2. Salient Achievements
Crop Improvement and Management

PLANT GENETIC RESOURCES

Germplasm exploration and collection

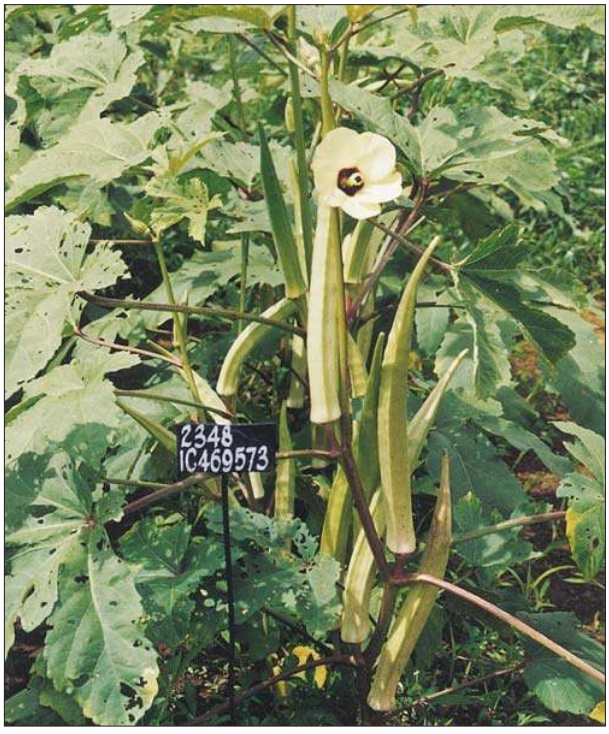
Accessions 2,607 (2,080 cultivated and 527 wild accessions) were collected from Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Nagaland, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh through 34 explorations. And to the National Herbarium of Cultivated Plants (NHCP), 953 herbarium specimens, 129 seed samples and 17 economic products have been added.

Profuse bearing in *Prunus armeniaca* from North-West Himalaya

Chilli variety Tangerine Dream (EC 583593) from the USA

- Accessions 25,847 of diverse crops introduced including transgenics and of international trials
- Out of 2,452 samples found infested with different pathogens, 2,441 salvaged
- Orthodox seed species accessions 29,404 added to National Gene Bank for long-term storage
- Pepino, a minor fruit plant of Andrean region, and New Zealand spinach, a leafy vegetable of New Zealand and Australia, established successfully
- Brinjal (Pusa Purple Long) transformants with synthetic gene, resistant to kanamycin, regenerated and confirmed by PCR

Accessions 25,847 of diverse crops, including transgenics and international trials (2,691 entries), have been introduced, and 138 accessions have been exported. Inland supply of germplasm comprise 8,523 samples. And some promising introductions include



Promising accession IC 469573 of okra from Goa

bacterial blight and grassy stunt virus resistant lines in rice (EC583378-453) from Philippines; *Brassica napus* germplasm with low erucic acid and low glucosinulate from Russia (EC564728-29) and common bean lines resistant to bean golden yellow mosaic virus, anthracnose, angular leaf spot and leaf blight from Honduras (EC559573-74).

Plant quarantine

Exotic accessions of various crops including transgenics, trial materials, and germplasm lines have been processed for quarantine clearance. Samples 2,452 were found infested/infected with insects and mites, nematodes, fungi, bacteria and viruses; of these, 2,441 have been salvaged.

Important interceptions include: ***insects***- *Brevipalpus phoenicis*, *Bruchus emarginatus*, *B. ervi*, *Lepidosaphes ulmi*, *Rhizopertha dominica*, *Sitophilus oryzae*, *S. zeamais*; ***nematodes***- *Aphelenchoides besseyi*; ***fungi***- *Colletotrichum graminicola*, *Peronospora manshurica*, *Phoma lingam*, *Puccinia helianthi*; ***viruses***- Alfalfa mosaic virus, Bean common mosaic virus, Broad bean wilt virus and Peanut stripe virus. Phytosanitary certificates numbered 142 have been issued.

Transgenic imported planting materials–164 of *Brassica oleracea*, *Gossypium* spp., *Oryza sativa, Zea mays* have been processed for quarantine clearance.

