus speciosus* (Zingiberaceae)- Nine accessions collected from different parts of the state of Jharkhand were characterized and averaged for 12 different characters. Observations were recorded on 10 plants of each accession. The arial stem length varied from 54.5 cm (IC439154) to 91.2 cm (IC336848) with a mean value of 69.7 cm. Leaf length and width were recorded on 10th leaf from the flag leaf in order to measure length and width of the largest possible leaf. The days to first flower opening ranged from 42 (Coll.No.JBT53/26) to 71 (IC336847) with average of 56.5 days. The smallest inflorescence was 4.8 cm (IC331511) in length and the longest was 17.8 cm (Coll. No. JBT53/12) with a mean value of 11.3 cm. *Costus speciousus* has a spike inflorescence and the numbers of flowers per inflorescence were counted. The number of flowers per spike ranged from 15 (IC336847) to 59 (IC336848) with an average of 37.0 flowers. The days to capsule maturity ranged from 87 (IC439154) and to 157 (IC336846) with an average of 122 days. The length of capsule was measured in centimeters and it ranged from 3.07 cm (IC336847) to 4.88 cm (IC336846) with a mean value of 3.97. The fruit of *Costus* is a dehiscence capsule and minimum number of capsule/ spike were 11 (IC331511) and maximum were 39 (Coll. No.JBT53/ 12) with mean of 25.00 capsules. Rhizome yield per plant constitutes one of the most important traits and it ranged from 247.25 g (IC587570) to 879.16 g (Coll. No.JBT53/ 26). The average rhizome yield was computed to be 563.2 g/ plant.

15.2.7 *Chlorophytum* sp. (Liliaceae)- Seventeen accessions collected from different parts of the state of Jharkhand were characterized and averaged for 14 different characters. Observations were recorded on ten plants of each accession. The stem thickness varied from 1.3 cm (IC331846, 439144, 587544) to 2.5 cm (IC36212) with a mean value of 1.9 cm. Number of green lanceolate leaflets per plant were varied from 9 to 22 and average of leaflets per plant were 15.5. Leaf length and width were recorded on 5th leaf from the flag leaf in order to measure length and width of the largest possible leaf. The days to flowering ranged from 61 (418084) to 119 (IC587614) with an average of 90 days. The smallest inflorescence was 14.5 cm (IC331847) in length and the longest was 58.9 cm (IC587498) with a mean value of 36.7 cm. *Chlorophytum* sp. has a panicle inflorescence and the numbers of flowers capsule per inflorescence were counted. The number of capsule per panicle ranged from 17 (IC587544) to 87 (IC385075, JBT59/14) with an average of 52 capsule. Number of root per plant were varied from 13 (IC331848) to 69 (IC587614) with a mean value of 41. The length of tuberous root was measured in centimeters and it ranged from 2.5 cm (IC336211) to 5.92 cm (IC587614) with a

mean value of 4.21. Tuberous root yield/ plant constitutes one of the most important trait and it ranged from 24.06 g (IC439144) to 158.83 g (IC418084). The average root yield was computed to be 91.44 g/ plant.

15.2.8 ***Asparagus racemosus*** – Twenty one accessions collected from different parts of the state of Jharkhand were characterized and averaged for 12 different characters. Observations were recorded on 10 plants of each accession. Stem colour of stem was green or light purple and bearing curved or straight spine. The stem diameter was measure from ground level and varied from 0.3 cm (IC336841, 551517) to 0.7 cm (IC331521, 398896) with a mean value of 0.5 cm. Plant has sparsely or profusely branching pattern. The flattened green colour cladodes were arranged in erect phyllotaxy and length was varied from 0.92 cm (IC398896) to 2.44 cm (IC439115) and average of length of cladode was 1.68 cm. Number of cladode/ cluster were range from 2.8 (IC336841, IC587594, JBT51/7, JBT50/100) to 3.2 (IC439113, IC331521, JBT53/8) with average of 3.0. The days to 50% flowering ranged from 76 (IC587542) to 127 (IC587594) with an average of 101.5 days. The smallest inflorescence was 0.88 cm (Coll. No. VKG24/ 128) in length and the longest was 5.6 cm (IC439113) with a mean value of 3.24 cm. *Asparagus racemosus* has a panicle inflorescence and bearing white colour flowers with scarlet, subglobose fruits. Plant height was varied from 81.5 cm (IC399620) to 247 cm (IC399624) with mean value of 164.25 cm. Numbers of roots/ plant were varied from 34 (IC399624) to 167 (IC439114) with a mean value of 100.5 roots. The length of tuberous root was measured in centimeters and it ranged from 15.28 cm (IC587497) to 40.68 cm (IC551517) with a mean value of 27.98 cm. fresh tuberous root yield/ plant constitutes one of the most important trait and it ranged from 247.42 g (Coll. No. JBT53/46) to 1265.48 g (Coll. No.JBT53/8) and average root yield was computed to be 756.42 g/ plant.

15.2.9 ***Dioscorea*** **sp.** (Dioscoreaceae) Seventeen accessions which are collected different districts of Jharkhand state were characterized for different 15 characters. The leaf arrangement of the vine was alternate or opposite and texture of lamina was leathery or membranous.The leaf colour was dark green or light green. Leaf lamina shape was cordate, shallowly cordate and Triangle. Lamina base of the leaf was deeply cordate, shallowly cordate and hastate. The leaf length varies from minimum 9 cm (Coll. No. JBT50/80) to maximum 17.4 cm (IC343045) with average of 13.2 cm. the minimum range of petiole length was 3.2 cm (IC447845) and maximum range 11.9 cm (IC332094). The mean value of petiole length was 7.55 cm. The range of rhizome length was varied from 3.2 cm (IC332094) to 80.7 cm (IC332094) with mean of 41.95 cm. Minimum girth of rhizome was 4.8 cm and maximum girth was 19.52 cm with an average 12.16 cm. The minimum number of buds per rhizome was 2 (IC348015, 447845) and maximum was three (IC417502) with an average of 3 buds per rhizome. The branching range of rhizome was varied from 2 (IC331836, 348015) to 3 (IC343045) with the mean of 2.5. Colour of rhizome was brown, grey and minimum yield was ranges from 9.52g (IC331734) to 1655.1 (IC332094) with average 832.31g. Flesh colour of rhizome was light purple, pale yellow and white.

15.2.10 ***Curculigo orchioides*****–**A total of 18 accessions collected from different parts of the state of Jharkhand were characterized and averaged for seven different characters. Observations were recorded on 5 plants of each accession. Leaf colour was dark green, glabrous and shape was linear lanceolate. Number of leaves per plant varied from 7 to 14 and average of leaves per plant was 10.5. Leaf length and width were recorded on 5th leaf from the flag leaf in order to measure length and width of the largest possible leaf. Leaf length ranged from 19.1 cm to 41.6 cm with a mean value of 30.35 cm whereas the width varied from 1.9 cm to 5.9 cm with a mean value of 3.6 cm. Root stock height rang varied from 5.3 cm to 21.3 cm (with a mean value of 13.3cm. The length of tuberous root was measured in centimeters and it ranged from 7.7 cm to 13.24 cm with a mean value of 10.47 cm. The minimum root diameter was recorded 0.4cm and the maximum was 0.7 cm with an average diameter of 0.55 cm. Tuberous root yield per plant constitutes one of the most important trait and it ranged from 3.38 g to 34.14 g. The average root yield was computed to be 18.76 g/ plant.

15.2.11 ***Tinospora cordifolia-*** A total of 18 accessions were evaluated for seven characters, collected from different state of Jharkhand. It is a perennial twinner with warty surface of stem was pubescent and glabrous. Bark colour of stem was grey and grey brown. Main stem thickness is measured at 10 cm above from the ground. Stem thickness varied from 4.7 cm (IC587580) to 2.1 cm (IC439235) with a mean value 3.4 cm. Leaf was cordate and length of

10th leaf measured from the flag leaf. Length of leaf varied from 5.2 cm (Coll.no.JBT59/9) to 16.7 cm (IC531616) with a mean value 10.95 cm. Leaf surface was pubescent and glabrous. Leaf colour was green and dark green. Petiole length varied from 2.3 cm to 14.1cm with a mean 8.2 cm.

15.3 Germplasm Maintenance in Field Genebank

Germplasm maintenance in field genebank- Jackfruit (154), Tamarind (51), Barhal (14), Aonla (19) *Mangifera* (19) *Musa* sp. (34) & *Moringa oleifera* (14)

15.4 Germplasm Conservation

15.4.1 Cryobank: *Cassia absus* (2), One Sample of each accession of *Aerva lanata, Luffa cylindrica, Ludwigia perinnis, Ocimum gratissimum, Cucumis hardwikii, Clitoria ternatea, Abutilon indicum, Ocimum sanctum, Abelmoschus moschatus, Plectranthus incanus, Ocimum basilicum & Momordica charantia. Bryonopsis laciniosa, Hyptis suaveolens, Cymbopogon citronella, Leea macrophylla, Plumbago zeylanica, Sonchus oleraceous, Thespasia lampas, Vetiveria zizinaoides, Vernonia anthelmntica* were conserved in cryobank

15.4.2 Long Term Storage: *Costus speciosus* (9), *Cymbopogn martini* (2), *Leea macrophylla,* (2) and one Sample of each accession of *Coix lachrymal jobi, Pentapetes phoenicia, Martynia ginandra, Zea Mexicana, Sasbania canabina, Solanum xanthocarpum, Datura metel, Celosia cristata, Dolichos lablab, Withania somnifera, Hibiscus pungens, Artemisia annua, Indigofera tictoria, Cymbopogon citronella, Hyptis suaveolens, Sida acutifolia, Abroma augusta, Plumbago zeylanica, Vetiveria zizianioides, Vernonia anthelmintica, Thespasia lampas, Sonchus oleraceous and Brynopsis laciniosa* were sent for LTS

15.5 Germplasm Supply

A total of 15 accessions, *Terminalia bellerica* (1), *Vitex peduncularis* (1), *Cajanus cajan* (1) and *Jatropha* sp. (12) were supplied to various national institutes.

Research Programme (Code, Title, Programme Leader)

PGR/PGC-BUR-RAN-01.00 Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in Bihar, Jharkhand and adjoining areas (**JB Tomar**)

Research Project (Code, Title, PI, Co-Pland Associates)

PGR/PGC-BUR-RAN-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agriculture crops, their wild relatives and economic species including medicinal plants (**JB Tomar**, SK Bishnoi and AK Gupta)

PGR/PGC-BUR-RAN-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of horticultural crops & perennial medicine (**JB Tomar**, SK Bishnoi and AK Gupta)

Externally Funded Projects

- Bio-survey, Inventorisation & Conservation of endangered, threatened and rare Medicinal and Aromatic Plants (MAPS) and Associated Indigenous Traditional Knowledge (ITK) in Tribal Region of Jharkhand. (Funded by DRDO) (**JB Tomar**)

16. REGIONAL STATION, SHILLONG

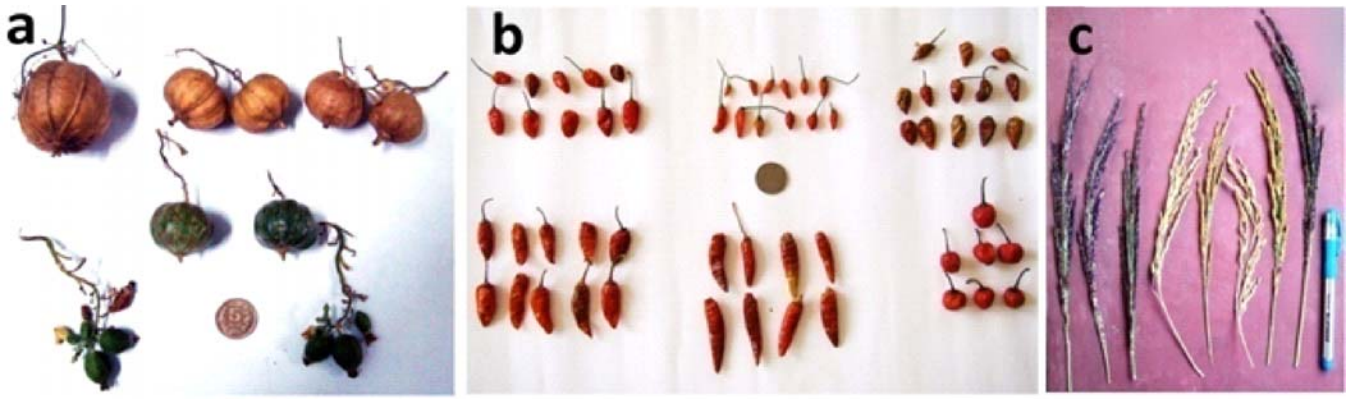
Summary: Three explorations were conducted in West Bengal, Arunachal Pradesh and Tripura, and a total of 185 accessions were collected. The Jalpaiguri and Cooch Behar districts of West Bengal were explored for collection of landraces of *Kharif* crops and 85 accessions comprising cereals and pseudocereals (27), pulses/ grain legume (6), vegetables (33), oil seeds (8), rhizomatous crops (8), fibre crop (1) and other (2) were collected. Collection of hill rice germplasm (67) was made from East Kameng, Kurung Kumey and Papum Pare districts of Arunachal Pradesh. Notable diversity was found for two distinct categories of rice: late maturing and bold grained type called *Umte,* and early maturing small grained type called *Tening*. All four districts of Tripura were explored for collecting pigeon diversity in the state. In addition to *Cajanas cajan*, the wild pigeonpea (*C. scaraboedes*) germplasm was collected from Lembucherra and Jumpui hills area. During *Kharif* 2012, a total of 1,134 accessions of different agri-horticultural crops comprising paddy (350), maize (132), rice bean (106), buckwheat (55), ginger (150), turmeric (185), chilli (105) and *Perilla* (51) were characterized and 137 accessions of under-utilized (UU) crops were evaluated under replicated trials. The germplasm of rhizomatous crops, such as *Dioscorea* (46), and fruit crops viz. banana (60), citrus (29), guava (8), other fruits (9) and M&APs (100) have been maintained in the FGB. A total of 170 accessions of different crop germplasm were supplied to various indenters. Nine-hundred and eight accessions of different crops were sent to National Genebank, New Delhi for long-term conservation and 114 accessions were added to medium-term storage facility of the station.

16.1 Exploration

Three explorations were led by the station and one was undertaken as a collaborator. All the explorations were undertaken as a part of NEH exploration programme. Both crop-specific and multi-crop explorations were conducted in northern parts of West Bengal, Arunachal Pradesh and Tripura.

16.1.1 Collection of multi-crops (landraces of major *Kharif* crops) from parts of West Bengal (North Bengal: Cooch Behar and Jalpaiguri): A total of 85 accessions comprising cereals and pseudocereals (27), pulses/ grain legume (6), vegetables (33), oil seeds (8), rhizomatous crops (8), fibre crop (1) and other (2) were collected from the explored regions of North Bengal. The exploration was conducted during October-November, 2012 in collaboration with UBKVV, Pundibari, Cooch Behar. Rice was the main crop, and considerable diversity was observed in the local cultivars collected from remote villages for grain size, colour, aroma, maturity period, and plant height. Good variability was also observed in bottle gourd and Chilli for fruit shape and size. Two accessions of sponge gourd with vary small fruit found in clusters (2-5) with length (2.0-3.0 cm) and width (2.5-3.5cm) was collected in Sitalkuchi and Mathabhanga-II blocks of Cooch Behar district. Medicinal and aromatic plants were also found to be grown by every household in their kitchen garden and home compounds in this area and having related ethno-medicinal traditional knowledge.

16.1.2 Collection of hill rice from East Kameng, Kurung Kumey and Papum pare districts of Arunachal Pradesh: The exploration was conducted



Variability collected from North Bengal. a. *Luffa cutangula*var: hermaphrodite collected from Cooch Behar; b. variation in fruit morphology in chilli; c. panicles of rice landraces collected.

during November, 2012 in collaboration with CRRI, Cuttack. The topography of the explored region was mountainous and the altitude of the collection sites ranged from 450-1400 m. The explored area is primarily inhabited by the *Nishi* tribe who practice hunting and fishing in addition to agriculture. In this exploration only the rice germplasm grown in *jhums* were collected. Crop was sown during May-June by dibbling method after clearing the forests. Harvesting was done during October-November. Collection was made mainly from the farm stores. A total of 67 rice accessions were collected. The collected germplasm comprised of two types: late maturing and bold grained type called *Umte,* and early maturing small grained type called *Tening*. Considerable diversity was observed for grain shape and colour in addition to maturity. Rice is locally called *Um* (East Kameng/ Papum Pare), *Dugu*and *Dagam* (Kurung Kumey). The hill rice are poor yielder that the lowland types, but people prefer to consume hill rices due to better taste.

16.1.3 Collection of pigeonpea with emphasis on its landraces & wild relatives from Tripura: All four districts of Tripura were explored during December, 2012 in collaboration with IIPR, Kanpur. In general, rich variability was observed in pigeonpea in the state. Considerable variability was observed and collected for plant height (243-488 cm), plant girth (up to 30 cm), pod length (5-8 cm), pod width up to 1cm, grain/ pod, pod colour, pod quality, flower colour, grain size and colour. The wild pigeonpea (*Cajanus scaraboedes*) was collected from Lembucherra and Jumpui hills area whose leaves are rubbed on hands to cure Jaundice.

In addition to these explorations, one exploration for the collection of mustard germplasm in West Siang, East Siang, Lower Subansiri and Papum Pare of Arunachal Pradesh was undertaken as a collaborator during February, 2012.

Collection of Pigeonpea from Tripura. a- c. Variability in pod and flower characteristics; d. *Cajnus scaraboedes*(Wild), collected from Lembucherra, Tripura; e. Variability in pod characteristics in the collected pigeonpea germplasm

16.2 Characterization and Maintenance of Germplasm

During *Kharif* 2012, a total of 1134 accessions of different agri-horticultural crops were characterized and 137 accessions of under-utilized (UU) crops were evaluated under replicated trials. The details of the characterization are as follows:

16.2.1 Paddy

16.2.1.1 Upland paddy: One-hundred three accessions of upland paddy were evaluated in augmented block design (ABD) with five checks namely Maniphou, Ngoba, Kalinga, Sarsha and Prasad. Wide variability was observed for both quantitative and qualitative traits.

Variability in grain morphology found in rice accessions of Nagaland

16.2.1.2 Lowland paddy: A total of 247 lowland rice acions from Nagaland. The aromatic rice germplasm of Manipur also showed wide variation in grain morphology and plant architecture.

16.2.2 Maize: One-hundred and thirty two maize accessions were characterized for 25 agro-morphological traits along with six checks (local yellow, local white, local red, Delhi check, Navjot and RCM-1-1). Observations were taken for 25 traits including 15 qualitative traits. Variability in maize germplasm for the quantitative traits was recorded.

16.2.3 Rice bean: A total of 106 rice bean accessions were characterized along with four checks viz. PRR-1, PRR-2, RBL-1 and RBL-6 during the period. Data were recorded for 8 qualitative and 11 quantitative traits.

16.2.4 Buckwheat: Fifty five accessions of buckwheat were characterized and five checks were used. Data were recorded for 18 morphological traits.

16.2.5 Germplasm trials: Following germplasm, AVT/ IVT trials were conducted during *Kharif*, 2012:

Crop	Number of accessions	Checks used	Experimental design
Rice bean	25	4	RBD
Perilla	25	2	RBD
Coix	25	2	RBD
Buckwheat	50	4	RBD
Rice bean	12 (IVT/AVT)	3	RBD

Variability in cob morphology in a set of maize accessions collected from Nagaland

16.2.6 Ginger: A total of one-hundred and fifty accessions were characterized with four checks and the descriptive statistics for some morphological traits recorded.

16.2.7 Turmeric: Agro-morphological variability in 185 turmeric accessions.

16.2.8 Other crops: 51 accessions of *Perilla* and 105 accessions of chilli were also characterized during the period.

16.2.10 Maintenance of horticultural germplasm in FGB: The germplasm of rhizomatous crops, such as *Dioscorea* (46), and fruit crops viz. banana (60), citrus (29), guava (8), other fruits (9) and M&APs (100) have been maintained in the FGB.

