INDIA:

COUNTRY REPORT TO THE FAO INTERNATIONAL TECHNICAL CONFERENCE ON PLANT GENETIC RESOURCES

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Prepared by:

Indian Agricultural Research Institute

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CHAPTER 1
Introduction

India is located in the northern hemisphere between 8^{o} 4' to 37^{o} 6'N latitude and 68^{o} 7' to 97^{o} 25' E longitude; stretched about 3,214 km from north to south and about 2.933 km from east to west; covers an area of 32,87,263 sq. km. lndia's population, based on 1991 census, stood at 846.30 million and is presently estimated to be above 920 million as per population clock. India is the home of 16 percent of world's population, and the second most populous country, although it covers only 2.42 per cent of the total world's area, being seventh in the area wise ranking. Trends in the increase in population since the beginning of the century have shown a steady increase in each decade except for the period between 1911 to 1921 when there was a marginal decrease of -0.31 per cent. The rate of increase, of 23.85 per cent between 1981 to 1991 was marginally decreased as compared with the corresponding highest values of 24.66 percent between 1971 to 1981. The population density has gone up from 77 in 1901 to 267 persons per sq. km. as observed during the last census, held in 1991; the highest density of 6,352 persons per sq. km. was recorded in capital Territory of Delhi and the census, lowest of 10 persons per sq. km, in Arunachal Pradesh.

The country can be broadly categorized into three geological regions: the Himalayas ant eastern Hills, the lndo-Gangetic plains (alluvial tract) and the Peninsular shield (metamorphosed racks). Geographically six regions can be outlined : the great plains. the mountain zone, the north western gangetic northeastern region comprising of Brahmputra and Surma valleys, the desert region, the central & southern Plateau region and the western and eastern peninsular region. Further, based on physiographic climatic and cultural features, India is reported to be divided into 20 agro-climatic regions, i) Arid ecosystem, representing three agroclimatic regions in the country; one in the cold arid zone of western Himalayas and two in hot arid zones in the western India and Deccan Plateau, ii) Semiarid Ecosystem comprising of five hot semi-arid ecoregions of northern plains and central highlands with alluvial derived soils, central (Malwa) Highlands, Gujarat Plains and Kathiawar with medium black soils, Deccan (Telangana) plateau with shallow and medium black soils, Deccan (Karnataka) plateau with Red loamy soils, iii) Subhumid ecosystem representing five hot and one warm subhumid eco-region in the northern central and eastern parts of the country, iv) Humid, prehumid Ecosystem comprising of 3 agroecological regions in the north eastern India including Bengal, v) Coastal Ecosystem covering two regions of western and eastern ghats and vi) Island Ecosystem covering Andaman-Nicobar and Lakshadweep.

India is floristically very rich, there being abort 45,000 species of plants in the country. The vascular flora, which forms the conspicuous vegetation cover comprises 20,000 species out of which more than 35 per cent are endemic and not so far reported from elsewhere in the world. The natural vegetation zones in the country can be broadly classified into i) Moist tropical (Deciduous and Evergreen), ii) Dry tropical (Deciduous, Evergreen and Thorn), iii) Montane subtropical, iv) Montane Temperate, v) Alpine and vi) Tidal.

About 19.47 per cent of the total geographical area of the country is under actual forest cover. An area of 7,523 million hectares is notified under forest of which 40.61 million hectares is classified as reserve and 21,51 million hectares as protected forest. Unclassified forest area is spread over 13.11 million hectares of forest types.

CHAPTER 2
Plant Genetic Resources of India

2.1 DOMESTICATION OF PLANT IN INDIAN GENE CENTRE

The domestication of plants began some 10,000 years ago, although man's existence on earth itself goes back to approximately 2 million years in its diverse phases of evolution. Historically most of this time, man has lived as hunter and gatherer depending heavily on biodiversity comprising of plants, animals, birds and fishes. It was his ingenuity of recognising plants and identifying its plant parts as source of food. Thus, he began the process of domestication of wild plants occurring abundantly at that period of times on which man and his companion species survived and subsisted. The unique process of domestication with inherent objectives of cultivating plants to serve as basic source of food and attaining sustainability of food production. Recent trends witness large scale loss of this invaluable diversity selected and bred by indigenous peasant communities situated particularly in the tropical and subtropical parts of the world.

The process of agriculture beginning itself was originally confined only to 4-5 cradles of agriculture, which became world's centre of great human civilization. Indian civilization itself is very old and unique and does not have any parallel in the world. Well authenticated account such as 'Vedas' substantiate this assertion.

De Candolle (1886) presented the first documented account of origin and diversity of species occurring in the Indian Gene Centre, which was primarily based on the Flora of British India (1876). These were later supplemented by publications of some useful information by Frain (1896) in Asiatic Society of Bengal. However, it was N.I. Vavilov (1949-50) who gave the concept of **Centre of Origin and Crop Plants.** In his accounts Indian Gene Centre focussed prominently.

About 2,400 cultivated plant species are accounted by Zeven and de Wet (1982), distributed in l2 mega gene centres of diversity (Zeven and Zhukovsky, 1975). It is estimated that approximately 20,000 species of higher plants (Angiosperms) alone occur in India and 160 species of cultivated plants are enumerated in the Hindustan Centre, distributed in eight diverse phytogeographical/agro-ecological regions of India. The Indian, gene centre is also recognised for its native wealth of plant genetic resources with over 800 species of ethnobotanical importance and 1200 species are known to possess medicinal and aromatic value.

2.2 GENETIC DIVERSITY IN AGRI-HORTICULTURAL CROP PLANTS

The prevalence of agri-biodiversity comprising of old traditional varieties and land races occurring in diverse agro-ecological regions and zones is very interesting.

Food crops: Crops in which considerable polymorphism is still found to exist, include wheat (*Triticum aestivum* and *T. durum*) barley (*Hordeum vulgare*) particularly in northern states in Himalayan region. Rice (*Oryza sativa*) is supposed to have enormous landrace diversity. It is estimated that some 16,000 landraces still occur in Indian Gene Centre along with several related genera. *Porteresia coarctata* (2n=48), a tetraploid species of the tribe *Oryzae*, is a salt tolerant perennial halophyte native of brackish waters and deltas occurring in South and SE Asia. It constitutes potential source for salt tolerant genes for rice improvement. Maize has rich diversity in Himalayan region including North-eastern states and India is considered rich centre of diversity.

Among Pseudo-cereal crops, considerable variability occurs in species particularly *A. hypocondriacus, A. caudatus* and *A. leucocephalus*. There are large number of related species that occur in disturbed habitats. Buckwheat has the prevalence of *Fagopyrum asculentum, F. tataricum* and a closely related wild *F. cymosus*. Sugar yielding species have *Saccharum officinarum* and allied genera and species distributed predominately. Minor millets such as *Echinochloa crusgalli* and *Panicul miliaceum, P. miliare, Paspalum scrobiculatum, Setaria italica* and *Digitaria spp*. etc. have been sources of staple food in several parts of the country. The build lip of variability in *Sorghum vulgare* and *Pennisetum americanum* over the past few centuries has been very impressive. Grain legumes comprise of the main source of protein to the mass population and the range of species and landrace diversity in this group of taxa is considerable. Rich germplasm diversity occurs in prominent grain legumes such as pigeon pea (*Cajanus cajan*), chickpea (*Cicer arietinum*), mung bean *(Vigna radiata)*, urid bean (*V. Mungo*), rice bean (*V. umbellata*), moth bean (*V. Aconitifolia*), lablab bean (*Lablab purpureus*), peas (*Pisum sativum* var. *arvense*) and faba bean

(*Vicia faba*). Among annual oil yielding species, rich genetic variability occurs in species particularly *B. juncea, B. nigra, B. campestris* var. yellow *sarson* and *B. campestris* var *toria* and var. *roxburghii*, sesame (*Sesamum indicum*) safflower (*Carthamus tinctorius*) and *Eruca sativa* also exhibit rich genetic diversity. Among introduced oilseed crops, Groundnut (*Arachis hypogaea*), Soybean (*Glysine max*) and sunflower (*Helianthus annus*) contribute significantly to our economy. Fibre plant species of Indian origin possess diversity in tree cotton (*Gossypium arboreum*), jute (*Corchorus capsularis),* Hibiscus sabdarifa and sunhemp (*Crotalaria juncea*).