Pepino (*Solanum muricatum*) at the NBPGR Regional Station, Shimla

Germplasm conservation

Orthodox seed species accessions (29,404) have been added to the National Genebank for long-term storage. For seed viability, seed quantity and seed health, 517 accessions were monitored after 10 years of storage.

Cereals (15), forages (3), legume (1), oilseeds (6), vegetables and tuber crops (4), fruit (1), spices (6), sugar-yielding plant (1), medicinal (3) and beverages (5) crop species have been approved for registration for unique traits.

A total of 579 accessions of fruits and nuts, industrial crops, mulberry dormant buds and pollen of mango varieties have been cryostored. And 205 accessions have been added of different crops in *in-vitro* gene bank, and 1,889 accession belonging to 152 species have been maintained. Shoot tips of *Morus alba, M. indica* and *M. sinensis* have exhibited 30–35% post-thaw recovery following liquid-nitrogen freezing.

New Zealand spinach at the NBPGR Regional Station, Shimla

Germplasm field day on chilli at the NBPGR Regional Station, Bhowali

Development and digitization of extant-notified plant varieties

Extant/notified varieties documentation has been taken up using software "INDUS" (Indian Information System). For this training has also been provided to all DUS test centres for statistical analysis of the DUS traits data.

Patenting of technique for detection of transgenes

Three patents have been filed for the technique elaborating simultaneous detection of 2 transgenes, *35S* promoter and *EPSPS*, in soybean, maize and wheat. Technology transfer of these patents is under negotiations.

Germplasm characterization, evaluation and maintenance

Accessions 16,183 of various crops have been characterized, evaluated and maintained at the NBPGR Headquarters and regional stations.

Pepino (*Solanum muricatum*), a minor fruit plant of Andean region, and New Zealand spinach (*Tetragonia expansa*), a leafy vegetable of New Zealand and Australia, were collected from Nilgiris, and have been established successfully at the Shimla regional station.

DNA fingerprinting

Forty-five new STMS primer pairs suitable for DNA profiling of mungbean and urdbean and 38 for generating polymorphic alleles in pigeonpea have been identified. Forty-eight new STMS primers containing core repeat motif $(AG)_n$ have been developed and identified in brinjal for cultivar identification.

Development of detection protocols for transgene testing: Transgenic lines of cotton, rice, maize and potato (180) were tested for terminator gene technology cassette using primer specific to *cre* sequence amplifying amplicon of 1031 bp. No evidence has been found for the presence of terminator gene in any of the samples.

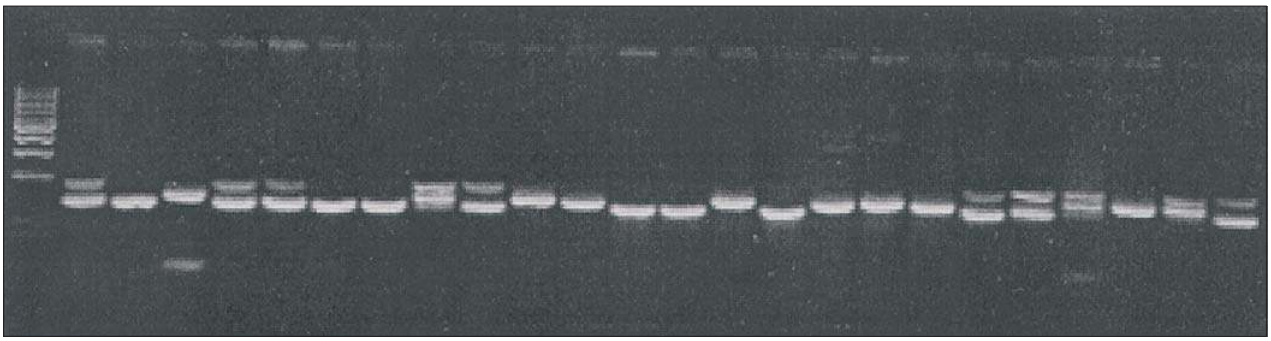
Genetic diversity studies: PCR-RFLP (Polymerase Chain Reaction- Restriction Fragment Length Polymorphism) analysis of trnH intergenic spacer region and ITS 1 region in 149 selected accessions representing 35 species of *Vigna* has indicated primitiveness of *V. hainiana* to closest wild relatives of mungbean and urdbean. Others related to mungbean-urdbean group include *V. trinervia* and *V. grandiflora*.