16.3 Germplasm Supply

- Planting materials of *Alpinia officinalis* (1), *Zingiber cassumunar* (1), *Bosenbergia* sp. (1), *Cautleya* sp. (1), *Costus speciosus* (1), *Curcuma caesia* (2), *Curcuma* sp. (10), *Elaeocarpus ganitrus* (5), *Kaempferia rotunda* (1), *Strobilanthes involucrate* (1) were supplied to Department of Biotechnology, IBSD, Takyelpat Institutional Area, Imphal, Manipur.
- 35 accessions of *Capsicum chinense* and *C. frutescens* were supplied to ICAR, RC for NEHR, Umiam, Meghalaya.
- Rice bean (25), Buckwheat (25), *Coix* (25), *Perilla* (25) to six locations (Shimla, Bhowali, Almora, Ranichauri, Palampur and Sangla) were supplied for germplasm evaluation trial under AICRP on UUC and one rice bean entry IC395028 supplied for IVT on UUC. Ten accession of *Perilla* were supplied for chemical analysis as per technical programme of AICRP on UUC Department of Plant Breeding, CCS, Hisar, Haryana.

16.4 Germplasm Conservation

16.4.1 Long term storage at National Genebank: Paddy (Lowland: 182; Upland: 176), maize (183), buckwheat (100), chilli (64), rice bean (64), *Coix* (54) and *Perilla* (34) were deposited for LTS at National Genebank, NBPGR, New Delhi. A total of 51 accessions comprising rice (22), Setaria (2), buckwheat (2), black gram (4), brinjal (2), green gram (1), coriander (2), *Malva* sp. (2), *Amarantthus* sp. (1), spinach (1), radish (1), mustard (3), sesame (3), niger (1), *Linum* (1) and jute (1) collected from North Bengal have been sent for LTS at NBPGR, New Delhi.

16.4.2 Medium-term storage at Umiam: Paddy (40 accessions of aromatic rice from Manipur), maize (45 accessions), buckwheat (29 accessions) were added to the MTS facility after multiplication.

Research Programme (Programme code: Title, Leader)

(PGR/PGC-BUR-SHL-01.00): Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of plant genetic resources in north-eastern India (**AK Misra**)

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. (**AK Misra**, RS Rathi, S Roy)

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. (**AK Misra**, RS Rathi, S Roy)

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. (**RS Rathi**, AK Misra, S Roy)

17. REGIONAL STATION, SHIMLA

Summary: Two germplasm explorations was undertaken to collect germplasm of wild and minor temperate fruits, common bean and rice landraces from different parts of Himachal Pradesh and Uttrakhand. A total of 86 accessions common bean (43), rice (18), *Malus baccata* (2), *Prunus mira* (3), *P. armenica* (4), *P. cornuta* (2), *Rubus* sp. (3), *Sorbus lanata* (2), *Hippopahe rhamnoides* (3), and *Cotoneaster rotundifolius* (2) were collected. Significant collections include landraces of rice, kidney bean and some wild relatives of temperate fruits and amaranth. A total of 2,979 germplasm accessions were grown during the year for characterization, evaluation and multiplication. Genetic variability for seed and pod colour, shape and size was recorded in pea, kidney bean, cowpea germplasm and also for other traits in different crops. Among fruits, 137 accessions of apple (25), pear (23), peach (24), plum (31), apricot (23) and walnut (34) were characterized and evaluated for different qualitative and quantitative characters. Wide range of variability was recorded for traits like fruit colour, shape and size. Accessions viz. EC349910, EC552628, EC44005 of apple and IC558065, EC539003 and EC346008 of apricot for multiple traits Among five varieties of nectarine cv. 'Silver King' was found free from gummosis and has large fruit with attractive skin colour. A total of 206 accessions comprising of pea (33), amaranth (127), chenopod (18), soybean (27) and rice bean (1) were supplied to National Genebank for Long Term Storage while 11,460 accessions of seed crops and 1,197 of perennial crops were conserved in the MTS and FGB, respectively. A variety 'VRB-3' for high yield (17.05 q/ha), and light green seed colour and mid maturity (133 days) was indentified for release. Germplasm comprising 1,998 seed samples of agricultural crops and 968 rooted plants/seedling and 253 bud sticks/ cuttings of fruit crops were supplied to researchers across the country.

17.1 Germplasm Exploration

Two germplasm explorations was undertaken to collect germplasm of wild and minor temperate fruits, common bean and rice landraces from different parts of Himachal Pradesh and Uttrakhand. A total of 86 accessions common bean (43), rice (18), *Malus baccata* (2), *Prunus mira* (3), *P. armenica* (4), *P. cornuta* (2), *Rubus* sp. (3), *Sorbus lanata* (2), *Hippopahe rhamnoides* (3), and *Cotoneaster rotundifolius* (2) were collected. Genetic diversity was collected for various traits such as seed shape, size, colour, plant types, and growing habitats. Farmers in the mountain regions grow common bean as mixture of several landraces, which eventually create more variability spatially and temporally. Some rare and important landraces of rice such as *Jauliya, Anjan, Suda, Sal, Kalthunia, Jhusia, Santola, Sunahari, Kaljari, Ushkala, Lalsatti, Kurbural, Satkuli, Bareeksatti, Garudiyadhan, Jiri, Jhinuwa, Rangadi, Ramjawan, Kurmundu, Safedfulpatash, Kala fulpatash, Dewalu, Kathedi, Jwasa, Jauliya* were collected from remote areas. These wild relatives of temperate fruits are used as rootstocks to their cultivated allies and possess gene for many important traits including soil borne diseases. For instance, *P. mira* locally called *bhemi* is a heterozygous autogamous species, believed to be a natural hybrid of almond and peach and is crossable with almond and peach.

17.2 Germplasm Characterization and Evaluation

17.2.1 Agricultural crops: A total of 2,979 germplasm accessions were grown during the year for characterization, evaluation and multiplication. The germplasm was characterized in augmented block design and also in randomized blocked design along with standard checks. The data were recorded as per the standard descriptors and analyzed for mean, range and promising accessions were identified for important traits.

Table 1: Crop-wise details of the germplasm grown

Crop	Accessions	Check
Amaranth	570	Annapurna, PRA-2, PRA-3, Durga
Buckwheat	228	Himgiri, Himpriya, VL-7, PRB1
Chenopod	83	PRC-9801, EC507741, IC22503
Kidney bean	1578	Triloki, Vaspa, Jawala, PLB-10-1, PLB-14-1, Kailash
Rice bean	28	PRR-1, PRR-2, RBL-1,RBL-6
Pea	365	DMR-7, DMR-11, Azad pea, Super Lincoln, Rachna, HFP-4
Adzuki bean	44	HPU-51, Totru local
Cowpea	16	Multiplication
Soybean	29	Multiplication
Kulthi	13	Multiplication
Urd bean	9	Multiplication
Small millets	16	Multiplication

Farmers generally grow a mixture of landraces of common bean in hills

***Prunus mira* – a close wild relative of peach and almond, cold hardy and used as rootstock**

17.2.2 Promising accessions for various traits were identified- Promising accessions for various traits were identified in grain amaranth, buck wheat, adzuki bean, rice bean, and kidney bean, pea and chenopod.

17.2.3 Characterization of fruit crops: The germplasm comprising apple (25), pear (23), peach (24), plum (31), apricot (23) and walnut (34) were characterized and evaluated for different qualitative and quantitative descriptions. In apple, fruit length ranges from (44-70.5mm) while days to fruit maturity ranged from 61 to 156 days, fruit weight ranged from 43.98 to 169.3g with mean value 101.26 g while TSS ranged from 10.4 to 19.50%. Accessions viz. EC349910, EC552628, EC44005 found superior for multiple traits. In pear, fruit weight was found 126-262 g, coefficient range 35.82% and days to fruit maturity ranged from 82 to 148 days. The fruit length value observed 38.5 to105 mm, fruit width 42.5 to 84.96 mm, flower stalk length (2.1-.5.1mm), TSS (7.4-14.1%) and no. of flower buds/ inflorescence 3-12. In peach, TSS 6.6 to 16% was observed, followed by fruit weight (77.96g). Fruit weight showed wide range of variation from 21.5 to 123.1g, Fruit pressure1.7- 4.8 kg. Among five varieties of nectarine cv. 'Silver King' was found free from gummosis and has large fruit with attractive skin colour.

In plum, fruit weight is 30.14g, followed by stone weight 1.29g. The fruit maturity ranges from 65 to 132 days while fruit weight ranged from 4.57 to 116.5g. Accessions viz. IC558082, IC566180, and EC539001 were found superior for multiple traits. In apricot**,** fruit weight was found (32.30g) followed by kernel weight (2.52g). Fruit maturity ranged from 61 to 91 days while fruit weight ranges from 18.7 to 73.82g. The TSS ranges from 11.20 to 22.80% and kernel length from 13.5 to 28.42mm. Accessions viz. IC558065, EC539003 and EC346008 showed superiority for early maturity, high TSS and fruit weight**.** In walnut kernel ratio 17.74 to 70.85%was recorded and shell thickness (1.27-4.82 mm) followed by kernel weight (1.18-13.2g) and nut weight (6.65-31.7).

Characterization of grain amaranth germplasm

EC047839 of common bean is bush type and identified high number of pods and seed yield

EC44005 of apple have attractive fruit colour and size

EC539001 of plum have large fruit size, attractive colour, high TSS and productivity

Apricot cv. EC539003 showed early maturity, large fruit size and high productivity

17.3 Germplasm Conservation

A total of 206 accessions comprising of pea (33), amaranth (127), chenopod (18), soybean (27) and rice bean (1) were supplied to National Genebank for Long Term Storage while 11,460 accessions of seed crops and 1,197 of perennial crops were conserved in the MTS and FGB, respectively.

c. Conservation of Crops Wild Relatives (CWR): Wild relatives of various agri-horticultural crops species have been maintained both in the MTS facility for seed crops and in the FGB for perennial and vegetative propagated crops

17.4 Germplasm Supply

Germplasm comprising 1,998 seed samples of agricultural crops and 968 rooted plants/ seedling and 253 bud sticks/ cuttings of fruit crops were supplied to researchers across the country.

Crop	Crops Wild Relatives
Amaranth	*Amaranthus hybridus, A. retroflexus, A. lividus, A. viridis, A. graecizans, A. dubius, A. spinosus* and *A. tricolor*
Buckwheat	*Fagopyrum emarginatum, F. Cymosum, F. tataricum* var. *himalaicum* and *F. giganteum*
Chenopod	*Chenopodium amaranticolor, C. botrys, C. murale* and *C. ambrosioides*
French bean	*Phaseolus lunatus* and *P. coccineus*
Faba bean	*Vicia hirsuta, V. tetrasperma, V. villosa*
Apple	*Malus baccata, M. spectabilis, M. micromalus, M. zumi, M. sargentii, M. sikkimensis, M. mandshurica, Malus x scheideckeri, M.sieversii, M.orientalis, M.drangensis, M.prunifolia*
Pear	*Pyrus pyrifolia, P. pashia* var. *kumaoni, P. jacquemontiana, P. pashia*
Prunus spp.	*Prunus nepaulensis, P. armeniaca, P. cerasoides, P. mira, P. mume, P. x pseudocerasus, P. cerasus, P. cornuta*
Walnut	*Juglans nigra, J. mandshurica, J. ailantifolia, J. cordiformis*
Kiwi	*Actinidia arguta, A.callosa*
Grapes	*Vitis ficifolia, V. arizonica, V. riparia, V. barlandierii, V. acerifolia, V. gerdiana, V. aestivalis, V. amurensis, V. cinerea, Parthenocissus quinquefolia, P. himalayana*
Pistachio nut	*Pista atlantica, P. terebinthus, P. chinensis* subsp. *integerrima*
Olive	*Olea grandulifera*
Rubus spp.	*Rubus ellipticus, R. niveus, R. paniculatus, R. lasiocarpus, R. fruticosus, R. macilentus, R. mollucanus, R. assamensis, R. nutans* and *R. calycinus*
Minor fruits	*Punica granatum, Cotoneaster. bacillaris, C. salicifolia, C. zabelli, C. franchettii, Crataegus wendlandii, C. melanocarpa, C. oxycantha, Feijoa sellowiana, Cydonia oblonga, Docynia indica, Viburnum cotinifolium, Elaeagnus umbellata, Castanea crenata, Olea cuspidata, Ziziphus jujuba, Diospyros lotus, Ficus palmata, F. carica, Corylus jacquemontii*
Allium spp.	*Allium fistulosum, A. tuberosum, A. schoenoprasum, A. sativa* var. *ophioscordon, A. ampeloprasum, A. angulosum, A. oschaninii. Allium ascalonicum. A. ledebouranum, A. clarkei, A. proliferum* and *A. alticum*

- **Seed Crops**: Chenopod (145), pea (91), French bean (116), wheat (21), barley (14), paddy (77), amaranth (1019), adzuki bean (60), rice bean (32), buckwheat (319), maize (26), finger millet (4), proso millet (3), foxtail millet (4), barnyard millet (3), cowpea (6), soybean (33) and kulthi (25).

- **Rooted plants/Seedlings:** Apple (100), kiwi (84), peach (6), plum (12), pear (463), pepino (12), persimmon (49), apricot (04), *Stevia* (02), pecan nut (13), pineapple-guava (63), Chinese ber (16), hazelnut (03),walnut (53), persimmon (48), grapes (17), stevia (03), fig (20).

- **Bud sticks/ Cutting:** Apple (62), pear (21), strawberry runner (150), Medicinal (20).

17.5 Development of Varieties

- Rice bean: A variety 'VRB-3' for high yield (17.05 q/ha), and light green seed colour amd mid maturity (133 days) was indentified for release in the 23rd Annual Group Meet of All India Coordinated Research Network on Under-utilized Crops– 2012 at MPKV, Rahuri.

- Two varieties viz. 'HPU-51' of adzuki bean for high yield (13.20 q/ha) and red seed color and 'IC415477' for high yield (10.34 q/ha), and early maturing (110 days) of chenopod were recommended to State Variety Release Committee by CVRC.

17.6. Germplasm Registration

- One accessions viz. IC218988 of pea for resistance against the four isolates viz. *rangway, trilokinath, stingri* and *kangra.*

- One accession of buckwheat viz. IC014889 for high rutin content (29.83 ug/mg).

- One accession of kidney bean viz. IC341862 against four races - 03, 515, 529, and 598 of bean anthracnose.

Research Projects ((Project Code, Title (PI and CoPI)

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 (**JC Rana** and VD Verma)

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. (**VD Verma**, JC Rana and Sandhya Gupta)

Externally Funded Ad-hoc Research Projects

- Impact of climate change on plant species composition: analyzing with a few typical plant species in Shimla and Kinnaur Districts of Himachal Pradesh **(JC Rana, DST)**
- Snout monitoring, mapping, mass and energy balance and assessment of biophysical environment of Nardu glacier, Baspa basin, District Kinnaur, Himachal Pradesh **(JC Rana, DST)**
- To understand the impact of retrieving snowline on the agri-diversity, other flora and societies in Spiti basin-A joint programmed of MOEF and DOS on the monitoring Snow and Glaciers of Himalayan Region **(JC Rana, DOS)**
- Evaluation of genetic diversity of Kidney bean, Field pea for agronomic, quality and processing traits **(JC Rana, DBT)**

18. REGIONAL STATION, SRINAGAR

Summary: Two explorations were undertaken and a total of 66 accessions comprising rice landraces (32), linseed (12) and wild safflower (22) were collected from different areas of Kashmir. Significant collections include some rare landraces of rice from high altitude areas. 672 accessions comprising of wheat (310), barley (264) and mustard (98) were evaluated for their morpho-agronomic characters as per the minimal descriptors during *rabi*2011-12 under rain fed conditions of Himalayas. 45 germplasm accessions of strawberry (3), *Allium cepa* var. *proliferum* (pran) (5), mint (1), *Iris* sp. (1), garlic (12) and *Dioscorea deltoidea* (23) are being maintained in the experimental field.

18.1 Exploration and Germplasm Collection

During the period under report two explorations were undertaken by Regional Station Srinagar and a total of 66 germplasm accessions of linseed, wild safflower and rice landraces were collected from different areas of Kashmir.

18.1.1 Exploration and collection of wild safflower and linseed from different areas of Kashmir: The exploration was conducted in the month of September 2012 and 22 accessions of wild safflower (*Carthamus lanatus*) were collected from different areas in the districts of Anantnag, Baramulla, Budgam and Pulwama. Also, 12 accessions of linseed (*Linum usitatissimum*), now rarely cultivated in Kashmir were collected from different villages of Budgam and Pulwama districts.

18.1.2 Exploration and collection of rice landrace diversity from high altitude areas of Kashmir: In collaboration with DRR Hyderabad, second exploration and germplasm collection programme of rice landraces from high altitude areas of Kashmir was conducted from September to October, 2012. Thirty two accessions of valuable germplasm of rice landraces were collected from high altitude areas with an altitudinal variation of 1510-2136 m, falling in the districts of Anantnag, Baramulla, Budgam and Kulgam. Besides 'Mushuq Budij'-famous aromatic rice landrace of Kashmir, other collections include landrace Kamad and very rare landraces like Baber, Barkat, Kathwara, Kawakuder, Shallakeau and some Zag (red rices) varieties. Most of these landraces are highly endangered.

18.2 Characterization and Evaluation of Germplasm

A total of 672 accessions comprising of wheat (310), barley (264) and mustard (98) were evaluated for their morpho-agronomic characters as per the minimal descriptors during *rabi* 2011-12 under rain fed conditions using Augmented Block Design and promising accessions identified for various agronomic traits in each of these crops.

Wild safflower (*Carthamus lanatus*) collected from different areas of Kashmir

Linseed (*Linum usitatissimum*) collected from Budgam and Pulwam districts of Kashmir

Genetic diversity in paddy fields in high altitude areas of Kashmir is highly endangered. Some accessions of landraces were collected from this field in Verinag Anananag

Rice landraces diversity collected from high altitude areas of Kashmir

Mushuqbudij-famous aromatic rice landrace of Kashmir collected from this field at Nunar Budgam

18.2 Maintenance of Germplasm

A total of 45 germplasm accessions of strawberry (3), *Allium cepa* var. *Proliferum* (pran) (5), mint (01), *Iris* (1), garlic (12) and *Dioscorea deltoidea* (23) are being maintained in the experimental field.

18.3 Supply of Germplasm

Eight germplasm accessions of walnut were supplied to NBPGR Regional Station Hyderabad for exhibition. Green pod pea (10 kgs.) multiplied at the station were supplied to farmers of nearby villages.

Research programme (code, title, leader)

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**)

19. REGIONAL STATION, THRISSUR

Summary: A total of 114 accessions of germplasm was collected in two exploration and collection missions carried out in one district of Arunachal Pradesh and nine districts of Assam. Besides, fifteen collections were added to the germplasm holdings through personal efforts. During *rabi* 2011-12, 160 accessions of rice (*Oryza sativa*), 100 of horsegram (*Macrotyloma uniflorum*) 34 of cucumber, 7 of *Alpinia galanga*, 5 of *Alpinia calcarata*, 17 of *Kaempferia galanga* and 31 of kokum were characterised/ evaluated. During *Kharif* 2012, 11 accessions of upland rice landraces, 126 of lowland rice and 30 of deepwater rice, 24 of sesame, 11 of bittergourd, 50 of teasel gourd, 27 of ashgourd and 34 of Malabar tamarind (*Garcinia cambogia*) were characterised/ evaluated. A new species of wild okra, *Abelmoschus enbeepeegearense* was discovered. Out of the collected germplasm, 1 accession of unique landrace of chillie, 59 of landraces of deep-water rice and 21 of *Oryza rufipogon* from Assam and 131 multiplied accessions mostly of forage crops and wild *Vigna* for were sent for long-term storage at NGB, NBPGR, New Delhi. For cryo-preservation, seven accessions of *Oryza* species were sent. A holding of 7,685 and 2,482 accessions of different crops/ species/ wild relatives/ weedy forms are being maintained in MTS and FGB, respectively. A total of 68 accessions in 4 crops (cassava–5, ginger–8, lesser galangal-1, greater galangal-17 and brahmi-22) and 2 crop wild related species (*Dioscorea pubera*-1, *D.pentaphylla*-3, *D.intermedia*-1, *D.belophylla*-1, *D.bulbifera*-2, *D.tomentosa*-1, *D.wallichii*-1, *D.oppositifolia*-1, *Curcuma raktakanta*-1 and *C.aeruginosa*-1) were maintained in *in vitro* conservation media. Based on material transfer agreement, 250 accessions mostly of wild *Abelmoschus*, horsegram, snakegourd and *Cucumis* were supplied to 12 user agencies mainly state agricultural universities.

19.1 Exploration and Collection

Two exploration and germplasm collection trips were undertaken during the period under report. In the first collaborative exploration and collection mission with CHES (IIHR), Bhubaneswar and in association with KVK Changlang district of Arunachal Pradesh and a total of 73 accessions of cucurbits were collected from home gardens and *Jhum* lands of primitive tribes. The collection included 23 of teasel gourd, 9 of cucumber, 11 of pumpkin, five of ash gourd, eight of bottle gourd, two of ridge gourd, four of melon, seven of sponge gourd, one of bitter gourd, two of *Trichosanthes lepeliana* and one of *Perilla ocimoides*. Good variability for fruit characters in teasle gourd, ash gourd, pumpkin, cucumber, smooth gourd and ridge gourd was collected. Efforts were made to visit maximum *Jhum* lands (shifting cultivation) for collection of land races and the agrarian tribes "Thangsa", and "Chakma" communities, besides Assamese farmers in Dibrugarh district of Assam were visited.