Vegetable crops: Vegetables that owe their origin to Indian gene centres include egg plant (*Solanum melongena*) and allied non tuberiferous *Solanum* species, several of which have genes for crop improvement (e.g. *S. incanum, S. insanum)* or may have medical importance (e.g. *S. surattense,* and *S. khasianum* etc.). Similarly, okra (*Abelmoschus esculentus)* and other retated species have good build up of diversity. Other vegetable crops of Indian origin include *Cucumis melo*, *Cucuais sativus*, *Luffa acutangula. Luffa cylindrica, Momordica charantea, Trichosanthes diocia, Lagenaria dicenaria. Cucurbita pepo, Citrulus vulgaris* and *C. Ianatus.* Several leafy vegetables *(Amaranths Chenopods),* lettuce *(Ipomoea aguatica*), *Convolvulus Fortulacca*, etc. exhibit remarkable variability. Taros -*Colocacia/Alocasia* and yams - *Dioscorea* species further enrich diversity in lndian tuber crops.

Spices hold great potential to India and some of the world famous spices such as ginger *(Zingiber officinale*), turmeric *(Curcuma longa)*, black pepper *(Piper nigrum*). pipli *(P. lonzum)*, betle vine *(P. betle)* and a host of other wild species occur in the tropical regions of India. Rich variability is also observed in cardamom and cinnamon. and *Myristica fragrance.* Among tree species areca-nut has rich variability.

Planting crops: Diversity in important fruit crops occurs in mango *(Mangifera indica), Citrus spp.*, jack fruit, banana and plantain *(Musa* species), aonla (*Emblica officinalis*), *Aegle marmelos*, jujube/ber (*Zizyphus jujube, Z. nummularia*), *Capparis decidua, Cordia myxa, Morus alba* and several *Prunus* and *Pyrus* species. Soft fruits include several wild/semi wild species of genera *Rubus* and *Ribes.* Nut crop species in which rich diversity occurs in the mainland as well as in Andaman/Nicobar group of islands includes coconut *(Cocos nucifera),* and cashew (*Anacadium occidentale*). Beverage and narcotics plant include tea (*Camellia sinensis* var. *assamica*), coffee (*Coffea arabica*), poppy and tobacco. Besides, rich diversity exists in tree species like Chilgoza (*Pinus gerandiana), Feronia Tamarindus india, Madhuca indica,* Bamboo and Rattan provide important diversity and multipurpose usage to tribal populations of our country.

Other Plants: Extremely rich diversity exists in forestry species including mangrove vegetation and medicinal and aromatic plants. Forage grasses and legumes, the herbal medicine of component possess some 1200 plant species therapeutic value used in the traditional medicine by native population and constitute an important resource with tremendous future prospects.

Diversity in wild species: Wild and weedy relatives comprising of ancestral forms (putative progenitors) of crop plants (e.g. *Oryza, Vigna, Cucumis* etc.) contain very valuable genes responsible for resistance to biotic and abiatic stresses. This resource is the treasure house for the identification of genes and application of biotechnology and modern techniques of genetic engineering. In future these genetic resources are likely to play a very prominent role in the development of new cultivars, hybrids and strains as well as in the restructuring of the existing ones that lack one or the other attributes. According to Arora and Nayar (1984), 325 wild species have been accounted in the Indian gene centre which occur in the natural habitats as members of disturbed, bioedaphic communities within the major vegetation types. Disturbed grasslands and scrub vegetation and similar open forest ecotones are considerably rich in such components except fruit trees which are largely associated with evergreen, subhumid, humid tropical and temperate forest ecosystems.

The distributional pattern of the wild plant genetic resources in different botanical/phyto-geographical region and the areas of their concentration where rich diversity of wild species still continues to survive and evolve are of special significance for undertaking programme on exploration and germplasm collection as well as conservation of biodiversity. The detailed phytogeographic distribution pattern of wild species in different phyto-geographical regions is as follows. For critical information, one may refer monograph on wild relatives brought out by Arora & Nayar (1984).

(i) Western Himalaya (125 species)

(ii) Eastern Himalayas (82 species)

(iii) North-eastern Region (132 species)

(iv) Gangetic plains (66 species)

(v) Indus plains/North-western Plains (45 species)

(vi) Western Peninsular region and Malabar coast (145 species)

(vii) Eastern Peninsular region/Deccan plateau (91 species)

Nearly two thirds of the country's population is engaged in farming and about 60 percent of the land is gross cropped area. However, net sown area is only

46.5 per cent and the rest being current fallows, old fallows or cultivable wastes. The main farming systems of the country can be classified into rice based farming systems, wheat based farming systems and millets based farming systems which are complimentary to each other and prevailing mainly in eastern and southern India, north -western and northern alluvial plains and north western arid region respectively. Pulses and oilseeds constitute a significant component of the Indian agriculture which is getting non-cereal zones are further impetus due to National Policies. Among the non agricultural and plantation crops, the important one are sugarcane, coconut, cotton, jute, tea, coffee and tobacco.

The specific components of National Conservation Strategy constitute: **i**) biosphere reserves: 14 potential sites have been identified out of which seven have already been established, **ii**) wetlands linked mainly with major river systems, and **iii**) mangroves ecosystems occur all along the coastline and islands. 15 mangrove areas have been identified for conservation.

India has emerged as the second largest producer of fruits and vegetables in the world. Currently it produces over 28.0 million tonnes of fruits and 58.0 million tonnes of vegetables. Traditional exports are of cashew, spices, by-products of coconut, and dry fruits especially walnut. Export of fruits, vegetables, flowers, tissue-cultured and other ornamental plants have an unmatched potential even though the export of these commodities remain small as compared to those of other countries.

Production of total food grains in 1992-93 was estimated to have been 181.2 million tonnes. Procurement of food grains at minimum support prices to ensure stability In farm prices was to the tune of 25.8 million tonnes of rice and wheat and buffer stocks of food grains with public agencies stood 14.7 million tonnes as on 31.03.1993. The import and export of food-grains during 1992-93 for plantations which fetched 1,338.91 crore rupees whereas for agricultural and allied products an increase of 20.2 percent was recorded with a total output of 5,513.33 crore rupees. In terms of imports 432.9 percent increase was recorded for cereals with a total investment of 924.22 crore rupees and a decrease of 30.4 percent was recorded in the import of edible oil with a total investment of 172.38 crore rupees. India is the largest producer and exporter of black tea whereas coffee, tobacco, rubber, jute and cardamom spices and marine products are other principal commodities of agricultural export.

In the past 30 years India has become the world's second largest producer of rice, sorghum, groundnut, and sugarcane, and third largest producer of wheat, cotton, rapeseed and mustard and seventh largest producer of potatoes. India is also the largest producer and exporter of black tea whereas Coffee, Tobacco, Rubber, Jute and Cardamom spices and marine products are other principal items of agricultural export. The country has emerged as the second largest producer of fruits and vegetables in the world. The production of fruits has reached over 28.0 million tonnes and 58.0 million tonnes of vegetables. Traditional exports are of cashew, spices, bye-products of coconut and dry fruits especially walnut. Export of fruits, vegetables, flowers, tissue- cultured and other ornamental plants have an unmatched potential even though our export of these commodities remain small as compared to those of other countries.

Area (m ha), productivity (q/ha), and production (m MT) of important food grains and other group of crops in the country during the year 1992 is given in the table below:

Table 1: Area, Production and Productivity of Principal Crops in India

Commodity	Area (m ha)	Productivity (q/ha)	Production (m MT)
Total cereals	100.8	21.1	212.5
Coarses grains	34.4	10.2	35.0
Total Pulses	24.0	6.1	14.5
Total oilseeds	33.6	7.2	28.1
Total vegetables	1.4	700.1	18.1
Plantation crops	0.3	10.6	0.3
Fibre crops	3.2	8.6	2.1
Sugarcane	3.6	645.6	231.0

Source: FAO Production Yearbook 1994

In nutshell, India has emerged a marginal exporter of food grains from stage of net importer which can be further improved by increasing the productivity of major crops which is too low in comparison with the other countries of the world. Area, Productivity and production of principal cereals and millet crops in the country along with their corresponding figures for the United States, China and the entire world are given in the table below:

Table 2: Comparative Production, Area and Productivity of important food grains for India, China and world during 1994

Crop	Parameter	India	USA	China	World
Wheat	Area (million ha)	24.4	25.0	30.5	215.9
	Productivity(q/ha)	24.2	25.3	33.2	24.5
	Production (m MT)	59.1	63.1	101.2	528.0
Rice	Area (million ha)	42.0	1.3	30.4	146.5
	Productivity(q/ha)	28.2	67.2	59.0	36.5
	Production (m MT)	118.4	9.0	178.3	534.7
Maize	Area (million ha)	60.0	29.5	20.6	131.5
	Productivity(q/ha)	17.5	87.0	50.3	43.3
	Production (m MT)	105.0	256.6	103.6	569.6
Millet	Area (million ha,)	14.7	0.2	1.8	37.7
	Productivity (q/ha.)	7.0	12.0	16.7	6.9
	Production (m MT)	10.3	0.2	3.0	259.8
Sorghum	Area (million ha)	12.8	3.6	1.3	43.7
	Productivity(q/ha)	9.8	45.9	37.1	13.9
	Production (m MT)	12.5	16.6	4.9	61.0

CHAPTER 3
Strategies for Conservation of Germplasm Diversity

The survival, perpetuation and continuance of a species to meet the demands of changing environments, largely depends on the extent of variability available in its gene pool. Hence, the most decisive factor in conservation of biological diversity is the maintenance of adequate genetic variability in populations or varieties of a species including its close relatives. Conservation programmes are envisaged to be implemented at three levels, namely, genotypes, species and ecosystems both *in situ* and *ex situ* approaches are adapted towards this objective employing *in vivo* and *in vitro* techniques.