Analysis of genetic diversity in horsegram accessions using molecular markers have indicated that the ones from Uttarakhand and Madhya Pradesh have high diversity compared to the rest of the country. And Indian horsegram cultivars are found more diverse than those from African countries.

Plant biotechnology

Development of Bt-brinjal: Chemical control of brinjal shoot and fruit borer (BSFB) is not only expensive but is also ineffective. A codon-modified gene encoding a delta-endotoxin of Bt (*Cry*1

Brinjal Pusa Purple Long has been transformed by the synthetic gene to contain the damage caused by the brinjal shoot and fruit borer. Its limited contained field test has been conducted. (Undamaged fruits harvested from Bt (*left*) and non-Bt plots (*right*))



Profile of rice varieties with Sequence Tagged Micro-Satellite (STMS) markers

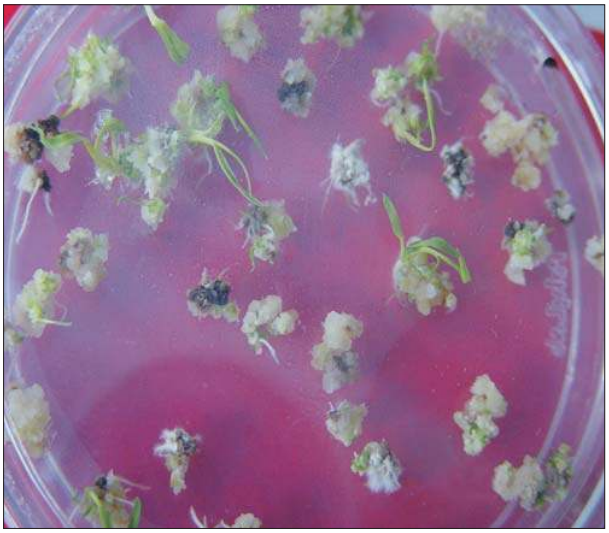
Intellectual Property Rights

- ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization have been approved by the Governing Body and President, ICAR. These are made operative from 2 October 2006.
- National Phase Applications based on the PCT Application entitled "Rapid Detection of Bt-Cry Toxin" to seek protection in (*i*) Uzbekistan, (*ii*) South Africa, (*iii*) China, (*iv*) South Korea, (*v*) Mexico have been filed, and are being pursued.
- New patent applications (76), replies of 32 examination reports and 10 requests for examination have been filed with the Patent Office, Delhi. So far, 14 patents have been sealed and another 21 applications have been accepted for grant of patent. These represent technologies from the Subject Matter Divisions of Crop Sciences (64), Horticulture (24), Animal Sciences (37), Agricultural Engineering (16), Fisheries (11) and NRM (1).
- Two fresh PCT application (i) An artificially synthesized peptide, and (ii) *In-vitro* pearl production using marine organisms, have been filed at the International Bureau of World Intellectual Property Organization.

Fa1) was constructed. Brinjal (cv. Pusa Purple Long) could be transformed with synthetic gene under the control of a constitutive promoter (CaMV 35S). Transformants resistant to kanamycin were regenerated and confirmed by the polymerase chain reaction (PCR) analysis. Transgenic lines with very high-level protection against BSFB have been identified. The fruit damage in transgenic lines was 5% in contrast to 47% in normal lines.

Cloning of blast resistance gene *Pi-k*^{b} and its transfer to rice: A blast resistance gene *Pi-k*^{b} from rice line Tetep has been cloned. Complete candidate rice blast resistance gene has been cloned in plant transformation vector pCAMBIA 1301.5, which contains CaMV 35S promoter, gene for hygromycin resistance (*hpt*) and gene for kanamycin resistance (*npt*11), as selectable marker. A japonica rice line TP 309 was used for transformation analysis. Mature scutellum calli were used as explants. Transformed calli have been regenerated to rice-plants.