In the second exploration and collection mission was undertaken in collaboration with Central Rice Research Institute, Cuttack to nine districts of Assam on the north and south banks of the river Brahmaputhra for the collection of wild gene pool of rice, a total of 41 accessions were collected with the help of KVKs of Assam Agricultural Univeristy at Napam (Sonitpur Dt.), N. Lakhimpur (Lakhimpur Dt.), Teok (Jorhat Dt.) and Diphu (Karbi Anglong Dt.) and RARSs of AAU at N. Lakhimpur and Diphu.

Among these, 40 accessions were either wild or weedy forms of *Oryza rufipogon* and one was cultivated *O. sativa* cultivar *Kokoabao* rice for comparison. Fourteen accessions were collected from Sonitpur district, 8 from Lakhimpur district (including one cultivated *Kako abao* rice), two from Dhemaji district, three from Golaghat district, six from Jorhat district, six from Nagaon district, one each from Marigaon and Kamrup districts. Only one population of typical wild form with shattered panicles was found in the explored areas of Karbi Anglong district. Typical *O. rufipogon* forms occur as limited wild populations either isolated from the cultivated deep-water rice fields or in fallow deep-water fields or in stagnant water in rivers or near river beds. The introgressed forms of *O. rufipogon* occur as weeds in deep-water *bao* rice fields where mostly landraces of deep-water rice were grown or in certain shallow-water rice fields.

Rice (IC324590) with very long prominent sterile glume

Twelve collections comprising of *Agave* sp. (1), *Aloe vera* (6), *Areca catechu* (1), *Azadirachtaindica* (1), *Catharanthusroseus* (2) and *Caesalpiniasappan* (1) were collected locally. Besides, seeds of one accession of *Medicago sativa* from Jodhpur, Rajasthan; one of *Datura stramonium* from Mannuthy, Thrissur, Kerala and suckers of an accession of *Aloe vera* from Cithaveru, Dindigul, Tamil Nadu were procured through personal efforts.

19.2 Characterisation and Evaluation

19.2.1 Cereals

19.2.1.1 Rice (*Oryza sativa*) (*Rabi* 2011-12): One-hundred and sixty accessions of rice were evaluated in an augmented block design for 12 qualitative and 10 quantitative characters along with four check varieties namely Ahalya, Jaya, Jyoti and Thulasi. No variability was found in 3 qualitative characters namely leaf pubescence, panicle exertion and panicle type. The variability observed in 10 quantitative characters is presented below:

The promising accessions were identified and compared to the respective best check varieties for yield and yield attributing traits.

19.1.2.2 Rice (*Oryza sativa*) (Upland *Kharif* 2012): A total of 11 accessions of upland rice landraces identified superior over past two years were evaluated in a randomized block design for 12 qualitative and 10 quantitative characters along with three check varieties namely Harsha, Vaishak and Jyoti. Yield data could not be recorded due to bird damage. However, *Mundodan* (IC203776), *Palkaima* (IC203769) and *Veluthadichan* (IC203792) were found to be field resistant to blast and were of non-lodging type.

19.1.2.3 Rice (*Oryza sativa*) (Lowland *Kharif* 2012): One hundred and twenty six accessions of lowland rice which were evaluated in the year 2000 in *Rabi* season were evaluated in an augmented block design along with four check varieties namely Ahalya, Jaya, Jyoti and Thulasi. Out of 126 accessions only 58 accessions came to flowering normally and were founds suitable for both *Kharif* and *Rabi* seasons. Among the remaining, 28 accessions came to flowering very late beyond 6 months and 40 accessions did not flower at all. The flowered 58 accessions were evaluated for 10 quantitative and 12 qualitative yield traits. Acessions IC074655, IC74622C, IC074659, IC074622B and IC074705A found to be superior for yield per plant with 15.0, 15.0, 17.0, 17.0 and 23.0 g, respectively, compared to the best check Thulasi with 12.0g.

19.1.2.4 Deep water rice (*Oryza sativa*) (*Kharif* 2012): Thirty accessions of deep water ricecollected from Assam were evaluated in replicated block design along with three check varieties namely Dinesh, Jalamanga and CR Dhan for 11 qualitative and 10 quantitative characters. Out of 30 accessions sown, 28 were harvested.

19.1.3 Grain legumes

19.1.3.1 Horsegram (*Rabi* 2011-12): Out of 100 accessions and nine check varieties sown in augmented design in three blocks, 99 survived accessions were characterized and evaluated for fore qualitative and 11 quantitative plant, pod and seed characters. The characterization and evaluation data computerized was analysed. Among the five qualitative characters variability was noticed in plant growth habit, early plant vigour, seed colour and seed mottleness.

19.1.4 Vegetables (*Kharif* 2012)

19.1.4.1 Cucumber (*Cucumis sativus*): Thirty-four accessions of cucumber were characterised for 9 qualitative and 18 quantitative traits. Wide variability was observed in respect of fruit color, size, shape and pericarp ornamentation besides flower size and petal number. The range of variability was observed for nine quantitative characters.

19.1.4.2 Bittergourd (*Momordica charantia*): Eleven collections of bittergourd collected from Mizoram and Tripura were regenerated and characterised. Compared to the best check (Priya), collection No. JB/11-124 was slightly higher for fruit yield per plant and JB/11-21, S.21 (Tripura), JB/11-15 and JB/11-114 were at par JB/11-124 was having the highest fruit length (27.5cm) also and was adjudged best from consumer preference angle.Prelimnary seed multiplication of exotic collections EC737643, EC737644, EC737645, EC737646 received from Germplasm Exchange Division was carried out.

19.1.4.3 Teasel gourd (*Momordica subangulata* subsp. *renigera*): In a joint effort with CHES (IIHR), Bhubaneshwar, 50 accessions collected from Mizoram (30 accessions) and Tripura (20) were characterised

following NBPGR minimal descriptor. Promising collections for high fruit weight were JB/11-83, JB/11-178B, JB/11-173, JB/11-176, JB/11-86, JB/11-173, JB/11-176, JB/11-86, JB/11-122, JB/11-93 and JB/11-169. All were with cylindrical fruits weighing above 80g/fruit. JB/11-214, JB/11-57, JB/11-79 and JB/11-179 were with rounded fruit and its single fruit weight recorded was round 80g each.

19.1.4.4 Ash gourd (*Benincasa hispida*): A total of 27 collections along with 4 check varieties (Pusa Ujwal, Kasi Dhawal, Pusa Dhawal and KAU local) were regenerated, multiplied and characterised for 20 qualitative and 20 quantitative traits. The Mizoram-Tripura collections belonged to a separate morphotype characterised by slender vines, highly lobed small leaves, comparatively small flowers, mealy, granular, scented flesh and very small dark brown seeds. High variability in fruit shape, (cylindrical, discoid, pear-shaped, globular, pyriform and crooked neck) was observed. Majority were ash coloured but a few from tribal pockets were dark green and some times ribbed with out any tinge of ash colour at any stage of fruit development. Promising collections for various quantitative traits were: JB/11-93 and JB/11-238 (58-60 cm long fruit), JB/11-238, JB/11-213(56-59cm fruit circumference), JB/11-185-A, JB/11-213, JB/11-53(4-5.5 kg. single fruit weight), JB/11-204 (low 100 seed weight,1.8g), JB/11-213, JB/11-53 (high 100 seed weight,5.09g) and JB/11-185 A, JB/11-53, JB/11-54 and JB/11-181(10-19 fruits/ plant).

19.1.4.5 Cluster bean (*Cyamopsis tetrgonaloba*): Twenty-two accessions of vegetable type cluster bean received from NBPGR RS, Jodhpur were sown for seed multiplication.

19.1.4.6 Cowpea (*Vigna unguiculata*): Five accessions of vegetable cowpea received from NBPGR, RS, were sown for seed multiplication.

19.1.5 Oilseeds

19.1.5.1 Sesame (*Sesamum indicum*) (*Kharif* 2012): A total of 123 accessions along with three checks namely, Kayamkulam-1, Thilak and Thiladra were sown in augmented design. Only 24 accessions, other than checks, germinated and attained the stage of fruiting. These accessions were observed for frequency distribution in respect of 10 qualitative characters, out of which two traits, such as branching habit and capsule shape, did not show any variation among the accessions. The variability observed in the quantitative characters is as below:

EC370735 and EC377236 were very early flowering (27 days) while the late flowering accessions were JJK-Tripura (52), NKD-1447 and NKD-1481 (58 days). Early maturing accessions were KKLM-1, EC370735 (75 days); IC205822 and EC376985 (76 days) while the accessions EC370418, NKD-1447, NKD-1481 and JJK-Tripura took 92 days to attain 50% maturity. EC361740 was the highest yielder (1.95 g/plant), followed by EC370343 (1.75g), EC351720 (1.30g), EC370360 (1.25 g) and the best check Kayamkulam-1 (1.22g/plant). EC370735 showed the highest 100 seed weight (0.40 g), followed by EC377236 (0.35g), while EC370418 recorded the least (0.10 g).

19.1.6 Spices

19.1.6.1 Malabar tamarind (*Garcinia cambogia*) (*Kharif* 2012): Fifteen grafts belonging to seven accessions were evaluated for 21 quantitative and 11 qualitative traits of fruit and seed characters. The yield characters studied included total number of fruits yielded, individual fresh fruit weight and total fresh fruit weight. The yield data were compared with the best checks (registered accessions) (IC244100-2 and IC244111). It was found that the grafts derived from IC244083-1 namely out yielded the checks with regard to number of fruits and total fresh fruit weight. Forty-four trees in 34 accessions were evaluated for 18 quantitative and 11 qualitative traits of fruit and seed. The yield characters studied included total number of fruits yielded/tree, individual fresh fruit weight and total fresh fruit yield. The yield data were compared with the checks (IC244100-2 and IC244111). It was found that the accessions IC244100-3 (179 kg/ tree), IC244101-3 (286 kg/tree) and IC244115 (134 kg/ tree) out yielded the bettercheck IC244100-2 (133 kg/ tree) with regard to total fresh fruit weight. The highest value for average single fruit weight was observed for accession IC354018-3 (170g/ fruit). The accession IC244101-3 (2118 fruits/ tree) yielded the highest number of fruits per tree.Seedlings of 17 trees in 15 were characterized forfive characters namely fleshy root length, fibrous root length, aerial shoot length, number of nodes/ seedling and number of leaves/ node. In some seedlings within an accession, vertical branching of fleshy root in addition to the lone fleshy vertical root was observed.

Variability in number of locules per capsule in sesame germplasm at Thrissur.

Variability in scented ash gourd collected from Mizoram and Tripura under evaluation

Variability in cucumber germplasm of north-east origin charactersied along with check varieties (Right)

JB-11/91 a carotenoid rich cucumber germplasm

Field view of cucumber characterisation

Viviparous germination observed in fruits of Cucumber (SKS 1222) collected from Sikkim

Quantitative	Range	Mean	SD	CV (%)
Plant height (cm)	46.8 - 145.8	85.3	18.00	22.21
Internode length (cm)	5.0 - 27.3	8.4	4.41	54.49
Days to 50% flowering (#)	27.0 - 58.0	37.0	8.11	21.79
Days to 50% maturity (#)	75.0 - 92.0	83.1	5.54	6.64
Capsule length (cm)	2.2 - 3.2	2.8	0.23	8.45
Average yield/plant (g)	0.16 - 1.95	0.81	0.52	69.78
100 seed weight (g)	0.10 - 0.40	0.26	0.07	

19.1.7 Fruits

19.1.7.1 Mango (*Mangifera indica*) (*Summer*-2012): Twenty-eight accessions of local mangoes were characterised for fruit characters. Seven accessions (IC202211, IC202208, IC202203, IC470698, IC202205, IC470625 and IC470621) were found poly-embryonic on germination.

19.1.8 Medicinal and Aromatic Plants

19.1.8.1 Greater galangal (*Alpinia galanga*) (*Rabi* 2011-12): Seven accessions of greater galangal including a registered accession (IC346796; INGR 08107) for comparison were evaluated in fore replications for 17 quantitative and seven qualitative underground rhizome and root, and aerial shoot and fruit characters. The range of variation, mean, SD and CV% obtained for the metric characters other than yield are presented below in respect of the six accessions studied in comparison with the registered material:

There was no variability in the qualitative traits studied namely leaf lamina hairiness (upper surface), leaf lamina hairiness (lower surface), lamina aroma, nature of rhizome, aroma of rhizome, internal colour of tender and matured rhizome. For maximum number of aerial shoots, NIC22962 was promising with 50.5 shoots; for rhizome thickness, IC336196 with 3.2 cm was superior; for root thickness, IC349746 with 3.7 mm was promising; for fresh rhizome yield/clump, NIC22962 with 11.7 kg was promising; and for fresh weight of aerial shoot, IC373609 was promising with 221.3 g. IC373609 was superior in dry weight of rhizome with 1.7g/ culm compared to the check IC346796 with 1.6g/ culm.

19.1.8.2 Lesser galangal (*Alpinia calcarata*) (*Rabi* 2011-12): Five accessions of lesser galangal were evaluated in four replications for four qualitative and 18 quantitative characters with the registered accession IC210421 as check. For all the five yield characters analysed, namely fresh weight of rhizome with root yield/ culm (5.68 kg), fresh weight of aerial shoot/ culm (3.48 kg), dry weight of rhizome/ culm (1.31 kg), dry weight of aerial shoot/ culm (1.84 kg) and dry weight of root/ culm (147.50 g), IC373608 out yielded the check with 5.03 kg, 2.88 kg, 1.17 kg, 1.54 kg and 143.80 g respectively. Another set of 10 accessions of lesser galangal were also evaluated for the same set of qualitative and quantitative characters. For all the five yield characters analysed, namely fresh weight of rhizome with root yield/ culm (7.47, 10.75 kg), fresh weight of aerial shoot/ culm (4.79, 7.07 kg), dry weight of rhizome/ culm (1.90, 1.90 kg), dry weight of aerial shoot/ culm (2.42, 2.62 kg) and dry weight of root/ culm (162.00, 167.00 g), IC550139 and IC565489 out yielded the check (IC210421) with 5.03 kg, 2.88 kg, 1.17 kg, 1.54 kg and 143.80 g, respectively.

19.1.8.3 Kacholam (*Kaempferia galanga*) (*Rabi* 2011-12): Seventeen accessions were evaluated with

Germinating poly-embryonic mango seedling

Field view of *Alpinia calcarata*

Characters	Range	Mean	SD	CV (%)	Check value (IC349746)
Inflorescence length (cm)	14.3-17.2	15.7	1.0	6.5	7.7
Aerial shoot height (cm)	139.8-167.5	158.2	10.3	6.5	58.3
Number of opened leaves/aerial shoot	12.7-14.6	13.6	0.7	5.2	6.5
Leaf lamina length (cm)	45.6-51.0	47.7	2.1	4.3	18.0
Leaf lamina width (cm)	8.3-9.5	8.8	0.5	6.1	5.2
Leaf sheath length (cm)	13.3-15.1	14.0	0.6	4.5	6.4
Ligule length (mm)	4.8-5.1	5.0	0.1	2.0	2.4
Fruit length (mm)	9.4-10.5	10.0	0.5	4.6	5.0
Fruit thickness (mm)	7.0-7.9	7.4	0.4	4.8	4.2
Number of seeds per fruit	1.9-3.0	2.7	0.4	14.9	6.0
Rhizome internode length (cm)	0.6-0.7	0.6	0.0	7.6	2.7
Dry weight of rhizome (kg)	1.1-1.7	1.5	0.2	12.5	4.7
Dry weight of single aerial shoot (g)	49.7-74.9	63.9	9.2	14.5	29.2
Fresh weight of all aerial shoot (g)	1.9-4.4	3.3	0.9	27.9	2.8

two released varieties as check in three replications for 18 quantitative characters. Variability was observed in almost all the characters studied. In terms of fresh rhizome yield, which is the most significant trait, IC550152 (44.1g), IC373593 (45.1g) and IC373591 (49.7g) were superior to the better check "Rajani' (43.9g). In terms of dry weight of rhizome, IC550152 (15.9g) and IC373593 (15.1g) were superior to the better check 'Rajini' (14.3g). IC550152 was consistently superior for two successive years in terms of fresh yield of rhizome.

19.1.8.4 *Caesalpinia* species: Seed germination studies were made in *Caesalpinia bonduc*, *C. sappan* and *Rauvolfia serpentina*. Fifteen seedlings of *C. sappan* were transplanted in field genebank.

19.1.8.5 *Aloe vera*: Eighteen accessions of *Aloe vera* were transplanted in field genebank.

19.2 Externally Funded Projects

19.2.1 NAIP: Biosystematics of the Genera *Vigna*, *Cucumis* and *Abelmoschus*: Under took a field collection trip, from December 20-23, 2012 for the survey and collection of rare taxa of *Abelmoschus, Cucumis* and *Vigna,* to the type localities and specific niches in Western Ghats covering Nelliampathy, Munnar,

Fruit variability in bittergourd germplasm of north-east origin charactersied at Thrissur, Kerala

Fruit variability in teasel gourd collected from Mizoram and jointly characterized at CHES, Bhuvaneshwar, Odisha

Chinnar WLS and Kodaikanal sholas and collected *A. angulosus* var. *angulosus*, *Cucumis callosus*, *C. melo* var. *agrestis* and *Vigna stipulacea*.

Based on morphology, inter-specific crossability and hybrid fertility, a new species of *Abelmoschus,* namely *Abelmoschus enbeepeegearense* was discovered. *Abelmoschus enbeepeegearense* J John, Scariah, Nissar, KV Bhat et Yadav is a new species occurring in the low elevation Western Ghats of India comprising Kerala, Karnataka and Tamil Nadu. The taxon is morphologically allied to *A. moschatus* subsp. *moschatus*, *A. moschatus* subsp. *tuberosus* and *A. crinitus,* but easily distinguishable by virtue of its orthotropic branching, 3 - 5 angled leaves, glandular hairy plant body with whitish waxy secretions, glandular non-setoseepiclayx which is more than eight in number and ovate hirsute fruits with a short mucron at apex. It can be crossed with all the three taxa with varying degree of success, but with hybrid sterility.

Based on morphology and inter-specific crossability studies, taxonomic conclusions on the status of Indian entities of wild *Cucumis* was drawn. There are seven valid species: *C. melo*, *C. sativus, C. hystrix, C. prophetarum, C. setosus, C. silentvallei* and *C. indicus*. *C. melo* with many cultivated subgroups is represented by a wild and feral form i.e.: *C. melo* subsp. *agrestis* in Deccan plateau and Indo-Gangetic plains. *C. sativus* also has a wild form in Western Ghats i.e.: *C sativus f. hardwickii. C. silentvallei* and *C indicus* are rare endemics of Western Ghats, the former in southern Western Ghats and the latter in Konkanghats and northern end of southern Western Ghats. *C. setosus* is a valid taxon endemic to Maharastra and adjoining regions and is morphologically and genetically distinct from *C. sativus*. *C. hystrix* is restricted to parts of North-East India and it has two taxonomic varieties distributed sympatrically. The entity *C. callosus* may be assigned a subspecific rank within C. *melo* as its hybrids with various cultivated groups of melon are fertile. Wild and feral forms of *C. melo, C. melo* subsp. *callosus* and *C. hystrix* are conspicuously absent in the Western Ghats region. F2 derivatives of *Cucumi smelo* x *C. callosus* were found field resistant to *Alternaria* leaf blightand bacterial fruit rot but fruits were very bitter. Regenerated *Cucumis hystrix*, *C. indicus* and *Mukialeio sperma* for crossability studies. *Cucumis indicus* was highly susceptible to spider mite.

In *Vigna*, out of 5 F1 hybrids germinated, 3 were found to be true hybrid. These belong to crosses involving *V. umbellata* as the male parent with *V.radiata* var. *sublobata*, *V.hainiana* and *V.mungo* var. *sylvestris*.

Flower buds in 43 wide crosses of *Abelmoschus*, 5 species of *Cucumis* and 6 species of *Vigna* were supplied to NEHU, Shillong. A total of 312 mounted herbarium sheets comprising various species of *Abelmoschus*, *Vigna* and *Cucumis* were prepared.