Conservation efforts have gained remarkable momentum world wide in recent years, since genes for genetic manipulation through new tools of biotechnology are to be obtained from the Germplasm collections (both land races and wild species) and also because of apprehensions raised by patenting of genes/genotypes restricting their availability to breeders and other researchers across the national boundaries.

3.1 *IN SITU* CONSERVATION

Conservation of biodiversity can best be achieved by *in situ* conservation of wild flora through protection of habitats and ecosystems. In India, the Department of Environment and Forests, Govt. of India is the nodal organisation that implements programmes related to biodiversity conservation. It also is responsible for negotiations and implementation of various agenda of convention on biodiversity (CBD). There exists a National Expert Committee involving inter-ministerial representative to dwell on all important issues. National Bureau of Plant Genetic Resources is one of the active organisation, which in fully involved and helps in the establishment of 'Biosphere Reserves' in India. Fourteen biosphere reserves were identified initially on the basis of critical survey of vegetational zones, where tremendous changes are occurring in the habitats, and loss of biological species has become apparent. On priority, seven (Table 3) have already become operational. These biosphere reserves (gene sanctuary) agro-exceptionally very high in genetic diversity.

Table 3: Biosphere Reserves (in situ) Conservation in India

S.N°.	Bio-geographic Region	Biosphere Reserve	Area (Sq. km.)	States involved
1.	Himalayan Highlands	Nanda Devi	1,560	Uttar Pradesh (Garhwal Hills)
2.	Indo-Burman Monsoon Region, N.E.	Nokrek	80	Meghalaya
3.	Bengalian	Manas	2,837	Assam
4.	Rain Forest Zone	Sundarbans	9,630	West Bengal
5.	Coromandel Region	Gulf of Mannar	555	Tamil Nadu
6.	Malabar (Western Ghat)	Nilgiri Hills	5,520	Karnataka, Kerala and Tamil Nadu
7.	Andaman & Nicobar Island	Great Nicobar	885	A & N Islands

3.2 *EX SITU* CONSERVATION

Conservation of genetic variability of cultivated plants and their wild relatives is the sole responsibility of the National Bureau of Plant Genetic Resources that operates under the Indian council of Agricultural Research. Thus all *ex situ* measures are undertaken by this organisation at national level. Besides, several botanical gardens managed by the Botanical Survey of India and other organisation also help in *ex situ* conservation of endangered, threatened and rare endemic plant species.

Field Gene Banks: Conservation of biological diversity involves an holistic approach, and both *in situ* and *ex situ* strategies hold promise.

Among the *ex situ* methods employed for germplasm conservation, high priority has been given to the maintenance of collections in fields, orchards, plantations, herbal gardens, and more recently in gene banks. Field gene banks have both advantages and limitations. In many cases, conservation Methods also involve storage as seeds backed by a limited number of clones in field or *in vitro* gene banks. The National Bureau of Plant Genetic Resources operates through its Regional Stations network and also co-operates with other ICAR institutions/centres working on diverse crop genetic resources. The primary objectives of co-operating centres is to regenerate, evaluate, characterise and document accessions to be stored in base collections of the National Gene Bank. Field maintenance and regeneration also provides opportunity for identifying donor stocks which are likely to be used in breeding programmes. However, it has been observed that too frequent regeneration of germplasm can lead to genetic erosion due to environmental hazards, genetic drift, selection, mechanical failure or human errors. Provision of medium-term storage facility for active/working germplasm can go a long way in overcoming this hazard.

National Gene Bank (Seed Repository): Creation of Gene Bank (Seed Repository) for long-term conservation of germplasm of diverse agri-horticultural crops, agri-pastoral and silvicultural plants is considered to be the most appropriate method under *ex situ* conservation, primarily because it avoids the need for too frequent regeneration in the field and all other attendant risks. The method is highly suitable for a majority of arable and horticultural crops (orthodox species). These are quite amenable to desiccation (seed drying) up to 5% moisture and can be easily stored at a very low temperature -20°C) for a considerably long time.

NBPGR has already established India's first 'National Gene Bank' with national mandate for long-term conservation of germplasm (base collections). This includes infrastructural facilities for long-term storage (-20°C). Presently, four cold storage vaults (2 units at 100 m^3 each and 2 units at 176 m^3 each) have been established; these operate at -20°C and provide opportunity for holding some 250,000 seed samples. The National Gene Bank is adequately backed with seed processing, seed drying and seed testing laboratory facilities and is also supported by automatic switch-on back-up power generation. The Gene Bank currently holds 1,44,109 accessions (Table 4). NBPGR New Gene Bank facility is likely to become operative in 1995 and will have an additional capacity to hold some 600,000 samples of diverse crop plants and their wild relatives. With the completion of this phase, India's National Gene Bank will be one of the biggest of its kind in the world.

Table 4: Base Collections in National Gene Bank at NBPGR (March, 1995)

Crop Groups	No. of accessions
Cereals	61,863
Pseudo cereals	560
Millets & Minor Millets	15,783
Oilseeds	20,520
Pulses	25,527
Fibre Crops	3,607
Vegetables	7,615
Spices & Condiments	67
Medicinal & Aromatic Plants	179
Others	178
Improved varieties	888
Duplicate safety samples (ICRISAT-Pigeonpea; ICARDA-Lentil)	6,722
Total	**144,109**

National Facility for Plant Tissue Culture Repository (NFPTCR): Several tropical plant species are known to possess recalcitrant seed behaviour, which pose a serious problem in their conservation. In addition, several species are completely devoid of sexual reproduction and they are propagated only through vegetative means. Some of them may be highly heterozygous or even suffer from pest and pathogen problems conditions. Collection and conservation of such species demand alternative strategies for their genetic conservation after making them disease free.

In recent years tissue culture *in vitro* culture technique has grown rapidly as an aid to the rapid clonal propagation as well as germplasm conservation. Meristems, shoot tip cultures, axillary buds, pollen, anthers and even embryos (both zygotic and somatic) can be preserved for varying length of time. It is evident that culture systems such as single cell, suspension and protoplast cultures, callus, organs couId aIso be preserved for short to medium period using *in vitro* technology. The *in* vitro cultures can be preserved using minimal media (SIow growth), growth retardants and through vitrification or osmotic regulations as weII as by variation in temperature and light regime. The above mentioned culture systems can also be freeze-preserved In liquid nitrogen (-196°C).

Encapsulation of shoot tips, meristems. dormant buds andembryos, can allow indefinite preservation. The **National Facility for Plant Tissue Culture**

Repository (NFPTCR) at NBPGR has wellI planned programmes on cryopreservation of seeds, pollen, embryos, embryonic axes as wellI as *in vitro* cultures. NFPTCR has taken up conservation of several vegetatively propagated crop plants, including bulbous, tuberous, fruit plants, species and other plantation crops. Medicinal and aromatic plants as well as several endangered plant species are also included in its ongoing programme (Table 5). The work on characterization and monitoring of genetic stability is currently undertaken using biochemical markers (isoenzyme) and molecular markers (RFLPs and RAPDs).