Regeneration of transformed rice-calli having a rice-blast disease resistance gene *Pi-k*^{h}



Development of an improved CMS line of *Brassica juncea*. CMS line developed through hybridization between *Diplotaxis berthautii* and *Brassica rapa,* followed by backcrossing with *B. juncea* had low female fertility and flowers lacked nectarines; and so was commercially unsuitable. An improved CMS line of this has been obtained by further backcrossing and selection. This has flowers with well developed nectaries and stable male fertility. The restorer of *Moricondia arvensis* system is able to confer male fertility to this CMS, and the mode of restoration is gametophytic.

Male sterile flowers of CMS (*Diplotaxis berthautii*) *Brassica juncea* line; suitable for commercial use

Flowers of fertility restored plant through restorer of *Moricondia arvensis* system

FOOD CROPS

Rice

Crop improvement: Thirty hybrids/varieties have been released for different ecosystems.

- Released hybrids/varieties 30 of rice, 8 of wheat, 1 of barley, 7 of maize and 1 of sorghum
- System of Rice Intensification technique recorded 11.47% higher grain yield of hybrid rice over rice transplanting
- Identified superior wheat and barley genetic stocks
- Promising wheat genotypes with various parameters, wet gluten, dry gluten, sedimentation value, extraction rate, grain hardness index, micronutrients, ß-carotene selected
- Identified promising entries of barley for malting quality traits
- Maize performed significantly better under ridge-and-furrow and broad-bed systems than under flat sowing and minimum tillage
- New maize hybrids found less susceptible to *Chilo partellus*
- HHB 67-Improved, the first finished product of marker-assisted selection for downy-mildew resistance in pearl millet, notified for release at the national level

Rice VL Dhan 85. It is an early-maturity, June-sown variety for Uttarakhand hills in irrigated areas. And is tolerant to neck blast and leaf blast

VL Dhan 207. This is a spring-sown, direct-seeded rice variety with medium maturity for Uttarakhand hills in rainfed areas

VL Dhan 208 rice. This variety is suitable for rainfed uplands of Uttarakhand

Crop production: System of Rice Intensification (SRI) technique has recorded 11.47% higher grain yield of hybrid rice over transplanting.

Phosphobacterium treatment in nursery or through dipping of roots of seedlings prior to transplanting or through application in the main field increased grain yield of rice by one tonne/ha over control.

Rice varieties/hybrids released

Variety	Flowering duration	Grain type	Ecosystem	Yield (tonnes/ha)	Reaction to pests/diseases	Recommended state/ region
Central Releases						
Naina	110–115	LS	Alkaline areas	3.91	R-LBL, RTD, GLH	Haryana, Pondicherry
Jarava	110–115	SB	Coastal saline areas	3.3–5.4	R-LBL; Tol-BLB, BPH	West Bengal, Pondicherry, Andamans
Warangal Samba	105–110	MS	Irrigated areas	5.5–6.5	R-RTD; Tol-BPH, ShBl, ShR	Andhra Pradesh, Kerala
NDR 1045-2	75–80	LB	Rainfed upland areas	3.5	Tol-LBL	Uttar Pradesh, Orissa, Bihar
NDR 8002	105–110	LS	Irrigated areas	5.5	Tol-LBL, BS, WBPH	Madhya Pradesh, Chhattisgarh
DRRH 2	86	LS	Irrigated areas	5.4	R-LBL, RTD	Uttarakhand, Haryana, West Bengal, Tamil Nadu
State Releases						
Pratikshya	112	MS	Irrigated and rainfed medium lands	4.8	R-BS, ShR, GM1, LF, SB; MR-BL, ShBl, WBPH, BPH	Orissa
Sidhanta	66	SB	Rainfed uplands	3.4	R-BS, BL, GM 1, 5, SB, LF; MR-NBL, BLB, RTD, ShR, WBPH, BPH	Orissa
Jogesh	59	MB	Rainfed uplands	2.3	R-BS, BL, GM1; MR-BL, ShBl, BLB, SB, BPH	Orissa
Uphar	132	SB	Shallow and semi-deep water lowlands	3.5	R-BL, GM1; MR-ShBl, BLB, RTD, ShR, SB, LF	Orissa