19.2.2 Collection, Clonal Multiplication, Conservation and Biochemical Profiling of Kokum (*Garcinia indica*), a Potential Source of Edible Oil found in Southern Western Ghats (NOVOD Board)

Sixty seven trees in 31 accessions of kokum were studied for 8 quantitative and 3 qualitative characters pertaining to leaf, trunk, branch and branching pattern. Out of these, 8 trees with accession numbers IC136682-2, IC136682-3, IC136684-3, IC136687-2, IC409060-2, IC342296-3, IC342303-2 and IC550571 were typically unbranched with single vertical main trunk and lateral drooping branches, suitable for close planting, which is an important promising agro-forestry trait in this crop.Thirty-four trees in 23 accessions along with 1 registered germplasm (IC136687-3; INGR No.04063) as check were characterized for 2 fruit yield, 8 fruit and 6 seed quantitative characters. IC342303-2 (3,741 fruits), IC342297-1 (1,291), IC342301-2 (1,244) and IC136682-2 (1,243) out-yielded the check (1,196 fruits/tree) in number of fruits/tree, and IC342303-2 (86.92 kg), IC342319-2 (37.36), IC136682-2 (37.31) and IC342301-2 (33.46) out-yielded the check (29.95 kg/tree) in fresh fruit yield/tree. Out of these, IC342303-2, IC136682-2 and IC342301-2 were superior for both number of fruits/tree and fresh fruit yield.

19.3 Germplasm Conservation

The following table gives details of germplasm holding conserved *ex situ* at this station

Medium-term storage at Thrissur:

In total, 7,685 accessions belonging to 18 genera and 85 species are being maintained. This includes 949 accessions of rice received from RARS, Pattambi.

Long-term storage at GCD, NBPGR, New Delhi

***Abelmoschus enbeepeegearense* J John, Scariah, Nissar, KV Bhat et Yadav - a new species of wild okra discovered from the southern Western Ghats forest in Palakkad district of Kerala.**

F_1 hybrid of cross *A. moschatus* subsp. *tuberosus* x *A.crinitus* – a potential ornamental

Direct Deposition: Trait specific deep water rice (59 accessions), Oryza *rufipogon* (1) and birdchillie (1) (*Capsicum frutescens*) were deposited in long-term storage, NGB, NBPGR New Delhi.

Multiplied germplasm: From the regenerated germplasm, 131 accessions comprising 15 accessions of *V. dalzelliana*, six each of *V. radiata* var. *sublobata* and *V.trinervia* var. *bourneae,* a total of 62 accessions of forage crops comprising one accession each of *Apluda mutica, Bothriochloa pertusa, Chloris barbata, Chrysopogon fulvus, Eragrostis tenella, Eragrostis tremula*, *Eriochloa procera*, two of *Alloteropsi scimicina*, three of *Cenchrus biflorus*, eight of *Chloris gayana*, nine of *Cenchrus setigerus*, 12 of *Dichanthium annulatum* and 21 of *Heteropogon contortus,* one of *Abelmoschus crinitus*, 11 of *Cucumis sativus,* 11 of *Cucumis melo*, 14 of ashgourd and three of bittergourd were deposited for long-term storage at National Genebank, Germplasm Conservation Division, NBPGR, New Delhi.Two varieties of cowpea (Bush cowpea Culture-1 and Bush Cowpea Culture-2) received from KAU, Vellayani were also deposited for IC allotment subsequently.

Supply of germplasm to TCC Unit, New Delhi

Seven accessions of *Oryza* species (*O. sativa*-1, *O.alta*, *O. rufipogon*-2, *O.australiensis*-1, *O.punctata*, *O. glumaepatula*) were sent for cryo-preservation at NBPGR, New Delhi.

Crop group	MTS	FGB	*In vitro*	TOTAL
Cereals	3,205	--	--	**3,205**
Grain legumes	973	--	--	**973**
Fruits	--	217	--	**217**
Vegetables	1,421	6	--	**1,427**
Tubers	--	589	5	**594**
Spices	--	693	8	**701**
Oilseeds	196	--	--	**196**
Medicinal & aromatic plants	51	328	41	**420**
Wild relatives	890	649	14	**1,553**
Rice (RARS, Pattambi)	949	--	--	**949**
TOTAL	**7,685**	**2,482**	**68**	**10,235**

IC553722 (JS/07-11) : *Baccaurea ramiflora* a wild edible fruit maintained in field genebank

IC554285 (JSS/07-66): *Sterculia foetida* – a wild ornamental shrub with potential domestication value, maintained in field genebank

***In vitro* conservation at Thrissur:** A total of 68 accessions of germplasm in four crops and two crop wild related species are being maintained *in vitro*.

Two accessions of Chinese potato (*Solenostemon rotundifolius*), I each of *Aloe vera*, *Rauvolfia serpentina* and *Dioscorea floribunda* were newly initiated and multiplied in culture.

Field Genebank at NBPGR RS, Thrissur: A total of 2,482 accessions in 139 species belonging to 40 genera are maintained in field and pots under the shade, net and poly houses.

19.5 Germplasm Supply

(i) Germplasm transfer to NAGS: A total of 150 accessions of cassava to CTCRI, Thiruvananathapuram and 28 of mango to CISH, Lucknowwere transferred.

(ii) Germplasm supply for multi-location evaluation: A set each of 100 accessions of horsegram was supplied to two centres namely UAS, Bangalore, Karnataka and RARS, KAU, Pattambi, Palakkad, Kerala for multi-location evaluation under the National Network Research Programme on Arid Legumes.

(iii) Germplasm supply under MTA to user agencies: A total of 250 accessions was supplied to 12 user agencies under MTA. Details are as below:

One hundred and fifty-five accessions comprising 17 accessions of *Kaempferia galanga*, 81 of Malabar tamarind, 28 of kokum, 1 of *Caesalpinia bonducella* 12 of *Alpinia galanga*, 16 of *A. calcarata* were supplied to Germplasm Evaluation Division for biochemical evaluation. Three accessions each of *Trichosanthes tricuspidata* and *T. wallchiana* and 1 of *T. lepiliana* were supplied to NBPGR RS, Shillong for seed multiplication. Thirty accessions of rice were multiplied and sent to NBPGR RS, Hyderabad for deposition under long term storage.

IC469741 Chinese potato – an accession newly initiated and multiplied in culture

IC373610 an accession of *Alpinia calcarata* under *in vitro* conservation

Sixty-three accessions comprising 1 of *Abelmoschus crinitus*, 7 of *A. esculentus*, 5 of *A. tuberculatus*, 3 of *A. ficulneus*, 24 of *A. caillei*, 5 of *A. moschatus* subsp. *moschatus*, 10 of *A. angulosus* subsp. *grandiflorus*, 2 of *A. moschatus* subsp. *tuberosus*, 5 of *A. tetraphyllus* and 1 of *Abelmoschus enbeepeegearense* and eighty-nine accessions in 12 species of *Vigna* were supplied to Germplasm Evaluation Division, NBPGR, New Delhi for field evaluation.

Twenty-three accessions comprising *Oryza rufipogon* (1), *O. sativa* f. *spontanea* (4) and *Oryza* spp. (2), *Momordica charantia* (12) and *M.cochinchinensis* (4) were supplied to NRC DNAFP, NBPGR, New Delhi for molecular analysis.

Research Programme (Code, Title and Programme Leader)

PGR/GEV-BUR-THR-01.00: Augmentation, Characterisation, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Plant Genetic Resources in Southern India including Goa and Andaman & Nicobar Islands (**Z Abraham** (till 12.02.2012), **NK Dwivedi** (w.e.f 13.02.2012)

Research Projects (Project Code, Title (PI and CoPI)

PGR/GEV-BUR-THR-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of field crops and their wild relatives (**M Latha**; NK Dwivedi, Z Abraham, KI Asha, R Asokan Nair, S Mani and A Indiradevi)

PGR/GEV-BUR-THR-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of tuber and fruit crops and their wild relatives (**KI Asha**; K Joseph John, R Asokan Nair and A Indiradevi)

PGR/GEV-BUR-THR-01.03: Augmentation, characterisation, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of spices, their wild relatives and medicinal & aromatic plants (**Z Abraham**; NK Dwivedi, K Joseph John, M Latha, R Asokan Nair and S Mani)

PGR/GEV-BUR-THR-01.04: Augmentation, characterisation, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of tropical vegetables and their wild relatives (**K Joseph John**; Z Abraham, M Latha, R Asokan Nair and S Mani)

PGR/GEV-BUR-THR-02.00: Use of in vitro technology for mass propagation and conservation of clonally / vegetatively propagated crops and their wild relatives (**NK Dwivedi**; KI Asha; A Indiradevi)

EXTERNALLY FUNDED PROJECTS:

- NAIP Project on Biosystematics of the Genera *Vigna*, *Cucumis* and *Abelmoschus* (**Joseph John K** and Latha M)
- NOVOD Board Project on Multiplication, Conservation and Biochemical Profiling of Kokum (Garciniaindica), a Potential Source of Edible Oil found in Southern Western Ghats (**Z Abraham**, Sangita Yadav and M Latha)

20. GENERAL INFORMATION

20.1 Institute Management Committee (IMC)

Director	
NBPGR, Pusa Campus, New Delhi	Chairman
Assistant Director General (Seed)	
ICAR, Krishi Bhawan, New Delhi	Member
Sh. Rakesh Poria	
Directorate of Agriculture, Haryana	Member
Dr. R Saikumar	
Project Director, Directorate of Maize Research, New Delhi	Member
Dr. S K Jain	
Principal Scientist, IARI, New Delhi	Member
Dr. TV Ananth Narayan	
Head (PGR), IIHR, Hassaraghatta Lake Post, Bangalore	Member
Dr. Pritam Kalia	
Head, Division of Vegetable Sciences, IARI, New Delhi	Member
Sh. Avesh Yadav	
FAO, IARI, New Delhi	Member
Chief F & A O	
IARI, New Delhi	Member
Senior Admn. Officer	
NBPGR, New Delhi	Member Secretary

20.2 Research Advisory Committee (RAC)

Dr. R S Rana	Chairman
Ex-Director, NBPGR; D-43, Indra Prastha Apartment, Sector-14, Rohini, New Delhi-110 085	
Dr. Akhilesh Kumar Tyagi	Member
Director, National Institute of Plant Genomic Research, Aruna Asaf Ali Marg; P.O. Box No. 10531, New Delhi-110 067	
Dr. P N Mathur	Member
Coordinator for South Asia Sub-Regional Office, Bioversity International, NASC, DPS Marg, Pusa Campus, New Delhi-110 012	
Dr. Ranjini Warrier	Member
Director, GOI, Ministry of Environment & Forests, CS Division, Paryavaran Bhawan, CGO Complex, Lodi Road, New Delhi-110 003	
Dr. K D Srivastava	Member
Ex-Professor, IASRI, House No. 23, Block No. 7, Sector 30-31, Springfield Colony, Faridabad-1211003, Haryana	
Dr. V A Parthasarthy	Member
Narmada Nilaya, Santhi Nagar, Chelavoor P.O., Calicut-673571	
Dr. K C Bansal	Member
Director, NBPGR, Pusa Campus, New Delhi-110012	
Dr. J S Sandhu	Member
Assistant Director General (Seed), Indian Council of Agricultural Research (ICAR), Krishi Bhavan, New Delhi - 110 001	
Dr. R Sai Kumar	Member
Project Director, Directorate of Maize Research, Pusa Campus, New Delhi-110 012	
Dr. Pritam Kalia	Member
Head, Division of Vegetable Sciences, IARI, New Delhi-110012	
Dr. I S Bisht	Member Secretary
Principal Scientist & I/C Technical Cell, NBPGR, New Delhi-110 012	

The XIV meeting of the RAC, NBPGR was held in New Delhi on July 25-26, 2012 under the Chairmanship of Dr. R S Rana. RAC members, all heads of Divisions, Officers-in-Charge of Regional Stations, Units and Cells and other scientists. One member, Dr. V A Parthasarthy, had sought leave of absence.

20.3 Institute Research Council (IRC)

Chairman- Director NBPGR

Member Secretary- Dr. K K Gangopadhyay

The first Institute Research Council (IRC) Meeting for the year 2012 was held under the Chairmanship of Prof. K C Bansal, Director, NBPGR during May 14-17 to discuss the progress of institute projects during 2011-12 and finalize the technical programme of 2012-13. More than 125 scientists and technical officers from both headquarters as well as regional stations attended the meeting. All the PIs made presentations on achievements in respect of their respective projects and recommendations on several projects were made.

20.4 Institute Joint Staff Council (IJSC)

Chairman- Director, NBPGR	
Members Staff Side	**Members Office Side**
Sh. R K Sharma Secretary (Office Side)	Dr. SK Malik, Senior Scientist, Secretary (Staff Side)
Sh. R C Yadav	Dr. Rekha Chaudhary, Principal Scientist
Sh. Subhash Chandra	Dr. Sushil Pandey, Senior Scientist
Sh. Yogesh Kumar Gupta	Sh. Vivek Purwar, Sr. Admn. Officer
Sh. Suresh Ram	Sh. DS Bisht, Sr. F&AO
Sh. Y K Yadav	

The IJSC meeting of NBPGR was held on June 4, 2012 under the Chairmanship of Prof. K C Bansal, Director, NBPGR and various agenda items were discussed.

20.5 Personnel

(i) Scientific Staff

S.No.	Name	Designation	Discipline
1.	Dr. K C Bansal	Director	Plant Physiology
Division of Germplasm Evaluation			
2.	Dr. Manoranjan Dutta	Head	Genetics & Cytogenetics
3.	Dr. Ranbir Singh	Principal Scientist	Economic Botany
4.	Dr. Ashok Kumar	Principal Scientist	Plant Breeding
5.	Dr. K K Gangopadhyay	Principal Scientist	Horticulture
6.	Sh. N K Gautam	Scientist (Sel. Grade)	Economic Botany
7.	Dr. (Mrs) Archana Raina	Principal Scientist	Plant Biochemistry
8.	Dr. (Mrs) Sangita Yadav	Senior Scientist	Biochemistry
9.	Dr. T V Prasad	Senior Scientist	Agricultural Entomology
10.	Dr. Mohar Singh	Senior Scientist	Plant Breeding
11.	Dr. Anirban Roy	Senior Scientist	Plant Pathology
12.	Dr. Tej Pal Singh	Senior Scientist	Plant Physiology
13.	Dr. Manas Kumar Bag	Senior Scientist	Plant Pathology
14.	Dr. Rakesh Bhardwaj	Senior Scientist	Biochemistry
15.	Dr. Sandeep Kumar	Senior Scientist	Biochemistry

16.	Dr. (Mrs) Pragya	Senior Scientist	Horticulture/ Floriculture
17.	Dr. (Mrs) Jyoti Kumari	Senior Scientist	Plant Breeding
18.	Dr. Rakesh Srivastava	Senior Scientist	Horticulture
19.	Dr. (Ms) Rashmi Yadav	Senior Scientist	Agronomy
20.	Ms. Sheela Mary	Scientist (On Probation)	Plant Breeding
Division of Plant Exploration and Germplasm Collection			
21.	Dr. D C Bhandari	Principal Scientist & Head	Economic Botany
22.	Dr. E Roshini Nayar	Principal Scientist	Economic Botany
23.	Dr. (Mrs) Anjula Pandey	Principal Scientist	Economic Botany
24.	Dr. KC Bhatt	Principal Scientist	Economic Botany
25.	Dr. K Pradheep	Senior Scientist	Economic Botany
26.	Dr. D P Semwal	Senior Scientist	Economic Botany
Division of Germplasm Conservation			
27	Dr. R K Tyagi	Principal Scientist & Head	Economic Botany
28	Dr. (Mrs) Kalyani Srinivasan	Principal Scientist	Plant Physiology
29	Dr. (Mrs) Veena Gupta	Principal Scientist	Economic Botany
30	Dr. (Mrs) Neeta Singh	Principal Scientist	Plant Physiology
31	Dr. (Mrs) J Radhamani	Principal Scientist	Plant Physiology
32	Dr. (Mrs) Anjali Kak	Principal Scientist	Economic Botany
33	Dr. (Mrs) Chitra Pandey	Senior Scientist	Seed Technology
34	Dr. Sushil Pandey	Senior Scientist	Seed Technology
35	Dr. (Mrs) Sherry Racheal Jacob	Scientist	Seed Technology
Division of Plant Quarantine			
36.	Dr. P C Agarwal	Principal Scientist & Head	Plant Pathology
37.	Dr. (Mrs) Manju Lata Kapur	Principal Scientist	Agricultural Entomology
38.	Dr. D B Parakh	Principal Scientist	Plant Pathology
39.	Dr. Baleshwar Singh	Principal Scientist	Plant Pathology
40.	Dr. (Mrs) Shashi Bhalla	Principal Scientist	Agricultural Entomology
41.	Dr. (Mrs) Celia Chalam V	Principal Scientist	Plant Pathology
42.	Dr. (Mrs) Kavita Gupta	Principal Scientist	Agricultural Entomology
43.	Dr. Mool Chand Singh	Principal Scientist	Agronomy
44.	Dr. Zakaullah Khan	Senior Scientist	Nematology
45.	Dr. Jameel Akhtar	Senior Scientist	Plant Pathology
46.	Dr. A Kandan	Senior Scientist	Plant Pathology
Germplasm Exchange Unit			
47.	Dr. Arjun Lal	Principal Scientist & OIC	Nematology
48.	Dr. (Mrs) Vandana Tyagi	Principal Scientist	Economic Botany
49.	Dr. (Mrs) Nidhi Verma	Senior Scientist	Economic Botany
50.	Dr. S K Yadav	Senior Scientist	Horticulture
51.	Ms Anitha Pedapati (on study leave)	Scientist	Horticulture
Policy Planning Unit			
52.	Dr. I S Bisht	Principal Scientist & Professor, PGR	Plant Pathology

53.	Dr. (Mrs) Pratibha Brahmi	Principal Scientist	Economic Botany
Tissue Culture & Cryopreservation Unit			
54.	Dr. (Mrs) Rekha Chaudhary	Principal Scientist &OIC	Economic Botany
55.	Dr. (Mrs) Ruchira Pandey	Principal Scientist	Economic Botany
56.	Dr. (Mrs) Neelam Sharma	Principal Scientist	Economic Botany
57.	Dr. (Ms) Anuradha Agarwal	Principal Scientist	Economic Botany
58.	Dr. (Mrs) Sandhya Gupta	Principal Scientist	Economic Botany
59.	Dr. S K Malik	Senior Scientist	Economic Botany
60.	Dr. Zakir Hussain	Senior Scientist	Genetics
61.	Dr. (Ms) Anju Jain	Senior Scientist	Economic Botany
Under Utilized & Under Exploited Plants Network Project			
62.	Dr. B S Phogat	Principal Scientist & OIC	Agronomy
63.	Dr. Hanuman Lal Raigar	Senior Scientist	Agricultural Statistics
Division of Genomic Resources			
64.	Dr. K V Bhat	Principal Scientist	Plant Breeding
65.	Dr. (Mrs) Gurinderjit Randhawa	Principal Scientist	Plant Physiology
66.	Dr. Soma Sundar Marla	Principal Scientist	Biotechnology
67.	Dr. Mukesh Kumar Rana	Senior Scientist	Plant Breeding
68.	Dr. M C Yadav	Principal Scientist	Biotechnology
69.	Dr. (Mrs) Lalit Arya	Senior Scientist	Biochemistry
70.	Dr. (Mrs) Ambika Baldev	Senior Scientist	Biotechnology
71.	Dr. Rakesh Singh	Senior Scientist	Biotechnology
72.	Dr. S Rajkumar	Senior Scientist	Biotechnology
73.	Dr. Sundeep Kumar	Senior Scientist	Biotechnology
74.	Dr. Tapan Kumar Mandal	Senior Scientist	Biotechnology
75.	Dr. Monendra Grover	Senior Scientist	Biotechnology
76.	Dr. Deep Narain Saha	Senior Scientist	Biotechnology
77.	Dr. Rajesh Kumar	Senior Scientist	Biotechnology
78.	Dr. (Mrs). Manjusha Verma	Scientist (Senior Scale)	Biotechnology
79.	Sh. R Parimalan	Scientist	Biotechnology
80.	Sh. Chet Ram (on study leave)	Scientist	Biotechnology
81.	Sh. Amit Kumar Singh	Scientist	Biotechnology
82.	Dr. (Ms) Yasin K. Jeshima, PDF	Scientist	Genetics and Plant Breeding
83.	Dr. Monika Singh	Scientist	Agricultural Biotechnology
84.	Mrs. Sheel Yadav	Scientist	Biotechnology Plant Science
ARIS Cell			
85.	Dr. Sunil Archak	Senior Scientist & OIC	Biotechnology
86.	Dr. (Mrs) Madhubala Priyadarshini	Scientist (Senior Scale)	Computer Applications in Agriculture
Regional Station, Akola			
87.	Dr. Nilamani Dikshit	Senior Scientist & OIC	Economic Botany
88.	Sh. Abdul Nizar	Scientist (Senior Scale)	Economic Botany