Table 5 : Status of in vitro Conservation programme at National Plant Tissue Culture Repository, NBPGR, New Delhi

Crop	No. of accessions	Storage temp. (°C)	Optimum sub-culture
Allium sativum	85	25,10	16-18
Allium spp.	15	25,10	12-18
Ipomea batatas	260	25	12
Dioscorea spp.	32	25	12
Colocacia esculenta	18	25	-
Curcuma spp.	24	25	8
Zinziber spp.	120	25	12
Musa spp.	260	25	12-22
Piper spp.	6	25	10-12
Citrus aurantifolia	2	25	10
Rauvolfia serpentina	6	25	15
R. canescens	1	25	15
Saussurea lappa	1	4	13
Picrorhiza kurroa	1	10	16
Gentiana kurroo	1	4	11
Pogostemon patchouli	2	25	9-10
Coleus forskohlii	7	25	18
Podophyllum hexandrum	1	25	-
Other Medicinal &	8	25	-

CHAPTER 4
In-Country Utilization of Plant Genetic Resources

4.1 USE OF CROP VARIETIES

Food crops: A systematic approach for germplasm survey, collection and use was begun in India with the onset of 20th century by the Indian (Imperial) Agricultural Research Institute (IARI), Pusa and the State Department of Agriculture. Several series of wheat, mostly pure-line selections from local types were evolved such as NP4, NP12 (New Pusa), Type 8A, Type 9D (from Punjab); K, RS and N1 series from Kanpur, Rajasthan, Niphad etc. (Paroda,1989). These primary selections from germplasm were further used to evolve disease resistant varieties through hybridization viz., NP 165, NP 710, NP 718, NP 770, NP 824, NP 783 etc., at IARI, C 591, C 518, C 273, WG-357 at Punjab.

These varieties provided a degree of stability against rusts in the respective area and some of these are still used to incorporate Desi amber quality in the wheat grains.

In rice, about 400 cultivars were released through selections from traditional farmers cultivars during the period 1911 to 1956. These improved local types made a 10-20 percent increase over the traditional types under local agronomic practices and ecological conditions (Sharma *et al.,* 1987). Similar potential is still available in agriculturally remote tribal areas of ArunachaI Pradesh where the farmers stiII retain the heritage seed of their diverse local selections and the introduction of High Yielding Varieties Programme is meager (Rana *et al.*, 1994). Nevertheless, the primary germplasm, collections/selections of the earlier period continued to play a significant role in varietal improvement for upland and/or drought conditions e.g. Lal Nakanda 41, Jhona 349, MTU 17, CO 31 etc.; deep water and or flood e.g. HBJ 1-HBJ-4, AR1, EB 1, EB 2, BR 15, BR 46 etc. ; saline soils e.g. Kumargore, Fatna1 23, Getu, Damodar etc. TKM-6, PTB-10, PTB-18, CB1, C04,CO 29 BAM 10, BJ 1 etc. continue to be identified as widely adaptable or resistant to biotic stresses. Many new promising varieties have been recently evolved as selections from germplasm e.g. Janaki, Sugandha. Majhera 3, VL206, Khonorullu, Ngoba, Suvarnamodan etc. Use of wild relatives of rice from India needs specific mention with the identification and incorporation of *Oryza Nivara* gene for resistance to grassy stunt virus. Transfer of *O. officinalis* genes for resistance against brown hopper is also made.

In maize some work has been done to classify 1571 germplasm accessions into 15 distinct races and three sub-races all of which could be assigned to three of the six lineages postulated by Mangelsdorf (Vasal and Taba,1987). Use of indigenous germplasm made for development and release of commercial cultivars such as Super Composite I (Mansar of Jammu and Kashmir), L 19 (Himachal Pradesh). Prolific maize germplasm such as Sikkim Primitive has been used for increasing the ear numbers per plant.

In pearl millet, as also in cotton, India provides the finest example of development of hybrids seed production among the developing countries. Use of local germplasm has been done in respect of incorporation of bristled ears (S 530), dwarfness (IP10401), sweetness of stalks (FD 832, NEP 18-5023-2, Giant Bajra), male sterility (5141A1 and 732 A) and a low degree of resistance to ergot (10 stocks) (Harinarayan *et al*, 1987).

Oilseeds and Pulses: Many of the varieties of oilseed crops and pulses even presently recommended fro cultivation in certain parts of the country were evolved as direct selections from local germplasm. These include TL 15, BSH 1, YS Pb 24, GSL 1, NC 60781, NC 60788 etc. in rapeseed and Mustard, Kangra local in Linseed etc. among oilseeds. The latter is being used as donor stock for incorporating powdery mildew resistance. Some of the good varieties developed in pulse from local germplasm through direct selection are JG 315 (wilt resistant), BDN 9-3 and Annigeri 1 in Bengal; UPAS120 (early maturing(, BR 65 (SMV resistant), Gwalior 3, No. 148, T-15-15, HY 3C, C 11, B 517 and BDN1 of Pigeonpea; Amrit, CO3, G 65 and Gujarat 1 in Mungbean/Green gram; Naveen, Zandewal, CO5, B-76 and T-9 of Uridbean/Black gram; JLS-1, K 75 and Ranjan of Lentil, RP 3 and T-163 of Field pea and RBL-1 of Rice bean. The extent of direct selections from local germplasm resulting into well adapted, popular varieties is highest in pulses and minor millets. It constitutes about two-thirds of the total varieties (nearing 300) recommended through different breeding methods in this group of crops.

In Cotton also, selections from Bikaneri Narma in American cotton (F 414) and from local *Sanguineum* types in Desi Cotton (G 27) have remained popular varieties for considerable length of time in the cotton group belt. India houses rich genetic wealth of *Gossypium arboreum*; races *cernuum*, *bengalenese* and *indicum*, *Gossypium herbaceum*; races *weightianum* and *acerigolium* and *Gossypium hirsutum* perennials which are put to use for different breeding objectives.

Horticultural Crops: In horticultural crops, genetic diversity is well represented in India with the occurrence of 190 species of economic importance in fruits (109), vegetables (54) and spices and condiments (27). The concept of 'National Collection Centres' was introduced by the ICAR for various fruit crops for augmentation, conservation and utilization of germplasm. This concept has developed into a system operated by NBPGR, the Indian National Plant Genetic Resources System (IN-PGRS) which networks 30 National Active Collection Sites in various Agri-horticultural crops. In vegetable crops, there are some noteworthy examples where introduced germplasm has been adapted per se as popular varieties in India e.g. Sioux, La Bonita and Roma in Tomato, Bonneville and Arkel in Pea, Contender in Frenchbean, California wonder in capsicum, Nantes in carrot etc.

Use of indigenous diversity in various vegetable crops may be cited for Onion (Pusa Red, N-53), Eggplant (PPL, PPC), Bottle gourd (Pusa Summer Prolific Long and round), Ridge gourd (Pusa Nasdhar), Sponge gourd (Pusa Chikni), Chillies (Pusa Jwala, Andhra Jyoti, Bhagyalaxmi) etc.

In tuber crops also a few direct selections have proven successful. Early maturing (Cl-856) and dwarf (Cl-590), clones have been identified in cassava; S-36, CO-1 and CO-2 have been released in sweet potato; Sree Latha (Da11) was identified for *Dioscorea esculenta*. Potato is believed to have been introduced in India in late sixteen century and it got naturalized in the country in due course. About thirty cultivars released in different parts of India are developed are developed from hybridization and selection. Yet two indigenous cultivars Phulwa and Darjeeling Red Round have been developed by direct clonal selection.

Medicinal and Aromatic Plants: Country's wealth in terms of medicinal and aromatic plants is plenty. Over 46 native species are under pressure of large scale collection from their natural habitats. Efforts are made to augment the indigenous genetic resources under national programmes. Some of the direct selection from local germplasm are IC-42 (Trishna) in Opium poppy and NC 66403, NC 66404 and NC 66416 in vetiver. Forest based medicinal plants in India are Squill (*Urgenia indica*), Safed MusIi (*Chlorophytum arundinaceum* and *C. tuberosum)*, Chiryata (*Swertia chirata*), Guggal (*Balsamodendron mukul*) etc.

Under-utilized crops: Some of the indigenous under-utilized under-utilized food crops of future promise in India and their direct selections are Grain Amaranth (IC 42258-1/Cv. Annapurna, GA-1), Buckwheat (IC-13374/Himpriya), Rice bean (RBL-1) etc. NBPGR holds one of the National Active Collection Sites, on pseudo cereals, at its regional station for augmentation and evaluation of germplasm.