Regional Station, Bhowali			
89.	Dr. S K Verma	Principal Scientist & OIC	Economic Botany
90.	Dr. K S Negi	Principal Scientist	Economic Botany
91.	Dr. A K Trivedi	Senior Scientist	Plant Physiology
Base Center, Cuttack			
92.	Sh. Diptiranjan Pani	Sr. Scientist & OIC	Economic Botany
93.	Dr. R C Mishra	Sr. Scientist & OIC	Economic Botany
Regional Station, Jodhpur			
94.	Dr. Omvir Singh	Principal Scientist & OIC	Economic Botany
95.	Dr. A K Singh	Senior Scientist	Economic Botany
Regional Station, Hyderabad			
96.	Dr. S K Chakraborty	Principal Scientist & OIC	Plant Pathology
97.	Dr. B Sarath Babu	Principal Scientist	Agricultural Entomology
98.	Dr. S R Pandrawada	Principal Scientist	Economic Botany
99.	Dr. (Ms) Kamla Venkateshwaran	Principal Scientist	Economic Botany
100.	Dr. Natrajan Sivaraj	Principal Scientist	Economic Botany
101.	Dr. (Mrs) Anitha Kodaru	Principal Scientist	Plant Pathology
102.	Sh.Sunil Neelam	Scientist (Senior Scale)	Economic Botany
103.	Dr. K Rameash	Senior Scientist	Entomology
Regional Station, Ranchi			
104.	Dr. J B Tomar	Principal Scientist & OIC	Economic Botany
105.	Sh. Santosh Kumar	Senior Scientist	Economic Botany
Regional Station, Shillong			
106.	Dr. A K Misra	Principal Scientist & OIC	Economic Botany
107.	Dr. R S Rathi	Senior Scientist	Plant Breeding
108.	Dr. Somnath Rai	Scientist	Economic Botany
Regional Station, Shimla			
109.	Dr. J C Rana	Principal Scientist & OIC	Economic Botany
Regional Station, Srinagar (J & K)			
110.	Dr. Sheikh Mohd Sultan	Senior Scientist	Economic Botany
Regional Station, Thrissur			
111.	Dr. N K Dwivedi	Principal Scientist & OIC	Economic Botany
112.	Dr. Z Abraham	Principal Scientist	Economic Botany
113.	Dr. Joseph John K	Principal Scientist	Economic Botany
114.	Dr. (Mrs) Asha KI	Principal Scientist	Economic Botany
115.	Dr. (Mrs) M Latha	Senior Scientist	Plant Breeding
116.	Mrs. Suma A	Scientist	Economic Botany

(ii) Technical Staff at NBPGR Headquarters and its Regional Stations

S.No	NAME	DESIGNATION
NBPGR Headquarters' at New Delhi		
1.	Sh. BP Dahiya	T-9 (Elect. Engineer)
2.	Dr. Om Prakash	T-7-8 (Tech. Officer)
3.	Sh. Rita Rani	T-6 (Tech. Officer)
4.	Sh. Abhay Sharma	T-5 (Tech. Officer)
5.	Sh. Charan Singh	T-7-8 (Tech. Officer)
6.	Sh. Rajiv Mathur	T-7-8 (Tech. Officer)
7.	Dr. C S Raghav	T-7-8 (Tech. Officer)
8.	Sh. S P Singh	T-7-8 (Tech. Officer)
9.	Dr. Rajivir Singh	T-7-8 (Tech. Officer)
10.	Sh. Ram Prasad Yadav	T-7-8 (Tech. Officer)
11.	Ms. Poonam Suneja	T-7-8 (Tech. Officer)
12.	Sh. K D Joshi	T-7-8 (Tech. Officer)
13.	Sh. Rajiv Gambhir	T-7-8 (Tech. Officer)
14.	Dr. Dinesh Chand	T-7-8 (Tech. Officer)
15.	Sh. Ashok Kumar Maurya	T-7-8 (Tech. Officer)
16.	Sh. Surender Singh Ranga	T-7-8 (Tech. Officer)
17.	Sh. Rakesh Singh	T-6 (Tech. Officer)
18.	Sh. Mahabir Singh Rathore	T-6 (Tech. Officer)
19.	Sh. Harinder Singh	T-6 (Tech. Officer)
20.	Sh. Ram Singh	T-6 (Tech. Officer)
21.	Sh. Axma Dutt Sharma	T-6 (Tech. Officer)
22.	Sh. Bharat Lal Meena	T-6 (Tech. Officer)
23.	Sh. Dinesh Chand Mishra	T-4 (Tech. Officer)
24.	Mrs. Rita Gupta	T-5 (Tech. Officer)
25.	Sh. Dinesh Kumar Pokhrial	T-2 (Lab. Asstt.)
26.	Sh. Rohtash Singh	T-2 (Lab. Asstt.)
27.	Sh. Babu Ram	T-6 (Tech. Officer)
28.	Mrs. Sangeeta Tanwar	T-6 (Tech. Officer)
29.	Dr. Narendra Singh Panwar	T-6 (Tech. Officer)
30.	Sh. R S Yadav	T-5 (Tech. Officer)
31.	Sh. Devendra Kumar Nerwal	T-6 (Tech. Officer)
32.	Sh. Bhopal Singh Panwar	T-6 (Tech. Officer)
33.	Sh. Y S Rathi	T-6 (Tech. Officer)
34.	Sh. Ombir Singh Ahlawat	T-6 (Fieldman)
35.	Sh. Om Prakash (Library)	T-5 (Lab. Tech.)
36.	Sh. Satya Prakash	T-5 (Elec./Mech.)
37.	Sh. Surender Singh Bhoj	T-4 (Lab. Tech.)
38.	Sh. Narendra Pal	T-5 (Tech. Asstt.)
39.	Sh. Parmesh Kumar	T-5 (Tech. Asstt.)
40.	Sh. Anang Pal	T-6 (Tech. Asstt.)
41.	Sh. Ram Chander Yadav	T-5 (Fieldman)
42.	Sh. Bhawnesh Kumar	T-4 (Fieldman)
43.	Sh. Ramesh Chander	T-5 (Lab. Asstt.)
44.	Sh. Ram Kumar Sharma	T-5 (Fieldman)
45.	Sh. Arun Kumar Sharma	T-4 (Lab. Asstt.)
46.	Sh. Diksha Gautam	T-4 (Tech. Asstt)
47.	Sh. Dharam Pal Singh Meena	T-5 (Fieldman)
48.	Sh. Om Prakash	T-3 (Fieldman)
49.	Sh. Lal Singh	T-3 (Electrician)
50.	Mrs. Nirmala Dabral	T-4
51.	Sh. Poonam Chand Binda	T-3
52.	Sh. Shashi Kant Sharma	T-4
53.	Sh. Ram Milan	T-1
54.	Sh. Vijay kumar Mandal	T-3
55.	Sh. Ram Nandan	T-2
56.	Sh. Harideo Prasad	T-2
57.	Sh. Naresh Kumar	T-2
58.	Sh. Sunil Kumar	T-3
59.	Mrs. Smita Jain	T-5
60.	Sh. S K Ojha	T-2
61	Sh. Balwant Singh	T-3 (Driver)
62	Sh. Braham Prakash	T-4 (Driver)
63	Sh. Khushvinder Kumar	T-2 (Driver)
64	Sh. Ram Balak Rai	T-2 (Driver)
65	Sh. Ravinder Kumar	T-2 (Driver)
66	Sh. Wazir Singh	T-3 (Driver)
67	Sh. Ranjit Singh	T-2 (Driver)
68	Sh. Gopal Singh	T- 1 (Driver)
NBPGR Regional Station, Akola		
69	Sh. J K Ingle	T-6 (Tech. Officer)
70	Sh. LT Dabekar	T-3 (Driver) Akola
NBPGR, Regional Station, Bhowali		
71	Sh. PS Mehta	T-6 (Tech. Officer)
72	Sh. Rattan Ram Arya	T-5 (Tech. Officer)
73	Sh. Ramit Joshi	T-4 (Fieldman)
74	Sh. Mohan Ram	T-4 (Driver)
NBPGR, Regional Station, Hyderabad		
75	Sh. Babu Abraham	T-7-8 (Tech. Officer)
76	Sh. R Gunasekharan	T-5 (Tech. Officer)
77	Sh. M Venkataraman Reddy	T-2 (Driver)
78	Sh. Mohd Abas Ali Khan	T-3 (Driver)

NBPGR, Regional Station, Jodhpur		
79	Sh. B C Bachhawandia	T-6 (Tech. Officer)
80	Sh. Bhatta Ram	T-4 (Expl. Asstt.)
81	Sh. Gordhan Singh	T-4 (Driver)
NBPGR, Regional Station, Ranchi		
82	Sh. Ashok Kumar Gupta	T-6 (Tech Officer)
83	Sh. Narendra Ram	T-4 (Driver)
NBPGR, Regional Station, Shillong		
84	Sh. M Goswami	T-4 (Expl. Asstt)
85	Sh. S N Sharma	T-3 (Fieldman)
86	Sh. Sanjeev Kumar Singh	T-4 (Tech. Officer)

NBPGR, Regional Station, Shimla		
87	Sh. Brij Pal Singh	T-6 (Tech. Officer)
88	Sh. Prakash Chand	T-3 (Fieldman)
89	Sh. Ram Chander	T-2
90	Sh. Dayal Singh	T-2
91	Sh. Joginder Singh	T-3, Shimla
NBPGR, Regional Station, Thrissur		
92	Sh. R Ashokan Nair	T-6 (Tech. Officer)
93	Sh. S Mani	T-6 (Tech. Officer)
94	Mrs. Indira Devi	T-6 (Tech. Officer)
95	Sh. E N Prabhakaran	T-2, Thrissur

(iii) Administrative Staff at HQs and Regional Stations

S.NO.	NAME	DESIGNATION
1.	Sh. Vivek Purwar (w.e.f. 30.04.2012)	Sr.A.O.
2.	Sh. D S Bisht (w.e.f. 06.11.2012)	Sr. F&AO
3.	Sh. Girish Chandra Chandola	AAO
4.	Mrs. Archna Raghav	A.D. (OL)
5.	Sh. Umesh Chandra Sati	Security Officer
6.	Sh. M K Ahuja	JAO
7.	Mrs. Vijay Laxmi Gulati, Delhi	AAO
8.	Sh. Nandan Singh Patwal, Bhowali	AAO
9.	Sh. Din Dayal, Delhi	AAO
10.	Sh. S.S. Wange, Akola	AAO
11.	Mrs. Vinay Bala Sharma, Delhi	AAO
12.	Mrs Kuljeet Kaur, Delhi	AAO
13.	Ms. Pratibha, Shimla	AAO
14.	Mrs. Yashoda Rani, Delhi	Assistant
15.	Sh. Dinesh Prasad, Delhi	Assistant
16.	Ms Sangeeta Gambhir, Delhi	Assistant
17.	Mrs. Surinder Kaur, Delhi	Assistant
18.	Sh. Surender Kumar, Delhi	Assistant
19.	Mrs. Bharti Sharma, Delhi	Assistant
20.	Mrs. Savitri Devi, Delhi	Assistant
21.	Mrs Vijay Laxmi Sharma, Delhi	Assistant
22.	Sh. Mahabir Singh Yadav, Delhi	Assistant
23.	Mrs. Leela Sharma, Jodhpur	Assistant
24.	Mrs. Radha Rani, Hyderabad	Assistant
25.	Sh. Yogesh Kumar Gupta, Delhi	UDC/ Sr. Clerk
26.	Sh. Purushottam Dhoke, Akola	Assistant
27.	Mrs. Satvinder Kaur, Delhi	Assistant
28.	Mrs. Madhu Bala, Delhi	UDC/Sr. Clerk
29.	Sh. Prabal Dasgupta, Delhi	Assistant
30.	Sh. Dinesh Sharma, Delhi	UDC/Sr. Clerk
31.	Mr. M Srinivasa Rao, Hyderabad	Assistant
32.	Sh. Avdhesh Kumar, Delhi	Assistant
33.	Ms. Amrita Negi	Assistant
34.	Sh. Sanjay Kumar Lal, Delhi	Sr. Clerk
35.	Sh. Benny Mathew, Thrissur	Sr. Clerk
36.	Mrs. Lakshmilian Kharnary, Shillong	Sr. Clerk
37.	Sh. J K Singh, Delhi	Sr. Clerk
38.	Sh. Sanjay Dangwal, Delhi	Sr. Clerk
39.	Sh. Arvind Kumar, Delhi	Jr. Clerk
40.	Sh. K C Kundu, Delhi	Sr. Clerk
41.	Sh. P. Suleman, Hyderabad	Sr. Clerk
42.	Sh. T V Govindon, Thrissur	P.A
43.	Ms. R S Latha Devdas, Delhi	P.S
44.	Ms. Graciously Dkhar, Shillong	P.S
45.	Ms. Kanchan Khurana, Delhi	P.A
46.	Ms. V Vijayalaxmi, Delhi	P.A
47.	Sh. Ganga Nand, Delhi	P.A
48.	Mrs. Urmila, Delhi	P.A
49.	Mrs. Neelam Khatri, Delhi	P.A
50.	Mrs. Poonam Batra, Delhi	P.A
51.	Sh. Rameshwar Dayal, Delhi	Jr. Clerk
52.	Sh. Dev Kumar, Delhi	Jr. Clerk
53.	Mrs. Smita D Karale, Akola	Jr. Clerk
54.	Sh. Surya Kant, Delhi	P.S. (ICAR) Staff NBPGR

(iv) List of Skilled Supporting Staff

S.No	Name	Designation
	Director Personnel Cell	
1.	Sh. Surender Kumar	Skilled Support Staff
2.	Sh. Hari Chand Paswan	Skilled Support Staff
	Director Technical Cell	
3.	Sh. Om Prakash	Skilled Support Staff
	Germplasm Conservation Division	
4.	Sh. Basant Kumar	Skilled Support Staff
5.	Sh. Sandesh Kumar	Skilled Support Staff
6.	Mrs. Laxmi Devi	Skilled Support Staff
7.	Sh. Bhun Bhun Shah	Skilled Support Staff
	Germplasm Evaluation Division	
8.	Sh. Mahesh Ram	Skilled Support Staff
9.	Sh. Ram Kishan	Skilled Support Staff
10.	Sh. Kush Kumar	Skilled Support Staff
11.	Sh. Mahadev Maurya	Skilled Support Staff
12.	Sh. Braham Dev Paswan	Skilled Support Staff
13.	Sh. Ram Kalit Rai	Skilled Support Staff
14.	Sh. Rohtash	Skilled Support Staff
15.	Sh. Yatish Chandra	Skilled Support Staff
16.	Mrs. Rukmani	Skilled Support Staff
17.	Sh. Chandeshwar Rai	Skilled Support Staff
18.	Sh. Sanjeev Paswan	Skilled Support Staff
19.	Sh. Suresh Ram	Skilled Support Staff
	Germplasm Exploration & Collection Division	
20.	Mrs. Manju Devi	Skilled Support Staff
21.	Mrs. Sharda Devi	Skilled Support Staff
	Plant Quarantine Division	
22	Sh. Suresh Chand Rai	Skilled Support Staff
23.	Sh. Satya Narayan Thakur	Skilled Support Staff
	TCCU	
24.	Mrs. Geeta Devi	Skilled Support Staff
25.	Sh. Nand Kishore	Skilled Support Staff
26.	Sh. Chandeshwar Rai	Skilled Support Staff
	GEX Unit	
27.	Sh. Arun Sharma	Skilled Support Staff
	Division of Genomic Resources	
28.	Mrs. Agya Devi	Skilled Support Staff
29.	Sh. Ramesh Chand	Skilled Support Staff
	ARIS Cell	
30.	Sh. Lalu Rai	Skilled Support Staff
	Library	
31.	Sh. Umesh Kumar	Skilled Support Staff
	Sr. A.O. Cell	
32.	Sh. T Pokheral	Skilled Support Staff
33.	Sh. Rajender	Skilled Support Staff
	Despatch Section	
34.	Sh. Anant Swaroop	Skilled Support Staff
	Accounts Section	
35.	Sh. Chander Shekher	Skilled Support Staff
	Audit Section	
36.	Sh. Sunil Kumar	Skilled Support Staff
37.	Sh. Yogesh Kumar	Skilled Support Staff
	Estt. CDN	
38	Sh. Roshan Lal	Skilled Support Staff
	Experimental Station, Issapur, New Delhi	
39.	Sh. Ram Karan	Skilled Support Staff
40.	Sh. Hari Ram	Skilled Support Staff
41.	Sh. Dharambir	Skilled Support Staff
42.	Sh. Daya Nand	Skilled Support Staff
43	Sh. Bindeshwar Thakur	Skilled Support Staff
44.	Sh. Dhir Singh	Skilled Support Staff
45.	Sh. Mahabir Singh	Skilled Support Staff
	Skilled Support Staff at NBPGR Regional Stations	
	NBPGR, Regional Station, Akola	
46.	Sh. S R Pacherwal	Skilled Support Staff
47.	Sh. R C More	Skilled Support Staff
48.	Sh. S R Patode	Skilled Support Staff
49.	Sh. R P Barsse	Skilled Support Staff
50.	Sh. Arun Diwakar Godlinga	Skilled Support Staff
51.	Sh. M B Nikose	Skilled Support Staff
	NBPGR, Regional Station, Bhowali	
52.	Sh. Anand Kumar	Skilled Support Staff
53.	Sh. Girish Chand Arya	Skilled Support Staff
54.	Mrs. Tulsi Devi	Skilled Support Staff
	NBPGR, Regional Station, Cuttack	
55.	Sh. Sarangdhar Barik	Skilled Support Staff
	NBPGR, Regional Station, Hyderabad	
56.	Mohd. Mazhar Pasha	Skilled Support Staff
57.	Sh. M Shankar	Skilled Support Staff
58.	Sh. E Satyanarayan	Skilled Support Staff
59.	Sh. M B Keshwa Raju	Skilled Support Staff
60.	Sh. M Srinivas	Skilled Support Staff
	NBPGR, Regional Station, Jodhpur	
61.	Sh. Sohan Singh	Skilled Support Staff
62.	Sh. Babu Lal	Skilled Support Staff

63.	Sh. Munender Pal Singh	Skilled Support Staff
64	Sh. Dashrath Singh Rajpurohit	Skilled Support Staff
	NBPGR, Regional Station, Ranchi	
65.	Sh. Vijay Kumar	Skilled Support Staff
	NBPGR, Regional Station, Shimla	
66.	Sh. Jagat Ram	Skilled Support Staff
67.	Sh. Bhagwan Singh	Skilled Support Staff
68.	Sh. Paras Ram	Skilled Support Staff
69.	Sh. Girdhar Gopal	Skilled Support Staff
70.	Sh. Rohit	Skilled Support Staff
71.	Sh. Sukh Dev	Skilled Support Staff
72.	Sh. Dalip Singh	Skilled Support Staff
73.	Sh. Inder Singh	Skilled Support Staff

	NBPGR, Regional Station, Shillong	
74.	Sh. D B Chettery	Skilled Support Staff
75.	Sh. D B Thapa	Skilled Support Staff
76	Sh. A K Deka	Skilled Support Staff
77.	Sh. A Rashid	Skilled Support Staff
78.	Sh. H K Dass	Skilled Support Staff
	NBPGR, Regional Station, Thrissur	
79.	Sh. K Permkumaran	Skilled Support Staff
80.	Sh. M K Prakasan	Skilled Support Staff
81.	Mrs. V K Rugmini	Skilled Support Staff
82.	Mrs. M K Gulathu	Skilled Support Staff
83.	Mrs. Anitha Komvalappil	Skilled Support Staff
84.	Mrs. E M Sumathy	Skilled Support Staff

20.6 Staff Reservations

Category	Total number of Employees	Total number of Scheduled Caste (SC) Employees	Total number of Scheduled Tribe (ST) Employees	Total number of OBC Employees
Scientist	117	10	-	8
Technical	89	14	3	6
Administrative	57	12	3	1
Supporting	86	31	4	11

20.7 Staff Transferred/ Retired/ New Appointments/Promotions

20.7.1 Transfers

- Dr. Omvir Singh, Principal Scientist & OIC, from Srinagar to Jodhpur on 09.02.2012
- Dr. N K Dwivedi, Principal Scientist & OIC from Jodhpur to Thrissur on 13.02.2012
- Ms. Suma A, Scientist, from NBPGR, New Delhi to Thrissur on 16.06.2012
- Dr. Arivalgan M. Scientist, from NBPGR, New Delhi to CPCRI, Kasargod, on 07.07.2012
- Sh. S K Sinha, Sr. Administrative Officer, from NBPGR New Delhi to E&M Section, ICAR on 30.04.2012
- Ms. Smita D Karale, LDC, from Pomegranate Anusandhan Kendra, Solapur, Maharashtra to NBPGR, R/S Akola on 05.12.2012

20.7.2 Retirements

- Sh. T K Vasu, SSS, NBPGR, R/S, Thrissur, retired w.e.f. 31.01.2012
- Sh. M L Malik, AAO, NBPGR, New Delhi retired w.e.f. 29.02.2012
- Sh. Daya Shankar, T-6, NBPGR, New Delhi retired w.e.f. 29.02.2012
- Sh. Kishan Nath, Driver (T-5), NBPGR, New Delhi retired w.e.f. 29.02.2012
- Mrs. Gurvinder Khera, T-4, NBPGR, New Delhi retired w.e.f. 29.02.2012
- Sh. Dev Sunder, Driver (T-4), NBPGR, New Delhi retired w.e.f. 29.02.2012
- Sh. Preet Singh, SSS, NBPGR Issapur Farm retired w.e.f. 29.02.2012

- Sh. P Vijayam, SSS, NBPGR, R/S, Thrissur retired w.e.f. 31.03.2012
- Sh. K K Balam, SSS, NBPGR, R/S, Thrissur retired w.e.f. 31.03.2012
- Sh. Dilawar Singh, T-3, NBPGR Issapur Farm retired w.e.f. 31.03.2012
- Sh. P. Venugopalan, AAO, NBPGR, R/S, Thrissur retired w.e.f. 30.04.2012
- Sh. Kulwant Singh, AAO, NBPGR, New Delhi retired w.e.f. 31.05.2012
- Sh. Om Prakash, SSS, NBPGR, Issapur Farm retired w.e.f. 31.05.2012
- Dr. (Mrs) Usha Dev, Principal Scientist, PQD, NBPGR, New Delhi retired w.e.f. 30.06.2012
- Sh. B K Bansal, Sr. Finance & Accounts Officer, NBPGR, New Delhi retired w.e.f. 30.09.2012
- Sh. P D Lazar, SSS, NBPGR, R/S, Thrissur retired w.e.f. 30.10.2012

20.7.3 New Appointments

- Sh. Vivek Purwar, Sr. Admn.Officer, w.e.f. 30.04.2012
- Dr. (Mrs.) Monika Singh, Scientist, NRC DNAFP, NBPGR, New Delhi w.e.f. 02.05.2012
- Ms. Amrita Negi, Assistant, w.e.f. 09.07.2012
- Ms. Sheela Mary, Scientist, w.e.f. 10.10.2012
- Sh. DS Bisht, Sr. Finance & Accounts Officer, w.e.f. 06.11.2012

20.7.4 Promotion of Staff

- Dr. (Mrs) J. Radhamani, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. (Mrs) Pratibha Brahmi, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. (Mrs) Kamala Venkateshwaran, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. (Mrs) Anuradha Agarwal, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. K K Gangopadhyay, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. (Mrs) V Celia Chalam, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. Natarajan Shivraj, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. K C Bhatt, Senior Scientist to Principal Scientist, w.e.f. 01.01.2009
- Dr. Joseph John, Senior Scientist to Principal Scientist, w.e.f. 1.1.2009
- Dr. (Mrs) Sandhya Gupta, Senior Scientist to Principal Scientist, w.e.f. 25.07.2009
- Dr. (Mrs) Archana P Raina, Senior Scientist to Principal Scientist, w.e.f. 20.02.2010
- Dr. S R Pandrawada, Senior Scientist to Principal Scientist, w.e.f. 02.08.2010
- Dr. (Mrs) Asha K I, Senior Scientist to Principal Scientist, w.e.f.14.09.2010
- Dr. (Mrs) Kavita Gupta, Senior Scientist to Principal Scientist, w.e.f. 23.01.2011
- Dr.Nilmani Dikshit, NBPGR, R/S, Akola, Scientist to Senior Scientist, w.e.f. 09.06.2011
- Dr. Mool Chand Singh, Senior Scientist to Principal Scientist, w.e.f. 24.08.2011
- Dr. (Mrs) Anjali Kak, Senior Scientist to Principal Scientist, w.e.f. 06.09.2011
- Dr. (Mrs) Vandana Tyagi, Senior Scientist to Principal Scientist, w.e.f. 23.01.2012
- Sh. Anang Pal Singh, NBPGR, New Delhi, T-5 to T-6, w.e.f. 10.09.2012

- Sh. Shashi Kant, NBPGR, New Delhi, T-3 to T-4, w.e.f. 11.09.2012
- Sh. Vijay Kumar Mandal, NBPGR, New Delhi, T-2 to T-3, w.e.f. 11.09.2012
- Sh. Narendra Ram, NBPGR, R/S, Ranchi, T-3 to T-4, w.e.f. 27.09.2012
- Sh. Wazir Singh, NBPGR, New Delhi, T-2 to T-3, w.e.f. 27.09.2012
- Sh. L T Dabekar, NBPGR, R/S, Akola, T-2 to T-3, w.e.f. 27.09.2012
- Mrs. Vinay Sharma, NBPGR, New Delhi Assistant to AAO, w.e.f. 10.10.2012
- Mrs. Kuljit Kaur, NBPGR, New Delhi, Assistant to AAO, w.e.f. 10.10.2012
- Mrs. Pratibha, NBPGR, R/S, Shimla, Assistant to AAO, w.e.f. 10.10.2012
- Sh. Rajvir Singh, NBPGR, New Delhi, T-6 to T-7, w.e.f. 15.04.2010

20.8 Awards/ Honours/ Prizes

- Monendra Grover**,** received 'Distinguished Bioinformatician Award' conferred by Society of Applied Biotechnology, Febuary. 24-25, 2012 at Kolhapur.
- Rakesh Singh got Best Research Paper Award for the paper entitled "A Linkage Map for *Cucurbita maxima* based on Randomly Amplified Polymorphic DNA (RAPD) Markers" at 5th Indian Horticultural Congress, PAU, Ludhiana, 6-9 November 2012 by the Horticultural Society of India.
- Anirban Roy, selected for SAB Young Scientist Award for 2012 by Society for Applied Biotechnology, Department of Botany, Karnataka University, Dharwad, Karnataka, India.
- K K Gangopadhyay awarded Best Poster Award (First prize) in the Golden Jubilee Seminar on Advances in Agricultural Research Towards Food Security and Environmental Sustenance organized at Viswa Bharati, Sriniketan, West Bengal during 1-3 September, 2012.
- Jyoti Kumari elected Fellow of Indian Society of Genetics and Plant Breeding for the year 2012.
- Veena Gupta, Lalit Arya, Ramya KN, Anjali Kak, Chitra Devi Pandey and Manjusha Verma bagged Best Paper presentation award for oral presentation on "Genetic diversity and relatedness in *Morinda tomentosa* using RAPD Markers" at 7th Noni Search on Noni – A tool for Wellness" by World Noni Research Foundation, Chennai.
- Veena Gupta conferred the Fellow Award of SPR, by the Society for Plant Research, Meerut.
- Shashi Bhalla awarded Fellow of the Indian Society of Plant Genetic Resources.
- Baleshwar Singh, Jameel Akhtar, Usha Dev, A Kandan, Dinesh Chand and P C Agarwal got Best Poster Presentation Award for the poster entitled "Interception of pathogenic fungi and a bacterium in introduced germplasm" presented in the International Conference (ICPHM 2012) on "Plant Health Management for Food Security" organized by Plant Protection Association of India, Hyderabad held at DDR, Rajendranagar, Hyderabad on November 28-30.

V Celia Chalam was awarded **"Dr RDVJ Prasada Rao Memorial Award 2012"** for outstanding contribution to the science of plant protection in Diagnostics and Plant Biosecurity by Plant Protection Association of India, Hyderabad during the International Conference (ICPHM 2012) on "Plant Health Management for Food Security" held at DDR, Rajendranagar, Hyderabad from Nov. 28-30, 2012.

- S K Yadav, Senior Scientist received "The Best Citizen of India Award for the year 2011" from the International Publishing House, New Delhi on 11th November, 2012 for his contributions in the field of Agricultural Sciences.
- N Ramakrishnan, B Sarath Babu and T Ramesh Babu bagged the "Smt Kavuri Sarada Memorial Award" for Best Research Paper published in IJPP 2011: Standardization of X-ray radiography methodology for the detection of hidden infestation in cereals during the ICPPM held at DRR Hyderabad from 28-30 Nov 2012.
- Soumya K, Maheshwari Y, Prasanthi Y, Anitha K, RK Jain and Bikash Mandal won the award of 2nd best poster for the poster entitled Immunodiagnosis of *Peanut mottle virus* using polyclonal antibodies to bacterial expressed core recombinant capsid protein. In the National Conference of Indian Virological Society, organised at Mukteswar during 8-10 Nov 2012.
- Arjun Lal, Shashi Bhalla, Kavita Gupta, Kamala Venkateswaran and S R Pandravada were elected "Fellow of the Plant Protection Association of India" at the International Conference on Plant Health Management for Food Security held at DRR, Hyderabad from 28-30, November, 2012.
- K Rameash and N Sunil awarded Young Scientist Award during the Fourth International Conference on Medicinal Plants and Herbal Products during 6-8 September, 2012 at Maryland, USA.
- S K Bishnoi awarded Best Paper Presentation Award for the paper entitled '*Ex situ* conservation of diversity of plant genetic resources-Biotechnological approaches' in National Symposium on Assessment and Conservation of Forest Genetic Resources through Biotechnological Interventions held on 19-21 December 2011 at Institute of Forest Productivity, (ICFR&E) Lal Gutwa, Ranchi.

Anuradha Agrawal, Principal Scientist, TCCU, conferred with the **Punjabrao Deshmukh Outstanding Woman Scientist Award 2011 of the ICAR,** during the ICAR Award Ceremony held on July 16, 2012. The award has been given in recognition of her work related to development and application of cost-effective *in vitro* conservation and cryopreservation protocols for medium- and long-term conservation of vegetatively propagated species, especially of banana and spice crops. Based on the research carried out by Dr Agrawal, cryobanking of banana germplasm is being carried out for the first time in India.

Dr Anuradha Agrawal receiving 'ICAR Outstanding Woman Scientist Award 2011' from the Hon'ble Union Cabinet Minister, Agriculture; Consumer Affairs, Food and Public Distribution, Shri Sharad Pawar

Marathon Man of ICAR

Dr. Arjun Lal, Principal Scientist & Head, Germplasm Exchange, NBPGR participated in Airtel Delhi Half Marathon held on 30 September, 2012 in New Delhi and Mumbai Half Marathon held on 20 January, 2013 in Mumbai & finished 21.097 km in 2 hour 14 minutes. Since 2009, he has participated in 8 half marathons (four in Delhi, two in Mumbai, one in Jaipur and one in Bengaluru).

Dr JC Rana receiving the 'SHARDA BHALAIK' trophy

NBPGR R/S Shimla honored with 'SHARDA BHALAIK' trophy by Shimla Amateur Garden and Environment Society (SAGES) for contribution towards genetic resources conservation and awareness generation in 2012

- J C Rana awarded Best Publication Award- 2011 by Society for Advancement of Human and Nature, Dr Y S Parmar University of Horticulture & Forestry, Nauni, Solan (HP) for his research paper entitled "Naturally occurring wild relatives of temperate fruits in western Himalayan region of India: an analysis" published in Biodiversity and Conservation.
- N K Dwivedi was awarded Fellow of Indian Society of Plant Genetic Resources (2010), NBPGR, New Delhi on October 6, 2012.

20.9 Deputations Abroad

- K C Bansal, Director, NBPGR participated in the Global Launch of the Maize and Wheat CGIAR Research Program in Mexico from January16-20.
- Kavita Gupta, Principal Scientist was invited to participate in the 'Invasive Species Consortium Workshop' organized by USDA and CABI to review the 'Invasive Species Compendium and other CABI Compendia', Washington DC, from April 26-27.
- Pratibha Brahmi, Principal Scientist attended the Advanced International Training on Genetic Resources and Intellectual Property Rights (GRIP) sponsored by Swedish International Development Agency (SIDA) at University of Agricultural Sciences, Uppsala and Stockholm, Sweden from 7 to 24 May, 2012. This was followed by the Regional Follow-Up Seminar as last phase of the training at International Livestock Research Institute, (ILRI), Nairobi, Kenya from November, 17 to 23.
- Gurinder Jit Randhawa, Principal Scientist was an invited expert in 4th European Commission-Asia Regional Network meeting on GMO Analysis Manila, Philippines from May 23-24.
- Rakesh Bhardwaj, Senior Scientist, participated in the "Regional Symposium on Promoting Underutilized Food Systems for Better Nutrition in Asia and Pacific" at Khon Kaen, Thailand and presented a paper entitled "Strategies to Explore, Document, Validate and Check Traditional Knowledge Erosion: Learning and Lessons from *Adi* Tribe of Arunachal Pradesh, India" as a key note speaker. The visit was sponsored by "Regional Office for Asia and Pacific, FAO from May 31 to June 2.
- Gurinder Jit Randhawa, Principal Scientist, under exchange visit within the frame of the Indian-Slovenian Department of Science and Technology (DST), Govt. of India's bilateral project, Novel cost-effective methods for GMO detection was at the Department of Biotechnology and Systems Biology, National Institute of Biology (NIB), Slovenia from June 7 to July 6.
- Sangita Yadav, Senior Scientist deputed for undergoing training in the area of "Biomolecule" (Horticulture) College of Biological Science, Genomics and Biosciences Facility, University of California, Davis, CA, USA under NAIP programme, from September 6 to December 4.
- Kavita Gupta, Principal Scientist invited to participate and present oral paper in the IUFRO International Disianes and parts of Tropical forest Trees working Party Conference organized by Asia Pacific Forest Invasive Species Network from October 8-10.

- Kavita Gupta, Principal Scientist invited to participate in the Regional Workshop on Use of Multi-Criteria Decision Analysis to Inform SPS Decision-making in the Asia Pacific organized by the Standards and Trade Development Facility (STDF) of WTO in Bangkok, Thailand from November 12-13.

20.10 Exchange visit under bilateral Indo-Slovenian Inter-governmental Programme

Dr. Dany Morisset, a scientist from National Institute of Biology (NIB), Ljubljana, Slovenia was on ten days exchange visit in GM detection laboratory from December 10 to 20, 2012, under the bilateral Indo-Slovenian Inter-governmental Programme of Cooperation in Science and Technology on "Novel cost-effective methods for GMO detection."

20.11 Library and Documentation Services

NBPGR library is a dedicated library on plant genetic resources management. Scientists, technical staff, researchers, students and trainees were regular users of the library. Library maintained its designated services and activities. Library played a significant role in providing articles to all ICAR scientists through "Document Delivery Request Services" under CeRA. Library also subscribed "Oxford University Press" on-line journals package for life sciences for its members. Library is also one of the members of E-Granth project and digitized 105 NBPGR publications for creating the NBPGR institute repository. Newspaper clippings service related to PGR and its allied subjects was regularly provided to the readers. During the year, 70 books related to various aspects of PGR management were added to the headquarters library through purchase and on exchange basis. Library procured 51 journals (26 foreign and 25 Indian) through subscription/gifts/exchange for the use at the headquarters and different regional stations. A monthly list of new arrivals was also provided to readers at the headquarters. Library maintained AGRIS, AGRICOLA, CABSAC, CAB-CD and PLANT GENE database for the scientific community. Scientists and technicals also have on-line access of CABI Database. Library also provides its members online-access of databases available in the IARI library through intranet. Bureau's publications were provided to 242 different organizations in India and abroad and in return 220 publications as gratis were received from various national and international organizations.

20.12 Germplasm Advisory Committee (GAC) Meeting

Germplasm Advisory Committees on various crop groups have been constituted by the Council under the Chairmanship of crop experts to deliberate and finalize strategies for germplasm management including all aspects of introduction, quarantine, exploration, conservation and characterization. Germplasm Advisory Committee (GAC) meeting on Maize, Sorghum and Pearl Millet was organized on July 12, 2012 under the chairmanship of Dr. N N Singh, Ex- Vice Chancellor, BAU, Ranchi. Besides, Dr. J S Sandhu, ADG (Seed) and Director, NBPGR, the other notable members of GAC present were Dr. J V Patil, Project Director, Sorghum; Dr. Sai Kumar, Project Director, Maize; Dr. B B Singh, Ex-Head, Division of Genetics IARI; Dr. O PYadav, Project Coordinator, Pearl millet and Director Research, JNKVV, Jabalpur.

20.13 Field Days & Biodiversity Fair Organized

20.13.1 Germplasm Field Day on Chickpea organized at MPKV, Rahuri: NBPGR has taken up a large scale programme on characterization and preliminary evaluation of germplasm conserved in the National Gene Bank in a collaborative mode with Project Coordinators, SAUs and crop based institutes to enhance their utilization. Under this mega programme, a total of 18,773 accessions of indigenous and exotic chickpea germplasm have been grown during *Rabi* 2011-12 at MPKV, Rahuri, Maharashtra, one of the best chickpea growing centres of the country. A germplasm field day was organized at MPKV, Rahuri on February 3-4, 2012 wherein, more than 150 participants from ICAR institutes, SAUs, progressive farmers and students attended this important event. Dr. T A More, Vice Chancellor, MPKV, Rahuri inaugurated the function in the university auditorium in which Dr. J S Sandhu, ADG (Seed), ICAR, was the Chief Guest. Among the other dignitaries present were Dr. S S Mehetre, Director of Research, MPKV, Rahuri; Dr. N P Singh, Project Co-ordinator (Chickpea), IIPR, Kanpur; Dr. M Dutta, Head, Germplasm Evaluation Division, NBPGR and Dr. R K Tyagi, Head, Germplasm Conservation Division, NBPGR, New Delhi. Dr. P N Harer, In-charge, Pulse Programme, MPKV, Rahuri was the local coordinator of the event. The

chickpea breeders/ workers were exposed to the invaluable wealth of live variability of chickpea germplasm and selected lines of their choice for utilization in the chickpea improvement programme.

20.13.2 Wheat Germplasm Week

During Rabi 2011-12 about 22,000 accessions of wheat germplasm were sown at CCS HAU, Hisar for development of a core set. The same set of germplasm has been grown under two sowing dates at NBPGR Issapur Farm for screening against terminal heat tolerance. To promote enhanced use of germplasm by the wheat workers/ breeders in crop improvement progamme a Wheat Germplasm Week from March 22 to 28, 2012 was organized at four locations comprising NBPGR Experimental Farm, Issapur, on 22 March; NBPGR Post Entry Quarantine Nursery (PEQN), New Delhi on March 23, NBPGR New Area Farm (IARI), New Delhi on 24 March and at CCS HAU, Hisar on March 26-28.

About 120 participants belonging more 12 organizations participated in the event. Dr. R P Narwal, Director Research, CCS HAU, Hisar inaugurated the function at CCS HAU, Hisar while Dr. Indu Sharma, Project Director (Wheat), DWR, Karnal was present in the closing ceremony. The participants appreciated the huge variability, made selections from the material and placed indents.

20.13.3 Germplasm Field Day on Maize and Pearl millet: A Field Day on maize and pearl millet was organized at NBPGR, IARI New Area Farm, New Delhi on September 21. The objective was to exhibit live variability of maize and pearl millet in the field and to give an opportunity to the concerned breeders/ crop scientists to select the material of their choice. A total of 658 accessions of maize and 100 accessions of pearl millet were grown that included a large number of maize germplasm collected from NEH region. More than 40 participants belonging to RVS KVV, Gwalior; PAU, Ludhiana; SKUAS&T, Srinagar; DMR, New Delhi; IARI, New Delhi and NBPGR participated and selected material of their choice for supply.

20.13.4 Germplasm Field Day on Okra and Cucurbits: A germplasm field day on okra and cucurbits was organized on October 11 to showcase the live variability of 440 diverse (both indigenous and exotic) accessions of three vegetable crops comprising okra and its nine wild species (260 accessions), cucumber (90 accs.) and sponge gourd (90 accs.) grown at NBPGR, New Area Farm, IARI during *Kharif* 2012. Twenty one researchers and scientists from different ICAR institutes and SAUs including Dr J P

Field Day on Wheat at NBPGR, Issapur Farm

Field Day on Wheat at PEQN, NBPGR

Field Day on Wheat at CCS HAU, Hisar

Field Day on Chickpea at MPKV, Rahuri

Field Day on Maize at IARI, New Area Farm

Singh, Director Research, GBPUAT, Pantnagar and Dr B Singh, Project Coordinator (AICRP Vegetable Crops) attended the field day. It was observed that okra wild species had good variability in respect of shape, size, colour and pubescence on leaf and fruits, field tolerance to yellow vein mosaic disease (YVMD) etc. The cucumber germplasm too showed good diversity four fruit size, shape, colour, field tolerance to downy mildew and virus complex. In sponge gourd germplasm, wide variability was observed for fruit shape, size, colour and bearing potential. The field day provided a good opportunity to the researchers to select the variability and utilize in crop improvement program.