Commercial Crops: *Saccharum spontaneum* has played a major role in the production of widely adapted/diverse sugarcane varieties. Chittan, Vellai, Poovan etc. are the clones utilized directly for sugarcane cultivation in India.

In tobacco, local indigenous germplasm provides good sources of resistance to viruses (Godavari spl., NC 73, NC 6-984, Motihari, Local Tarab, Abaj, NP 18 etc.), powdery mildew (Bejaj), nematodes (NC 98) etc.

Among the spices, certain high quality types in black pepper viz., Kottanadan, Kumbhakkodi and Aimpiriyan have been incorporated into breeding programmes. PCT-8-Suvarne in turmeric is a high yielding direct selection in turmeric whereas Nadia is a popular cultivar of ginger.

In coffee, intensive breeding programmes were undertaken using both indigenous and exotic germplasm. as a result, selections 4 to 11 in arabica, Sel. 2 R in robusta series, Sel 8 and Sel 9 for resistant to rust and drought conditions. Sel. 7 for dwarf type, Sel. 5 for horizontal resistance to coffee rust etc. were prominent. S 795, a popular cultivar was used in several crosses for improving the bean quality, rust resistance and to some extent suitability for continued wet soil conditions. In tea, over 120 clonal and seed cultivars have been released to the tea industry in India using above 150 germplasm accessions. India abounds in tea genetic resources which have been utilized in other tea growing countries as well for per se adaptation or plant improvement.

Agro Forestry: With increasing human and live stock population and growing cultural demands, there is increasing pressure on all natural resources including forests and land. Rates of regression in tropical forests and rates of desertification are well established. Of particular importance in this context are the fuel wood deficit in southeast Asia and India. The cumulative effect of all these pressures result in soil erosion, high sediment load in run off, silting up of reservoirs and dams and, of late, in rise in the sub-ground water table particularly in north western plains zone. A massive increase in energy planting activity is required to meet the challenges.

Abundant genetic diversity is available for the multipurpose trees of use in agro forestry for different agro-climatic zones of the country for use in different cropping systems such as multipurpose forest tree production system (*Cassia siamica*, *Casurina equisetifolia, Eucalyptus umbellata, Sesbania grandiflora*, etc.,) silvipastoral system (*Acacia senegal, Albizzia lebbeck, Azadirachta indica, Prosopis cineraria* etc.), Cropping system (Block or Marginal Planting- *Acacia nilotica, Salvadora oleoides, S. persica, Zizyphus nummularia, Borassus flabellifer* etc.).

4.2 SEED PRODUCTION

Research Networking and Production of Breeders'/Foundation Seed

India provides one of the finest examples of the crop research networks under the national Project Directorates and Coordinated Programmes. Their programmes together form a component of the National Agricultural Research Programme of the Indian Council of Agricultural Research (ICAR). The components of these networks include multilocation evaluation and varietal identification, Allocation of Breeders' seed production to the mother location, the production of foundation seed to various coordinated centers, Front line and Mini Kit demonstrations of proven technology, including improved variety cultivation, at the farmers' fields and adoption of farm families for demonstration of package of cropping systems and farm related technologies.

The National Plant Genetic Resources Programme (IN-PGRP) is also fast building up in terms of promotion of germplasm use through multiIocation testing at National Germplasm Screening Nurseries and development of national data-base.

Germplasm Advisory Committees are now functional in a few crops/group of crops to review and advise on the conservation and utilisation of country's plant genetic resources of respective crops and their related species.

Production and Distribution of Quality Seed

The seed industry has developed rapidly in the last 20 years. Various agencies involved in the seed production Universities programme are : ICAR institutes/state Agricultural for the production of Breeders' and Foundation seed, National Seed Corporation (NSC), State Agro-seed Corporations and Private Seed agencies for production of certified seed. Rigorous quality tests and labelling is followed by central and state seed agencies. There is a provision of truthful labelling also by the private seed agencies in certain cases. Inspite of this, only one fifth of the required seed is produced and marketed by the organised public and private seed sector. A new seed policy which came into effect from October 1988, has liberalised the import of seeds and planting materials of oil seeds, pulses, coarse grains, vegetables, fruits and flowers by slashing down import duty on seeds to 15 percent from the previous range of 90 to 105 percent. The procedures for import/clearance have also been simplified.

Special care has been taken to prevent repetitive bulk import of seeds and to encourage meeting the market demand from domestic seed production. It has therefore, been stipulated that the companies which have technical and financial collaboration with the foreign seed producers should secure the parental lines from the overseas firm within two years from the Government. The concept of seed village, wherein the entire village would be committed to produce quality seed of released improved variety under the guidance of specialists became popular in the green revolution era. The Agreement on Tariffs and Trade (GATT) of the World Trade Organisation (WTO), has enthused policy makers in India to allow farmers' rights to retain and barter quality seeds for meeting the future challenges of seed input in the agricultural production of the country. The concept of quality seed productions needs to be extended to the remote tribal pockets which could be safely adapted for on-farm conservation, being the diversity rich areas.

CHAPTER 5
National Goals, Policies, Programmes and Legislation

5.1 NATIONAL PLANT GENETIC RESOURCES SYSTEM

National Bureau of Plant Genetic Resources (NBPGR) established as an independent organisation under ICAR in 1976 under the Union Ministry of Agriculture functions as an nodal organisation in India for planning, organising, conducting, promoting, co-ordinating and leading all activities concerning plant exploration/collection, introduction, exchange, evaluation, documentation, safe conservation and sustainable management of diverse germplasm of crop plants and their wild relatives with a view to ensuring their continuous availability for use by other researchers in India and elsewhere.

Mandate and Objectives of NBPGR

- To plan, conduct and co-ordinate plant explorations for their collection of diversity in germplasm of cultivated plants, their wild relatives and naturally occurring species of economic importance.
- To undertake introduction and exchange of plant germplasm for research purpose.
- To examine seed and plant propagules under exchange for the presence of associated pests and pathogens and also to salvage healthy materials from the infected/infested/contaminated samples.
- To undertake and promote characterisation, evaluation and documentation of plant germplasm collections and their distribution to user scientists.
- To undertake and promote conservation of plant genetic resources and retrieval on a long-term basis employing *in vivo, in vitro* and cryopreservation techniques and also to assist *in situ* conservation efforts.
- To develop and operate the National Data base for storage and retrieval of information on plant genetic resources. To conduct basic research for providing a sound scientific back up to its services.
- To develop and operate the National Herbarium of Crop Plants and their wild relatives.

- To organise suitable training programmes at the national, regional and international levels.
- To develop and-implement work plans based on memoranda of understanding and bilateral agreements.

NBPGR is organised into five Divisions at its headquarters namely, Plant Exploration and Collection, Germplasm Exchange, Plant Quarantine, Germplasm Evaluation and Characterisation and Germplasm Conservation.

Indian National Plant Genetic Resources System, operated by the NBPGR comprises i) National Seed Repository (Gene bank) for base collection, and ii) National Facility for Plant Tissue Culture Repository, iii) NationaI Seed Museum and Herbarium of cultivated plants and their wild relatives which provides comprehensive strategy for germplasm conservation and their sustainable rise. In addition, iv) three all India Co-ordinated Projects namely, on Medicinal and Aromatic Plants, Arid Legumes and Under-utilised and Under-exploited plants.

NBPGR' s national PGR system is supported by its own Regional Stations network based on the principles of agro-ecological analogues. Besides an active collaboration of over 30 Institutions/centres designated as the `National Active Germplasm Sites' allows NBPGR functionally to be more dynamic and vibrant.

With this setup at the Bureau, India has taken a lead among the developing nations in establishing a well organised and effective plant genetic resources system.

5.2 CROP ADVISORY COMMITTEES AND CROP CURATORS

Crop Advisory Committees were constituted for specific crops or groups of crops. They render valuable advise to the Bureau regarding the status of current holdings of different crops, possible gaps in germplasm collection, areas for exploration and conservation as well as in developing sound management system. These Committees would also suggest promising countries that need to be explored or approached for introduction of new crops/genetic variability to sustain our current and future crop improvement programmes. Crop curators have also been designated for major crops.

5.3 NATIONAL POLICY ON PLANT VARIETY RECOGNITION AND INDIA

Agricultural plants along with life-saving drugs were excluded from the purview of Indian Patent Act of 1970 that permitted process patenting only and not the end product patenting. An effort is now underway to develop an effective *Sui generis* system for plant variety protection and provide a suitable legal framework as required under GATT provisions. Essential features of the 1978 UPOV Convention are being considered for adoption retaining exemptions for farmers rights and also for researchers use. It is proposed to entitle farmers to suitable compensation from the breeders of the protected variety/dealer in the event of failure in the stated performance.