Participants of the Field Day on Okra & Cucurbits

20.13.5 All India Plant Breeders' Meet organized at NBPGR

The All India Plant Breeders' Meet was organized at NBPGR, New Delhi on May 3-4, 2012. The meeting was inaugurated by Dr. P L Gautam, Chairman, PPV&FRA as Chief Guest, and was presided over by Dr. S Ayyappan, Secretary, DARE & DG, ICAR. Dr. H S Gupta, Director, IARI; Dr. Bangali Baboo, National Director, NAIP; Dr. M N Nayar, Ex-Director, CPRI & CTCRI; ADGs of ICAR (Commercial Crops, Agro-forestry, IPR, etc.), Project Directors and other senior officials from ICAR and IARI were the distinguished participants along with about 125 plant breeders from across the country representing ICAR institutes and SAUs. Dr. P L Gautam in his remarks stressed upon the need of sustained efforts on maintenance breeding and pre-breeding to cope with future challenges in plant breeding. He urged the plant breeders to play a pivotal role as their holistic perspective will be instrumental in guiding future of agriculture. Dr. S Ayyappan, in his chairman's remarks impressed upon the plant breeders to consider major emerging issues such as input use efficiency, multiple stress resilience, ecosystem health, farm mechanization and social dimension of agriculture, and strategically apply advanced tools to keep pace with the fast changing agricultural scenario. Dr. M N Nayar, in his remarks highlighted the importance of using indigenous diversity and the evolving tools for its effective management.

L to R Dr. M Dutta; Dr. K C Bansal, Dr. P L Gautam, Dr. S Ayyappan, Dr. H S Gupta and Dr. Bangali Baboo

Participants of Plant Breeders' Meet

During the discussions detailed action plans for pre-breeding and germplasm evaluation including the lead centres, associated centres, target traits in prioritized crops and possible sources of genes in wild and related species were prepared by concerned plant breeders for specific crop groups and presented for possible consideration in the XII Plan.

20.13.6 Tribal Biodiversity Fair Organized

A tribal biodiversity fair was organized in the tribal dominated Dharni area of Melghat in Amravati district of Maharashtra on March 2, 2012. More than 200 participants belonging to Gond and Korku tribal community participated in the fair. Local landraces of millets, pulses, vegetables and oilseeds maintained by the native/ aboriginal people since ages were displayed by these participants and later these valuable germplasm were brought to the R/S for characterization, multiplication and conservation.

A view of the Tribal Biodiversity Fair organized by the NBPGR R/S, Akola at Dharni

Local tribals viewing exhibits displayed by NBPGR R/S, Akola at Tribal Biodiversitry Fair at Dharni

20.13.7 Extension and Awareness Programme under TSP at RS Cuttack:

An awareness programme on Plant Biodiversity in tribal areas was organized at Kundura block, Lima Panchayat, Koraput, Odisha under "Tribal Sub Project" on March 23, 2012 in collaboration with M S Swaminathan Research Foundation, Regional Centre, Phulabada, Jeypore (Odisha). Seedlings of M&AP and horticultural plants were distributed to the farming communities and plantation programme was conducted at the village premises of Kundura, Koraput.

Awareness programme on Plant Biodiversity Conservation-organized at village Nuaguda, Kundura, Koraput, Odisha

Biodiversity fair Organized at Ghatkumari, Similipal, Odisha

A Biodiversity fair on "Promoting conservation of indigenous food and commercially important medicinal plants" was organized at Ghatkumari, Bisoi range, Similipal Biosphere Reserve on March 28, 2012 under "Tribal Sub-Project". Seedlings of medicinal plants, horticultural plants and other economic plants were distributed among the farming communities.

20.13.8 Pulses Field Day at RS Hyderabad: A Field Day was organized at the station for *Kharif* pulses germplasm on September 5, 2012. Fifteen scientists comprising pulse breeders, pathologists and entomologists from the Departments of Plant Breeding, Seed Technology, Biotechnology and regional stations (Nandyal, Palem, Madhira) of ANGRAU, Hyderabad participated in the programme. In addition, five Ph D scholars also attended the programme. A total of 502 accessions of pulses including blackgram (216), greengram (128), cowpea (50) and *Vigna trilobata* (108) in the field were assessed for different agronomic (good yield/ bearing, lustrous/ bold seed, and determinate plant type) and resistance traits. Accessions selected by them including black gram (21), green gram (6), pillipesara bean (21), cowpea (20) for different traits.

the benefit of the visitors. A continuous slide show of the diversity available in various important crops including cereals, pulses, oilseeds, vegetables, etc was displayed in 40 inch LED TV. Live plants of wild rice (*Oryza nivara, O. rufipogon*, etc.,), medicinal and aromatic plants attracted lot of interest as did the diversity in seeds of different crops displayed. CoP11-ICAR Exhibition video is present in the following link,
http://www.youtube.comwatch?feature=player embedded&v = YW2h3 fjeyd8

NBPGR staff with Dr P L Gautam, Chairman, PPV&FRA and Dr RS Rana, Member, NBA during their visit to the ICAR-NBPGR stall in the COP-MOP Exhibition at Hyderabad

Participants at the Kharif Pulses Field Day on September 5, 2012 organized at NBPGR R/S, Hyderabad

20.13.9 Exhibition at the "Interactive Fair for Biodiversity" during COP 11 Biodiversity Meet from October 1 to 19: NBPGR took part in the ICAR Exhibition in the Interactive Fair for Biodiversity during the COP-11 conference and showcased the activities of the Bureau. The activities were shown through display of posters depicting the biodiversity of our country. In addition, there were three touch screen interactive kiosks depicting the activities on diversity, collection, characterization, evaluation, conservation, documentation and utilization of plant genetic resources. A short film on activities of NBPGR was screened for

20.13.10 Events organized at Regional Station, Jodhpur

Celebration of guar day: In collaboration with CAZRI and KVK guar day was celebrated on May 8, 2012. More than 150 farmers, scientists, students and traders participated in the function. The objective of guar day celebration was to educate people about *Summer* cultivation of guar. The gathering was addressed by many senior persons including Director CAZRI and OIC, NBPGR.

Celebration of germplasm field day: The germplasm field day was organized on October 15, 2012. More than 150 participants including scientists, farmers and students participated in the event. The programme was chaired by the former ASRB chairman Dr. A S Faroda. Scientists identified the accessions of their requirement of cowpea, mungbean, mothbean and guar and submitted indent for supply to them.

20.13.11 Hindi week was organized w.e.f. September 17 to 22, 2012 under "Rajbhasha Chetna Mas" by R/S, Bhowali during which eight different events like competition on essay writing, poetry, dictation in Hindi, translation Hindi to English and English to Hindi were organized and prizes were distributed to the winners of different events. The Hindi week was inaugurated by Dr A B Pandey, Station Incharge, IVRI Mukteshwar and concluded with prize distribution by Chief guest Dr J P Singh, Director, Research, GBPUA&T, Pant Nagar, UK under the chairmanship of Dr. R K Tyagi, Head, Germplasm Conservation Division, NBPGR, New Delhi-12.

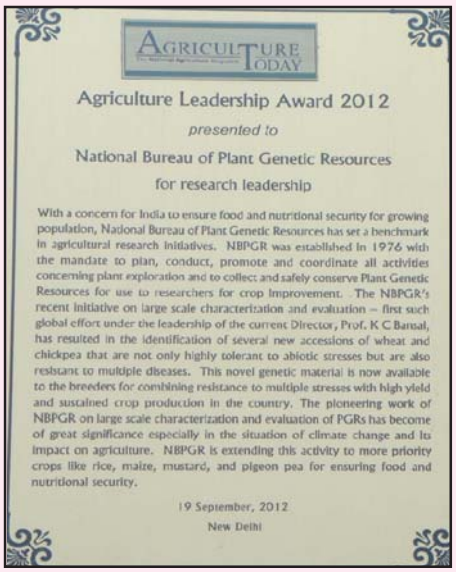
NBPGR participation in *Pusa Krishi Vigyan Mela*

NBPGR participated in the *Pusa Krishi Vigyan Mela* held at IARI from March 1 to 3, 2012. A total of six stalls were put up to depict its main activities focusing on 'Use of PGR for crop improvement: efficient linking to farmers'. Information on grassroot level training to farmers for geranium cultivation and oil extraction, kiwi fruits plantations and potentiality of hops, introduced by NBPGR as successful ventures was disseminated. Outcome of NAIP projects operational at disadvantaged districts of Adilabad in Andhra Pradesh, Chamba in Himachal Pradesh and Udaipur in Rajasthan was depicted. In order to enhance livelihood security of the farmers of these districts, NBPGR is promoting local landraces of maize, rice and pea and also their semi-processed products. A unique mega program on evaluation of 22,000 accessions of wheat for morphological traits at CCSHAU, Hisar, for biotic traits at IARI R/S, Wellington and for abiotic traits (terminal heat tolerance) at NBPGR Experimental Farm, Issapur was detailed to the visitors. Information on varieties released based on germplasm introduced with NBPGR efforts and on varieties developed using indigenous germplasm supplied by NBPGR was provided. Exhaustive display of live materials of registered germplasm, regenerated fruiting plants and plantlets from 1 to 20 years cryostored seeds and vegetative tissues (*Musa* spp.) after retrieval from ultra low temperatures of -196^{0}C was done. The NBPGR stall was visited by Chief Guest of Inaugural Function, Hon'ble Dr Charan Das Mahant, Minister of State for Agriculture and Food Processing Industries and President of the function, Hon'ble Sh. Harish Rawat, Minister of State for Agriculture, Food Processing Industries and Parliamentary Affairs.

Dr KC Bansal, Director, NBPGR explaining the displays at the NBPGR stall to Hon'ble Dr Charan Das Mahant and Hon'ble Sh. Harish Rawat

Research Leadership Award 2012 Conferred on NBPGR

NBPGR was bestowed with the prestigious '5th Research Leadership Award' constituted by Agriculture Today, the national agriculture magazine. The award was presented by Shri Harish Rawat, Minister of State for Agriculture, Food Processing Industries and Parliamentary Affairs and received by the Director, Professor K C Bansal on behalf of NBPGR in the presence of Shri P K Dhumal, Chief Minister of Himachal Pradesh and Shri K P Mohanan, Minister of Agriculture, Kerala. Dr. P L Gautam, Chairman, PPV&FRA, Dr. J S Sandhu, ADG (Seed), ICAR and Dr. R C Agarwal, Registrar General, PPV& FRA were also present in the Award Ceremony held on September 19.



AGRICULTURE TODAY

Agriculture Leadership Award 2012

presented to

National Bureau of Plant Genetic Resources

for research leadership

With a concern for India to ensure food and nutritional security for growing population, National Bureau of Plant Genetic Resources has set a benchmark in agricultural research initiatives. NBPGR was established in 1976 with the mandate to plan, conduct, promote and coordinate all activities concerning plant exploration and to collect and safely conserve Plant Genetic Resources for use to researchers for crop improvement. The NBPGR's recent initiative on large scale characterization and evaluation – first such global effort under the leadership of the current Director, Prof. K C Bansal, has resulted in the identification of several new accessions of wheat and chickpea that are not only highly tolerant to abiotic stresses but are also resistant to multiple diseases. This novel genetic material is now available to the breeders for combining resistance to multiple stresses with high yield and sustained crop production in the country. The pioneering work of NBPGR on large scale characterization and evaluation of PGRs has become of great significance especially in the situation of climate change and its impact on agriculture. NBPGR is extending this activity to more priority crops like rice, maize, mustard, and pigeon pea for ensuring food and nutritional security.

19 September, 2012

New Delhi

Citation for the 5thResearch Leadership Award

Prof. K C Bansal, Director, NBPGR, receiving the 5thResearch Leadership Award from Shri Harish Rawat, Minister of State for Agriculture, Food Processing Industries and Parliamentary Affairs

36th NBPGR Foundation Day Celebrated

The 36th Foundation Day of NBPGR was celebrated on August 6. Dr Dr P L Gautam, Chairperson, PPVFRA was the Chief Guest and Prof. R B Singh, President, NAAS, Former Chairperson, ASRB and Former Director, IARI, delivered the Foundation Day lecture on "Harnessing the treasure of plant genetic resources". Prof. S K Datta, DDG (Crop Science), ICAR and Dr J S Sandhu, ADG (Seed), ICAR were the Guests of Honour. Prof. K C Bansal, Director, NBPGR, in his welcome address highlighted the major achievements of the Bureau. During the Foundation Day Lecture, Prof R B Singh emphasised the need to remain focussed and concentrate more on utilization of PGR.

Prof K C Bansal, Director, NBPGR, Prof. R B Singh, the Chief Guest, Dr P L Gautam, and the Guests of Honour, Prof. S K Datta and Dr J S Sandhu during the 36th Foundation Day of NBPGR

On the occasion, Best Worker Awards were given by the Chief Guest, Dr P L Gautam to encourage and motivate the staff. The Chief Guest congratulated all the staff for their commendable contribution in making NBPGR visible at the global level. In his address he emphasised on the need to focus on enhancing national networking on acquisition, conservation, evaluation and utilization of crop germplasm, strengthening database on PGR information and monitoring national and international regulations in PGR policy to ensure efficient PGR management. The celebrations culminated with a cultural programme presented by the staff of NBPGR.

20.14 Workshops/ Group meetings/ Trainings organized

SNo.	Title of Programme	Duration	Venue
1	Conservation of Plant Genomic Resources	March 12 to 25, 2012	NBPGR, New Delhi
2	Workshop and Training on Gene Expression data analysis and structural Bioinformatics	March 1 to 11, 2012	NBPGR, New Delhi
3.	Model Training Course on Role of Underutilized and Neglected Plant Genetic Resources in Health and Nutritional Security:	March 12 to 19, 2012	NBPGR, New Delhi
4.	National Workshop cum training on Computational Genome Analysis Techniques in discovery of Agronomically Important Crop Genes	Sept 24 to 29, 2012	NBPGR, New Delhi
5.	Bioinformatics software training & sensitization workshop	October 19 to 25, 2012	NBPGR, New Delhi.
6.	Training programme on *Jaiv Vividhta Sanrakshan evam Satat Vikas*	October 17, 2012	NBPGR, Bhowali (at village – Nagua thagu,Khatima)
7.	Training programme on *Jaiv Vividhta Sanrakshan evam Satat Vikas*	November 26, 2012	NBPGR, Bhowali (at Karuwa, Dehradun)

Participants and Faculty of Training on 'Conservation of Plant Genomic Resources' with Prof. K C Bansal, Director, NBPGR

Participants of the Workshop-cum-Training Programme on 'Computational Genome Analysis Techniques' along with Prof. K C Bansal, Director, NBPGR and Faculty

20.15 Participation of Staff in Seminars/ Symposia/ Conferences/ Workshops/ Training Programmes

Name	Title of Seminar/ Symposium/ Conference/ Workshop/ Training programmes	Place and period
R Parimalan	Winter School on Molecular Approaches for Allele Mining and Crop Improvement	Genetics Division, IARI, New Delhi, 2 to 25 January
J Akhtar	3rd Global Conference of ISMPP on Plant Pathology for Food Security	MPUAT, Udaipur, Rajasthan 10 to 13 January
K K Gangopadhyay S K Yadav	XXX Group Meeting on AICRP on Vegetable Crops	GBPUAT, Pantnagar, Uttarakhand 13 to 16 January
N Sivaraj, S R Pandravada N Dikshit, N K Dwivedi	8th International Safflower Conference Safflower Research and Development in the World: Status and Strategies	DOR, Hyderabad 19 to 23 January

K Rameash	Workshop on Use and Application of Agropedia	ICRISAT, Patancheru, Andhra Pradesh 23 January
Zakir Husain	Global Conference on Aroids: Opportunities and Challenges	Bhubaneswar, Odisha, 23 January
Anuradha Agarwal, Arjun Lal, M Dutta Nidhi Verma, Pratibha Brahmi, S K Yadav, Sunil Archak, Sushil Pandey, VandanaTyagi	Strategies for Implementing the International Treaty's Multilateral System of Access and Benefits Sharing in India	NBPGR, New Delhi 23 to 25 January
Sherry Jacob	National Seed Congress	JW Marriot hotel, Chandigarh 23 to 25 January
Anuradha Agarwal, R K Tyagi	International Symposium on Banana	Chiang Mai, Thailand, 23 to 26 January
N Sivaraj	International Conference on Eco-conservation for sustainable development (ICECSD-2012)	Quaid-E-Millath Government College for Women, Chennai 1 to 3 February
M K Bag	National Symposium on Frontlines of Microbiological Research: Concepts and Applications	Kolkata University, Kolkata 2 to 4 February
SangitaYadav	Project Appraisal Committee Meeting for Development of DUS Descriptors	NASC Complex, New Delhi 6 February
Ashok Kumar	National Seminar on New Perspectives in Medicinal and Aromatic Plants	CCS HAU, Hisar 8 to 9 February
K Anitha	Workshop on Management of Stress	NAARM, Hyderabad 14 to 16 February
Archana P Raina, Rakesh Bhardwaj, Sandeep Kumar, Sangita Yadav T V Prasad	2nd International Conference on Agrochemicals, 2nd International Conference on Agrochemicals, Protecting Crops, Health and Natural Environment: Role of Chemistry for Sustainable Agriculture	IARI, New Delhi 15 to 18 February
SangitaYadav	National Conference on Shaping Human Resource for Global Competitiveness and Global Alumni Meet	IARI, New Delhi 18 February
Anirban Roy, Rakesh Bhardwaj	Workshop on Project Proposal Development by NFBSRA	NAARM, Hyderabad 20 to 23 February
Ambika Baldev Gaikwad, Jyothi Kumari, SangitaYadav, Sunil Archak	International Conference on Plant Biotechnology for Food Security: New Frontiers (ICPBFS – 2012)	NASC, New Delhi 21 to 24 February
K Rameash	International Conference on Ecotechnology and Sustainability Science-Biodiversity and Sustainable Development	Tirupati, AP 29 February to 1 March
Sandeep Kumar, SangitaYadav	Ist National *Brassica* Conference on Production Barriers and Technological Options in Oilseed *Brassica*	CCS HAU, Hisar 2 to 3 March
S Roy	Farmers Innovation Day and Showcasing of Technology	ICAR RC for NEHR, Umiam, Shillong 5 March
Chitra Devi, Jyoti Kumari, Lalit Anand, Manjusha Verma, Pragya	Global Conference on Women in Agriculture	NASC, New Delhi, 13 to 15 March
Z Abraham	Awareness Generation cum Training Programme on PPVFR Act	SBI, Coimbatore 16 to 17 March

N Sivaraj	National Training on Applications of Geo-informatics and Crop Simulation Models in Agricultural Management	NAARM, Hyderabad 13 to 26 March
K C Bhatt	National Seminar on Impact of Developmental Activities on Traditional Ethno-medicine, Biodiversity and its Conservation	NBRI, Lucknow 17 to 19 March
E Roshini Nayar, K Pradheep	Workshop on Geometric Morphometrics	University of Delhi, Delhi 20 to 30 March
Nidhi Verma	42nd Annual Group Meeting of AICRP on Soybean	CSKHPKV, Palampur 22 to 24 March
Archana P Raina	National Conference on Medicinal Plants: Scientist, Grower and Industry Interaction	INSA, New Delhi 23 March
D P Semwal	Medicinal Plants - Scientist, Grower and Industry Interaction	INSA, New Delhi 26 to 27 March
S R Pandravada	Awareness cum Taining Programme on PPVFRA	Mahaboobnagar, Hyderabad 27 March
S K Yadav	National Seminar on Sustainable Agriculture & Food Security: Challenges of Changing Climate	CCS HAU, Hisar 27 to 28 March
K Anitha, N Sivaraj	National Seminar on Impact of Climate Change and Industrial Pollution on Biodiversity and the Need for Community Conservation Initiative	Indian Medical Association, Hyderabad, 28 to 29 March
N Sivaraj	Annual Research Workers Group Meeting on Sunflower, Sesame and Niger	University of Agricultural Sciences, Bengaluru, Karnataka, 26 to 28 April
B S Phogat, Om Vir Singh R S Rathi	XXIII Annual Meet of AICRN on Underutilized Crops	MPKV, Rahuri 2 to 3 May
N K Gautam	Annual Group Meet on Pigeonpea, Mung bean and Urd bean	OUAT, Bhubneshwar 4 – 6 May
N Dikshit	Annual Group Meeting on Castor	Regional Research Station, Tamil Nadu Agricultural University, Yercaud, 10 to 12 May
A K Misra, J C Rana, N K Gautam R S Rathi, S Roy	National Seminar on Plant Genetic Research for Eastern and North–Eastern India	ICAR Research Complex for NEH Region, Umiam, Shillong 11 to 12 May
Kamala Venkateswaran	Annual Pigeonpea workshop	University of Agricultural Sciences, Bengaluru, 13 to 15 May
M Dutta, Mohar Singh	DAC-ICARDA Meeting on Prebreeding	NASC, New Delhi 23 to 24 May
N K Dwivedi, Om Vir Singh	28th annual Group meeting of National Network Research Project on Arid Legumes	Regional Agricultural Research Station, KAU, Pattambi May 26 to 27
Anirban Roy, D Saha, M Arivalagan M K Bag, Pragya, Rashmi Yadav T V Prasad	Global Conference on Horticulture for Food, Nutrition and Livelihood Options	Bhubaneswar, Orissa 28 to 31 May
Kavita Gupta, Shashi Bhalla V Celia Chalam	Consultative Meeting for Preparation of MOP-6 and Stocktaking Assessment for Phase-II Capacity Building Project on Biosafety	NASC, New Delhi 29 May

Rakesh Bhardwaj	Regional Symposium on Promoting Underutilized Food Systems for Better Nutrition in Asia and Pacific	KhonKaen, Thailand 31 May to 2 June
D P Semwal, K C Bhatt	GIS Training Programme on Introduction to ArcGIS Desktop	NIIT, New Delhi 4 to 8 June
V Celia Chalam	Brainstorming Session on Impact of Capacity Building	NASC, New Delhi 12 June
N Sivaraj	Workshop on Capacity building on Access and Benefit sharing in Biodiversity	Hotel Green Park, Hyderabad 12 June
D C Bhandari	XII Annual Group Meeting of AICRP on Tuber Crops	MPUAT, Udaipur 18 June
Kavita Gupta Shashi Bhalla V Celia Chalam	Inception Workshop of UNEP/GEF supported Phase II Capacity Building Project on Biosafety	NASC, New Delhi 18 to 19 June
Pratibha Brahmi, Vandana Tyagi	Joint Capacity Building Workshop with the Convention on Biological Diversity	Vigyan Bhawan, New Delhi 30 June to 1 July
M Dutta	Training on Knowledge Management & Knowledge Sharing in Organization (DST)	Indian Institute of Public Administration, New Delhi 23 to 29 July
M K Rana	National Seminar on Indian Agriculture: Present Situation, Challenges, Remedies and Road Map	CSKHPKV Palampur 2 to 6, August
Ranbir Singh	XIX Annual Research Workers Group Meeting on Rapeseed-Mustard	Birsa Agricultural University, Ranchi, Jharkhand 3 to 5 August
Jyoti Kumari	51st All India Wheat and Barley Research Worker's Meet	Jaipur 24 to 27 August
N Sunil	Farmer's Day.	DOR, Hyderabad, 1 September
K K Gangopadhyay	Golden Jubilee Seminar on Advances in Agricultural Research Towards Food Security and Environmental Sustenance	ViswaBharati, Sriniketan, WB 1 to 3 September
M Dutta, Mohar Singh	AICRP Workshop on Chickpea	GBPUAT, Pantnagar 1 to 3 September
Kavita Gupta, Shashi Bhalla, V Celia Chalam	Inter Ministerial cum Expert Group Meeting of MoEF	NASC, New Delhi 4 September
N Sivaraj	Annual Group Meeting on Safflower and Linseed	IGKVV, Raipur 6 to 8 September
N K Gautam	Annual Group Meet on *Rabi* MULLaRP crops	IIPR, Kanpur 7 to 8 September
N Sunil	Technology Week	CRIDA, Hyderbad, 10 September
D C Bhandari	Germplasm Conservation, Climate Change Mitigation and E-networking	CTCRI, Thiruvananthapuram 24 September
M Dutta	Project Inception Meeting for Implementation of Benefit Sharing Fund of the International Treaty on Plant Genetic Resources for Food and Agriculture Collaborative Projects	NASC, New Delhi 1 October
Anirban Roy, J C Rana, M K Bag, M K Rana, T K Mondal	VI International Conference on Legume Genetics and Genomics (ICLGG)	ICRISAT, Hyderabad 2 to 7 October
Ashok Kumar	20thAICRP Workshop on Medicinal, Aromatic Plants and Betelvine (MAP&B)	CCS HAU, Hisar 8 to 10 October

B Abraham, B Sarath Babu, K Anitha, K Rameash, Kamala Venkateswaran, N Sivaraj, N Sunil, S K Chakrabarty, S R Pandravada	CoP -11 & MoP to the Convention on Biological Diversity	International Convention Centre, Hyderabad 1 to 19 October
Kavita Gupta, Pratibha Brahmi	XI Conference of Parties of the Convention on Biological Diversity,	International Convention Centre, Hyderabad, 9 to 19 October
M K Rana	Silver Jubilée International Symposium on "Global Cotton Production Technology vis-à-vis Climate Change	CCSHAU, Hisar 10 to 12 October
Shashi Bhalla, V Celia Chalam	Expert Consultation on Managing Transboundary Diseases of Agricultural Importance in Asia Pacific	NASC, New Delhi 10 to 12 October
M C Singh	Silver Jubilee International Symposium on Global Cotton Production Technologies vis-à-vis Climate Change	CCSHAU, Hisar 10 to 12 October
Nidhi Verma, S K Yadav, Vandana Tyagi	National Symposium on Management of Plant Genetic Resources in Horticultural Crops	NBPGR, New Delhi 18 to 19 December
Ambika Baldev Gaikwad	4th International Saffron Symposium-Advances in Saffron Biology, Technology and Trade	SKUAST, Srinagar 22 to 25 October
K Pradheep	International Symposium and XII Annual Conference of Indian Association for Angiosperm Taxonomy on 'Innovative Perspectives in Angiosperm Taxonomy	Sant Gadge Baba Amravati University, Amravati Maharashtra 28 to 30 October
N K Dwivedi	XXIII Workshop of AICRP on Spices Indian	Institute of Spice Research, Kozhikode 29 September to 1 October
Anuradha Agrawal, Neelam Sharma, Ruchira Pandey, SK Malik	5th Indian Horticulture Congress 2012 - An International Meet	PAU, Ludhiana 6 to 9 November
Sheel Yadav	Workshop on Recent Advances in Quantitative Genetics and Statistical Genomics	IASRI New Delhi 6 – 26 November
N Dikshit	International Conference on Recent Trends in *Lathyrus sativus* Research	National Institute of Nutrition, Hyderabad, 8 to 9 November
M Abdul Nizar	22nd Meeting of ICAR Regional Committee No. VII	The International Centre, Goa 9 to 10 November
Anirban Roy, D B Parakh, V Celia Chalam	XXI National Conference on Immunobiology and Management of Viral Diseases in 21st Century	IVRI, Mukteswar Campus, Nainital, 8 to 10 November
M Dutta	National Seminar on Sustainable Development	Gurgaon, Haryana 8 to 9 November
Anirban Roy	National Symposium on Innovative Approaches and Modern Technologies for Crop Productivity, Food Safety and Environmental Sustainability	Thrissur, Kerala 19 to 20 November
Jyoti Kumari, M C Singh, Rashmi Yadav, T P Singh	Third International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods	IARI, New Delhi 26 to 30 November
A Kandan, Arjun Lal, Baleshwar Singh, B Sarath Babu,	International Conference(ICPHM 2012) on Plant Health Management and	DRR, Hyderabad 28 – 30 November

Babu Abraham, Jameel Akhtar Jairam, K Anitha, K Rameash, Kamala Venkateswaran, N Sivaraj, P C Agarwal Prasanthi, Rakesh Bhardwaj, S K Chakrabarty, S R Pandravada, Sunil Neelam, T V Prasad V Celia Chalam, Z Khan	Food Security	
M Dutta	Review Meeting on ICAR-ICARDA Collaborative Research Programme	NASC, New Delhi 29 November
Rakesh Bhardwaj	Golden Jubilee Conference of Indian Dietetic Association	National Institute of Nutrition, Hyderabad, 29 Nov to 1 December
A.K. Singh, N K Dwivedi, Om Vir Singh	Symposium on Managing Stress in Drylands under Climate Change Scenario	CAZRI, Jodhpur, Rajasthan 1 to 2 December
M K Bag	ICRISAT-ICAR International Training Course on High Throughput Phenotyping for Chickpea and Pigeon pea Diseases	ICRISAT, Hyderabad 3 to 8 December
P C Agarwal	National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture	Bangalore, India 4 to 6 December
Om Vir Singh, A K Singh	"3rd National Conference on Biotechnology for Environment Management" Sponsored by UGC"	Mahila P.G. Mahavidyalaya, Jodhpur, 4 to 5 December
Pragya	Winter School on Breeding for Higher Productivity and Industry Suitable Food Colorants and Bioactive Health Compounds in Vegetable Crop Plants: Conventional and Hi-Tech Cutting Edge Approaches	IARI, New Delhi 4 to 24 December
V Celia Chalam	Brain Storming Session on Phytoplasma Disease Management in Coconut and Arecanut	Kayankulam, Kerala 8 December
M Dutta	Consultation on How to Achieve Food Security in World of Growing Scarcity: Role of Technology Development Strategies	NASC, New Delhi 11 December
M Dutta	Workshop on Trade, Agricultural Policies and Structural Changes in India's Agri-Food System: Implications for National and Global Markets (TAPSIM)	NASC, New Delhi 14 December
Jyoti Kumari	International Conference on Statistics and Informatics in Agricultural Research	New Delhi 18 to 20 December
Ambika B Gaikwad, A Kandan, Chitra Devi, Lalit Anand, Manju usha verma, Rakesh Bhardwaj, Rashmi Yadav, Sandeep Kumar, Sandhya Gupta, Sunil Archak, Sushil Pandey, S K Yadav, Vandana Tyagi, Veena Gupta, Zakir Hussain	International Conference on Biotechnology: A Rendezvous with Basic Sciences for Global Prosperity	NASC Complex, New Delhi 26 to 27 December
Rakesh Bhardwaj, M K Bag	2nd National Conference on Environment and Biodiversity of India	University of Delhi, Delhi 29 to 30 December

20.16 Publications

20.16.1 Research Papers

1. Agrawal, Veena Gupta and Rup Narayan (2012) Ecological study of wild medicinal plants in a dry tropical peri-urban region of Uttar Pradesh in India. *Int. J. Med. Arom. Pl.* 2(2): 246-253.

2. Agrawal RC, Sunil Archak and RK Tyagi (2012) An overview of biodiversity informatics with special reference to plant genetic resources. *Computers and Electronics in Agri.* 84: 92–99.

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4. Akhtar J, KR Tiu, HC Lal, A Kumar, VK Singh and Z Khan (2012) Impact of soil solarization on some solanaceous vegetables nursery in plateau region of Jharkhand, India. *Vegetos* 25(2): 109-114.

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20.16.4 Manuals /Teaching aids

1 Malik SK, Rekha Chaudhury, S Kumar, OP Dhariwal and DC Bhandari (2012) Citrus genetic resources in India NBPGR, New Delhi, 174 p.

2 Raiger HL and M Dutta (2012) Annual Report on Characterization and Evaluation of *Rabi* Crops (2010-11). NBPGR, New Delhi, 315 p.

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20.16.6 Crop Catalogues

1 Phogat BS, HL Raiger, Sushila Kundu, YS Rathi and Dutta M (2012) Catalogue on Multi-location Evaluation of Wheat Germplasm (2010-11). NBPGR, New Delhi, 464 p.

20.16.7 Genebank Submissions

1 Banerjee A, SS Roy, S Roy and SV Ngachan (2012) *Chilli veinal mottle virus* isolate Meghalaya-1 cytoplasmic cylindrical inclusion protein gene, partial cds. KC119086-93.

2 Banerjee A, NA Deshmukh, S Roy and SV Ngachan (2012) *Candidatus Liberibacter asiaticus* isolate Umiam-1 16S ribosomal RNA gene, partial sequence. JX284239-44.

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20.16.8 Radio Talks

1 Sh. R R Arya delivered a radio talk entitled "*Sajawati Podho Ka Vyavasayik Prabandhan*" at AIR, Almora on 12.01.2012.

2 Dr. S K Yadav delivered a radio talk on *"Chaulai Utpadan: Aam ke Aam aur Guthliyon ke Daam"* All India Radio, New Delhi on 20.02.2012.

3 Dr. S K Yadav delivered a radio talk on *"Bush Mango ki Nai Fasal"* All India Radio, New Delhi on 26.03.2012.

4 Dr. P S Mehta, Technical Officer, T-6 delivered a Radio Talk entitled "*Agaiti dhan ki Vaigyanik Kheti*"at AIR, Almora, Uttarakhand on 01.03.2012.

5 Dr. P S Mehta, Technical Officer, T-6 delivered a Radio Talk entitled "*Dhan ki Adhunik Kheti*"at AIR, Almora, Uttarakhand on 11.06.2012.

6 Dr. K S Negi, Principal Scientist, delivered a Radio Talk entitled "*Aushadiya Padap Satavar – Upyogita*

Evam Krishikaran" at AIR, Almora, Uttarakhand on 22.08.2012.

7 Dr. A K Trivedi, Senior Scientist, delivered a Radio Talk entitled "*Jaiv Vividhata Sanrakshan tatha Upyogita"* at AIR, Almora, Uttarakhand on 06.08.2012.

8 Dr. S K Verma, Principal Scientist & Officer-in-Charge, delivered a Radio Talk entitled "*Uttarakhand mein Bagwani Vikas – Samasyaein evam Chunautiya*" at AIR, Almora, Uttarakhand on 10.09.2012.

9 Dr. P S Mehta, Technical Officer, T-6, delivered a Radio Talk entitled "*Vaigyanik Beej Prayog ke Laabh*" at AIR, Almora, Uttarakhand on 24.09.2012.

20.16.9 TV phone in programme

1 Dr. S K Yadav participated in Doordarshan Krishidarshan phone in live programme on: "Shakiye Faslon ki Unnat Kheti avem rakh-rakhav" on 26.4.2012

20.17 Patents Granted

Randhawa G J, Firke P K and Karihaloo J L Patent No. 254341. Process enabling simultaneous detection of two transgenes in transgenic wheat

20.18 Distinguished Visitors

Visit of Director General (ICAR) to NBPGR RS, Jodhpur: Dr. S Ayyappan, the Director General of ICAR visited NBPGR R/S Jodhpur and discussed and analyzed critically the work being done at the centre. He also emphasized that NBPGR and CAZRI should work on collaborative mode. The ICAR authorities present at the occasion made a pledge to work in collaboration of each other. The DG, ICAR was accompanied by Dr. M M Pandey, DDG (Engineering), Dr. K M L Pathak, DDG (Animal Science), Dr. C Nimbkar Member, GB, ICAR, Dr. K C Bansal, Director, NBPGR, and Dr. S Mauria, ADG (IP&TM). The other ICAR authorities who visited the centre during the period were Dr. V N Sharda, member (ASRB), Dr. A K Singh DDG (NRM), Dr. J S Sandhu ADG (Seeds), Dr. R P Dua, ADG (F&FC), Dr. O P Yadav, Director, Directorate of Maize Research and Dr. R K Tyagi, NBPGR.

Visit of Director General (ICAR) to NBPGR RS, Ranchi : Dr S Ayyappan, Secretary (DARE) and Director General (ICAR), Dr T P Rajendran, Assistant Director General (Plant Protection), Dr Bhagwati Prasad Bhatt, Director ICAR Research Complex for Eastern Region, Patna, Dr R Ramani, Director, Indian Institute of Natural Resins and Gums, Ranchi and Dr S Kumar, Head, iCAR Research Complex for Eastern Rehion, Research Centre Ranchi visited NBPGR R/S, Ranchi on October 14, 2012.

DG, DDG (Engg.), DDG (AS), Director (NBPGR), Director (CAZRI) and ADG (IP&TM) made a pledge at NBPGR R/S Jodhpur to work in collaborative mode.

Dr. S Ayyappan, DG ICAR planted a sapling of pomegranate at NBPGR R/S, Jodhpur

Dr. K C Bansal, Director, NBPGR briefing DG, ICAR about the work being done at NBPGR R/S, Jodhpur

Dr. K C Bansal, Director, NBPGR visited on 10 January, 2012 and inaugurated the Office-cum-laboratory Building of NBPGR R/S, Ranchi

Dr. J S Sandhu, ADG (Seed), ICAR planting a Cycas plant during a visit on August 2, 2012

Dr. PL Gautam, Chairman, PPV&FR Authority and Dr. KR Dhiman, Vice Chancellor, Dr YS Parmar UHF, Solan looking at peach germplasm in the field genebank

Annexure 1: Meteorological data (temperature in degrees Celsius and rainfall in mm) at NBPGR Regional Stations

Station	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Akola	Max temp	28.6	32.8	37.5	41.2	42.4	37.5	30.6	28.9	31.1	33.3	31.3	30.0
	Min temp	12.9	14.3	18.4	26.3	28.4	26.5	24.1	23.2	23.1	18.8	14.7	13.1
	Rainfall	6.2	0.0	0.0	0.7	10.1	111.0	270.7	106.0	154.0	42.4	0.0	0.0
Bhowali	Max temp	11.1	19.4	31.0	25.8	28.1	25.4	25.7	23.1	25.1	25.8	17.2	18.2
	Min temp	0.1	1.8	4.0	9.9	6.2	16.8	14.9	16.6	16.1	12.5	4.7	0.6
	Rainfall	55	0.0	0.0	34.4	7.0	84.4	585	236.0	225	0.0	5.0	25.0
Cuttack	Max temp	26.4	30.7	34.6	35.1	36.8	35.7	30.5	30.4	31.4	30.7	28.9	29.5
	Min temp	0.0	0.0	0.0	26.3	27.1	27.0	25.5	25.6	25.9	23.0	19.2	16.7
	Rainfall	97.2	0.0	0.0	23.2	55.4	84.6	477.2	361.8	96.2	86.0	137.4	0.0
Hyderabad	Max temp	30.1	33.0	36.9	37.5	40.5	35.1	30.2	30.2	30.1	30.3	28.7	29.9
	Min temp	14.2	15.4	17.3	22.6	26.8	25.5	23.1	22.5	22.2	18.5	19.9	13.0
	Rainfall	0.0	0.0	0	30.8	10.9	139.5	261.6	99.4	117.9	58.9	47.0	0.0
Jodhpur	Max temp	23.3	26.4	33.8	38.4	41.6	39.9	37.7	33.0	33.5	35.7	31.3	26.8
	Min temp	9.3	11.8	16.9	23.4	27.4	28.4	28.5	25.6	24.6	19.0	14.1	11.6
	Rainfall	0.0	0.0	0.0	29.2	2.1	17.7	11.7	291.1	132.8	0.0	0.0	0.0
Shillong	Max temp	18.5	23.0	26.9	27.9	29.2	28.2	28.8	29.1	27.5	26.5	24.1	21.0
	Min temp	5.4	7.2	12.0	16.1	17.6	19.5	20.3	19.7	19.0	14.9	10.1	7.3
	Rainfall	32.9	0.0	1.8	139.6	273.9	312.7	256.0	440.0	348.8	251.5	30.0	0.0
Shimla	Max temp	9.8	13.8	19.2	21.8	27.5	29.2	24.8	23.1	24.3	21.5	18.1	12.6
	Min temp	2.2	4.7	9.8	11.7	17.2	18.8	18.1	17.4	16.5	12.5	10.0	5.9
	Rainfall	14.7	55.9	37.6	19.0	80.0	198.9	163.2	159.2	92.3	0.8	0.0	0.4
Srinagar	Max temp	4.0	8.0	13.0	19.0	25.0	29.0	31.0	30.0	28.0	23.0	16.0	10.0
	Min temp	-2.0	-1.0	4.0	7.0	11.0	14.0	18.0	18.0	13.0	6.0	0.0	-2.0
	Rainfall	73.0	72.0	104.0	78.0	63.0	36.0	61.0	62.0	32.0	29.0	18.0	36.0
Thrissur	Max temp	32.8	35.1	35.2	34.7	32.6	30.1	30.0	29.2	30.4	32.1	32.5	33.0
	Min temp	21.3	22.1	24.2	24.8	25.3	23.9	23.7	23.0	23.3	23.5	22.7	23.2
	Rainfall	0.0	0.0	3.5	101.9	117.3	551.5	375.8	616.5	191.8	145.6	46.7	19.8

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