Period of protection is being proposed to be 18 years for annual crop plants and 15 years for fruit trees and vines. It is being made compulsory to deposit a reference seed sample in the National Gene Bank and also to do cataloguing in the National Register. Certification may also be made compulsory. There will be a provision for compulsory licensing also. It is being proposed to set up a National Authority for Plant variety Protection, i.e. protection of Breeder's farmers' and research use rights. There will also be an Appellate Board to resolve arising disputes. NBPGR is expected to play a vital role in the proposed legislation and efforts have already been undertaken to develop the anticipated capabilities and scientific competence.

The key point is how to ensure flow of plant genetic resources for research purpose and also the research information while providing adequate legal protection to plant variety across countries.

5.4 NBPGR'S NATIONAL INFORMATION SYSTEM

Information database system is very important at national, regional and global levels to back up conservation of genetic resources for not only immediate utilization of already conserved and evaluated/characterized germplasm in the ongoing plant breeding programmes but also, for future use. Success of both these activities is to a large extent dependent upon the availability of descriptive information on accessions stored in the genebank. National database system gathers all relevant data from diverse sources that are used by user scientists belonging to different disciplines. Selection of appropriate descriptors and descriptor states, software computer programmes and retrieval system are prerequisite for development of computerized information on genetic resources. The computer based software design need (i) internal process for information and retrieval and (ii) interface with user scientists/agencies. Genetic resources database management also requires continued co-operation between genetic resources personnel, computer experts and plant breeders/biotechnologists. NBPGR proposes to expand its database through strong regional co-operation and international linkages.

5.5 LINKAGES WITH OTHER ORGANISATIONS

National Linkages: NBPGR, operates under the Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education (DARE), Union Ministry of Agriculture, Government of India. Plant Protection Directorate, Government of India has delegated quarantine powers and authority to the Director, NBPGR for incoming and outgoing germplasm for research purposes. Thus quarantine responsibility of the genetic resources programme is exercised by the Director, NBPGR in issuance of import permit, quarantine clearance and phytosanitary certificate. It also envisages import of a small sample (100-200 seeds) or limited plant propagules accompanied by a phytosanitary certificate. Quarantine isolation nursery keeps an effective check on the introduction of new pathogens and keeps a constant vigil.

NBPGR has active collaboration with the Department of Environment and Forest, Government of India, Indian Council of Forestry Research and Education, Dehradun and with Botanical Survey of India.

In recent years, NBPGR has also developed strong linkages with the Department of Biotechnology, Government of India which has established first **National Facility for Plant Tissue Culture** Repository at NBPGR to carry out work on *in vitro* conservation and cryopreservation of germplasm. Also a G-15 project on the establishment of Gene Bank for Medicinal and Aromatic Plants operates at NBPGR.

CHAPTER 6
International Collaboration

6.1 COLLABORATION WITH INTERNATIONAL AGRICULTURAL RESEARCH CENTRES

The International Agricultural Research Centres (IARCS) have also come up in a big way in recent years with respect to their mandate crops, NBPGR has active collaboration with ICRISAT, Hyderabad on joint exploration and multi-location evaluation programmes on five ICRISAT mandate crops. This has enriched considerably the germplasm in pearl millet, sorghum, pigeon pea, chick pea and groundnut.

Considerable exchange of germplasm has taken place in the past and accelerated efforts have continued in the present times between NBPGR, ICARDA (Syria). IRRI (Philippines), CIMMYT (Mexico), CIP (Peru), CIAT (Cali, Columbia) and IJO (Bangladesh). The activities, besides germplasm introductions also included exploration and collection of germplasm as well as evaluation, multi-location testing, documentation/cataloguing and training of personnel.

6.2 COLLABORATIONS UNDER BILATERAL PROGRAMMES

Several countries in Europe, USA, Canada, Australia, New Zealand, Soviet Russia have well developed systems for assemblage, enrichment. documentation and conservation of plant genetic resources. Several of them also have computerized data-base networks. ICAR has Memoranda of understanding as well as bilateral agreements with several such international organisations and national programmes. The plant genetic resources activities are carried out by NBPGR through active involvement with them. The important bilateral programmes currently operative include those with USSR, China, Pakistan, Vietnam, Japan, USA, Canada, UK and several other countries in Europe and Africa.

6.3 COLLABORATION WITH IPGRI

IPGRI's Office for South Asia is located in the NBPGR Campus. There is an active collaboration based on biennial work plans. NBPGR has in recent years, implemented several IPGRI sponsored project on collection, characterisation, evaluation and conservation in eggplant, okra, sesame and maize and more recently research project on recalcitrant seed species and analysis of genetic diversity in Abelmoschus species to elucidate species relationship is promote further the utilization of okra gene pool.

6.4 GLOBAL RESPONSIBILITY FOR PLANT GENETIC RESOURCES

Following a critical assessment of the infrastructural facilities, trained manpower available at NBPGR, the International Plant Genetic Resources Institute assigned responsibility for global and regional base collection for more than a dozen crops (Table 6). The first international Workshops on okra and sesame were organised by NBPGR in collaboration with IPGRI at New Delhi and Akola respectively.

Table 6: IBPGR-Assigned Responsibility to NBPGR for Long-Term Conservation of Crop Germplasm

No.	Crop	Scope of collection
1.	Pigeonpea	Global
2.	Safflower	Global
3.	Sesame	Global
4.	*Vigna mungo*	Global
5.	*V. umbellata*	Global
6.	Okra	Global
7.	Eggplant	Global
8.	*Amaranthus*	Asian
9.	*Capsicum*	Asian
10.	*Raphanus*	Asian
11.	*Brassica juncea*	Asian
12.	Minor Indian millets	Indian

CHAPTER 7
National Needs and Opportunities

Sufficient infrastructure and technology are available for both conservation as well as utilization of genetic resources in India. These are being further developed to meet the emerging challenges. National Bureau is the focal point for all such activities. India, among the developing countries, holds rich agri-biodiversity in plant genetic wealth. This diversity has been extensively explored, collected, conserved, partially characterized and put to use for plant breeding and crop improvement activities. There has been an era closely following the green revolution, of scientific developments in India defining the system and build up of a network programme on plant genetic resources in the country. The country, on record, holds one of the best Gene Banks for long-term *ex situ* conservation and their wild relatives. India is further expanding its capacity under a bilateral arrangement and developing a national database system and network. It has not only trained/oriented its scientific and technical manpower by providing their scientists opportunity to study and acquire advanced technologies related to PGR in USA and UK, but has build up its own capabilities to impart training and guidance at the national/regional level. PGR scientists from various national institutes/state agricultural universities have received the training.

In the wake of rapidly increasing population pressure, socio-economic changes, genetic erosion, existing plateaus in the yield potentials of new improved varieties to meet the growing food demand, the country's vast plant genetic resources/wealth need to be conserved and sustainably utilized for plant improvement programmes. Conservation of PGR has to best integrated through different approaches such as *in situ, ex situ* on farm etc.

There is also a need to work out an optimum balance between these approaches the conservation of wild relatives may be best carried out *in situ* whereas the land races may be conserved 'on farm' in identified pockets based on prevalences and history of cultivation. *Ex situ* conservation of germplasm needs to be done from the areas lesser explored or the ones which still possess higher diversity. The national programme has also to conserve those genetic stocks which hold promise for specific traits such as resistance to biotic and abiotic stresses, quality etc. National repository (National Gene Bank) thus has a pivotal role both in conservation and in ensuring long-term supplies.

7.1 SOME MAJOR ISSUES NEEDING ATTENTION IN NATIONAL PERSPECTIVE, IN TERMS OF PGR CONSERVATION ARE:

i) Strengthening facilities and developing/refining technologies for long term *ex situ* conservation of germplasm PLANT GENETIC RESOURCES including orthodox seeds. recalcitrant seeds and vegetative propagules and storage of duplicate sets in naturally safe zones e.g. permafrost areas.

ii) Strengthening characterization of its germplasm holding creation and updating of national database its networking in the national PGR programme for active reference by user scientists.

iii) Developing scientific ways and means to delineate representative subsets of crop germplasm for promoting directional use of accessions and to reduce the cost of maintenance of representative active germplasm.

iv) Identifying and adopting areas for protection and *in situ*/on farm conservation of wild germplasm and landraces of cultivated types respectively. Needs and mechanism to community/farmer's compensation for conserving on farm variability to find out optimal degree of diversity for 'on farm' conservation.

7.2 IN TERMS OF PGR UTILIZATION

The national priorities include gradual and consistent release of representative/potential germplasm into various plant improvement programmes in the country. Their actual utilization has to be preceded by extensive multilocation evaluation for finding out their genotypic potentials for adaptability, yield contributing traits. Screening against biotic stresses at hot spots and under controlled conditions would be essential to pinpoint diverse and potential resistance sources. Biochemical and quality assessment must receive high priority to pave way for their proper utilization. On the other side, compelling proprietary considerations in the growing internationalization and publics, private fields demand the molecular characterization of accessions for their verification, in case of dispute whatsoever. Besides, the application of molecular biology techniques to characterise and classify biodiversity for its potential use would also be emphasised. A co-ordinated, organised approach will be required for developing facilities for rapid micropropagation of elite strains of important agri-horticultural crops, forestry species and medicinal and aromatic plants, for developing resistant cultivars, hybrids and for safe exchange of disease free germplasm. For this *in vitro* (tissue culture) technology has to receive further strengthening and renewed thrust to augment India's capabilities.

7.3 *SUI GENERIS* SYSTEM AND IPRS

Use of germplasm by national and multinational private sector seed industry through free access of plant genetic resources from public sector institutions would require developing national guidelines, procedure, policies, legislation and modalities for reciprocation, particularly when private seed companies seek restricted accessibility to their product except for its commercial use. Modalities for compensation, whether through direct payments or through research grants for PGR etc.; and the cut off period beyond which the material would be available for general use would require clear and transparent procedure.

Farmers' rights to use their saved seed and to ensure the quality of seed are two issues which need essential consideration in formulating a *sui generis* system for the country. Whereas the latter could be covered by a comprehensive updated Seed Policy, through the use of a well elaborated compulsory seed certification programme which should be mandatory for all including, private sector seed companies, the quality of seed retained by farmers has also to be through government or semi-government agencies, mandatory or voluntary seed testing by the farmers, particularly with a view to minimise the spread of associated weed flora. Recognition and reward for informal innovations by farm famiIies, as well as breeders has to become an essential component of seed programme vis-à-vis germplasm conservation and use.

7.4 GERMPLASM EXCHANGE AND FUNDING MECHANISM

Germplasm exchange should be accelerated at the global and regional levels. India is committed like FE, to the free exchange of germplasm resources for their active use. This however, creates difficulties of reciprocal exchange and withholding during lock-in periods on value addition to the product. Use of "Material Transfer Agreements" on mutually agreed terms and other contractual arrangements has, therefore, to be encouraged. Inventorisation of germplasm under active use and its possibIe follow up action has to be ascertained for obvious implications of free exchange of germplasm.

Technical and financial needs to conserve germplasm and promotion of sustainable use of PGR are important tasks ahead. Priorities have to be set for projects to be funded and mechanisms evolved to focus on support for the activities of farmers and communities.

Nature of funding, whether through payments or developmental funds, voluntary or mandatory, the recommending and distributing agencies and the linkage between financial responsibilities and benefits derived from the use of PGR need to be scrutinized. Funding for maintenance of giant infrastructure, genebank and medium term storage facilities has to be ensured on long term basis.

CHAPTER 8
Proposal for a Global Plan of Action

The role of India is noteworthy as the gene rich country among developing nation with adequately trained scientific manpower. Considerable conservation capabilities and PGR expertise with a sufficient technical know-how. It can serve as a model to many national programmes and a key partner to the IARCs of the CGIAR system. A brief outline of the proposals which India envisages in terms of Global Action Plan on PGR would be as below :

1. Clearly identifying the gaps in collection of diversity at the national, regional and global levels, and with the build up of huge germplasm resources and their *ex situ* conservation in long term storage, there has to be a more specific approach to follow lip on collection priorities after ascertaining the above gaps. Availability of partially computerized data. files and non- uniform data base models with national programmes/IARCs is a hindrance, which has to be coped up with the constitution of expert groups and sub groups for identifying and recommending appropriate measures to bridge the gaps.

Funding for priority collections needs to be critically examined based on completes reports. *Ad hoc* measures can be adapted for collection from areas having variability for specific traits such as disease & pest resistance etc. Thus exhaustive exploration and collection of Tungro virus resistant rice germplasm from eastern parts of Gangetic plains becomes a priority far which funds should be provided for collection, augmentation, molecular characterization and conservation. By and large collecting priorities need also to be assigned to wild relatives, endemic diversity and in perennial crops such as fruit trees.

2. Similarly, projects on *ex situ* conservation of such resources should also be duly funded. The gene rich but financially poor countries should get funding for infrastructure build up, training of manpower and arranging expertise/expert consultancy from competent and well experienced institutions/countries.

3. Characterization and analysing extent of genetic diversity using conventional and molecular characterization tools should be extensively taken up for allowing adequate utilization of PGR.

4. On farm conservation of landraces and *in situ* conservation of wild relatives needs regional/global priorities to cover those areas uniformly which overlap over the international boundaries of nations.

5. Mechanism of rewards/compensation to farming families, communities and farmers have to be viewed globally in principle, for the benefit of the human race, wherein the mechanism such as compensation, rewards/incentives have to be decided at global levels under the auspices of FAO. The increasing role of NGOs particularly in terms of imparting awareness should be recognised and funded through governmental bodies at the national levels and also well co-ordinated.

6. Mechanism of legal protection to the peasants, farming communities and indigenous people need to be developed through proper legislation at national level to protect their rights.

7. Ultimately, it would be prudent to consider sustainability of agricultural production, food security, nutritional security, better social life etc. simultaneously for the benefit of the poor and under nourished people in the developing countries.

8. Capacity building assumes great concern in the developing countries. FAO may identify strong national programmes such as NBPGR to serve as nodal centres for imparting training in PGR - both short-term and long-term, the latter leading to M.Sc./Ph.D. degrees. Strengthening of existing infrastructure with international collaboration is recommended to strengthen training needs in this (Asia) region.

9. Regional expertise in PGR conservation and management needs to be effectively utilized by FAO In national programme development. Weak NARS in the region can upgrade their PGR technical facilities through sharing of knowledge/scientific technical know-how developed under similar socio-economic, agro-ecological conditions, from countries such as India.

10. The Indian/National Gene Bank Facility can be utilized under the FAO umbrella for long-term conservation of regional/global collections as per global needs/crop priorities.

11. FAO may consider building up/establishing some centres of Excellence around. Strong NPs possessing infrastructure for new technologies and requisite expertise. NationaI facility for Plant Tissue Culture Repository at NBPGR can be assigned regional responsibilities for research and training in *in vitro* techniques - cryopreservation and in use of molecular markers. There is need in the region to strengthen research base on complementary conservation strategies.

12. FAO needs to promote/strengthen studies on underutilized crops, plants of potential economic value hither to neglected, and to safeguard their conservation and use.

13. Basic studies may be encouraged to authenticate taxonomic status of species, biosystematic studies elucidate species relationships : primary, secondary and tertiary gene pools; to promote use of wild species.

14. Regional data-base on selected crops may be linked with National Genebank.

APPENDIX 1
Directory of National Active Germplasm Sites

No.	Crop	NAC Site	No. of Accessions
1.	Wheat	Directorate of Wheat Research, Karnal 132001 (Haryana)	18,000
2.	Rice	Central Rice Research Institute, Cuttack 753006 (Orissa)	42,000
3.	Maize	Directorate of Maize Research, Indian Agricultural Research Institute, New Delhi 110012	2,500
4.	Barley	Directorate of Wheat Research, Karnal 132001 (Haryana)	11,050
5.	Sorghum	National Research Centre for Sorghum, Rajendranagar, Hyderabad 500 030 (Andhra Pradesh)	5,160
6.	Pearl millet	All India Coordinated Pearl millet Improvement Project, College of Agril., Shivaji Nagar, Pune 411005 (Maharashtra)	2,794
7.	Small millet	All India Coordinated small Millets Improvement Project, Univ. of Agril. Sciences, Bangalore 560065 (Karnataka)	8,572
8.	Pulses	Indian Institute of Pulses Research, (ICAR), Kanpur 208024 (UP) Indore 42500 (Madhya Pradesh)	9,810
9.	Soybean	National Research Centre for Soybean,	2,500
10.	Oilseeds	Directorate of Oilseeds Research (ICAR), Rajendranagar, Hyderabad	15,629
11.	Rapeseed	National Research Centre on Rapeseed & Mustard, Bharatpur (Rajasthan)	8,082
12.	Groundnut	National Research Centre for Groundnut, Timbawadi, P.O. Junagarh 362015 (Gujarat)	6,432
13.	Sugarcane	Sugarcane Breeding Institute, Coimbatore 641007 (Tamil Nadu)	8,979
14.	Cotton	Central Institute for Cotton Research P.B. No. 125, Nagpur 440001 (Maharashtra)	6,896

No.	Crop	NAC Site	No. of Accessions
15.	Jute & Allied Fibres	Central Institute of Jute & Allied Fibres, Barrackpore 743101 (West Bengal)	3,226
16.	Vegetables	Directorate of Vegetable Research, Varanasi (UP)	16,139
17.	Potato	Central Potato Research Institute, Shimla 171001 (Himachal Pradesh)	2,375
18.	Forages	Indian Grassland & Fodder Research Institute , Jhansi 284003	6,267
19.	Spices	National Research Centre for Spices, Marikunnu, Calicut 673012 (Kerala)	2,847
20.	Tobacco	Centra Tobacco Research Institute, Rajahmundry 533105 (Andhra Pradesh)	1,500
21.	Plantation	Central Plantation Crops Research Institute, Kasargod 671024	307
22.	Medicinal & Aromatic Plants	All India Coordinated M&AP Improvement Project, NBPGR, New Delhi 110012	375
23.	Agro-	National Research Centre for Agro Forestry, Indian Grassland & fodder Research Institute, Jhansi 284003	40
24.	Fruits (Semi-Arid)	National Research Centre on Arid Horticulture, Bikaner (Rajashtan)	541
25.	Fruits (Subtropical & Temperate)	NBPGR Regional Station, Phagli, Shimla 171004 (Himachal Pradesh)	454
26.	Fruits	Indian Institute of Horticultural Research, 255, Upper Palace orchards, Bangalore 560080 (Karnataka)	13,118
27.	Citrus	National Research Centre for Citrus, Seminary Hills, Nagpur 440006 (Maharashtra)	51
28.	Fruits (Northern)	Central Institute for Horticulture for Northern Plants, Lucknow	587
29.	Tuber crops	Central Tuber Crops Research Institute, Sreekariyam, Trivandrum 695017	3,586
30.	Pseudo cereals	NBPGR Regional Station, Phagli, Shimla 171004 (Himachal Pradesh)	3,682

APPENDIX 2
Project Profile

Project Activity	Thrust Areas	Estimate Funding US$
A. EXPLORATION		
1. Exploration and Collection IN ANDAMAN & NICOBAR ISLAND	Collection of agri- biodiversity (mango, jack fruit, banana, coconut, yams)	50,000
2. Survey and collection of crop diversity (Rice, legumes, yams, taros)	North-Eastern Region of India	40,000
3. Survey and collection in Desert of Rajasthan	Endangered species	25,000
B. EVALUATION & DIVERSITY STUDIES using biochemical and molecular Techniques (Isozyme, RFLP, RAPDS & AFLPS)	Solanum complex, Abelmoschus, Cucumis species, Vigna species complex and Sesamum etc.	250,000
C. CONSERVATION		
1. ON FARM CONSERVATION OF Diversity	Cold Desert of Spiti (Barley and Field peas)	50,000
2. ON FARM CONSERVATION OF DIVERSITY IN ORYZA	Land Race Diversity in Chota Nagpur Plateau	50,000
3. *In vitro* and cryopreservation of Native Diversity	Vegetatively propagated	100,000
4. Basic research in Seed Native Diversity	Major crops of Indian gene centre	60,000
D. DOCUMENTATION & DISSEMINATION OF INFORMATION	Characterization, documentation and production of catalogues in major crops	150,000
E. REGIONAL COOPERATION & ACTIVITIES		
1. Joint Exploration in Bangladesh	Native Diversity	60,000
2. Joint Exploration in Bangladesh	Mango, Jack fruit, Rice and Vegetable	60,000
3. Teaching & Training in the field of Plant Genetic Resources for South/South East Asia and Pacific Region	Short and medium term training M.Sc. course (1 year)	250,000

References

Arora, R.K. and **E. Roshini Nayar**, 1984. *Wild Relatives of crop plants in India.* NBPGR Sci. Monogr. 7, 90 p.

De Candolle, A. 1886. Origin of Cultivated Plants. Hafner, New York.

Harinarayana, G. : Appa Rao, S. and Mengesha, M.H. 1988. Prospects of utilising genetic diversity in pearl millet. **In** Plant Genetic Resources: Indian Perspective (Eds. R.S. Paroda, R.K. Arora & K.P.S. Chandel) NBPGR, New Delhi, pp. 170-182.

Paroda, R.S. 1989. Research advances in crop sciences. **In**: 40 Years of Agricultural Research and Education in India. ICAR Publication, New Delhi, pp. 35-78.

Prain, D. 1897. Noviciae Indicae - 15. J. Asiat. Soc. Bengal 66: 347-519.

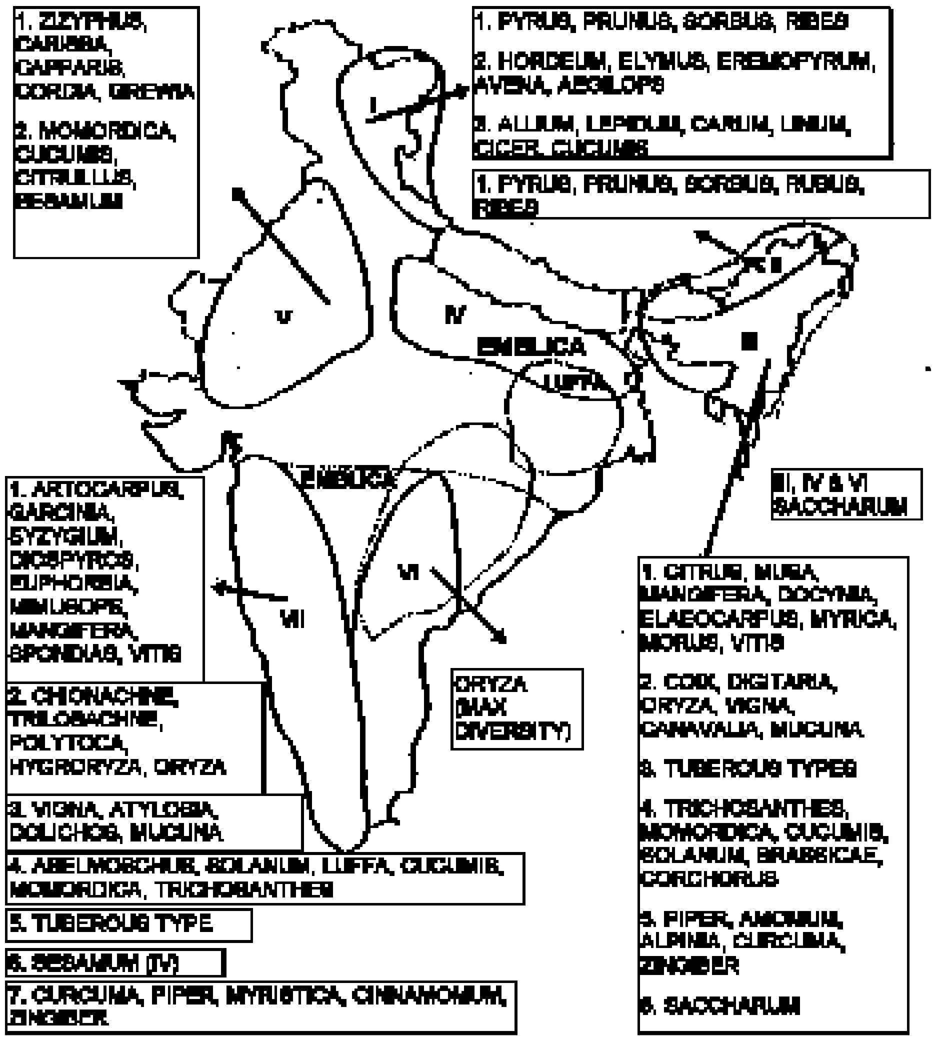
Rana, R.S., Arora, R.K., Singh, B.P. and **Kochar, S.** (Eds.) 1994. Plant Genetic Resources - Developing National Policy Option. ISPGR Dialogue 1993. ISPGR, New Delhi, 219 p.

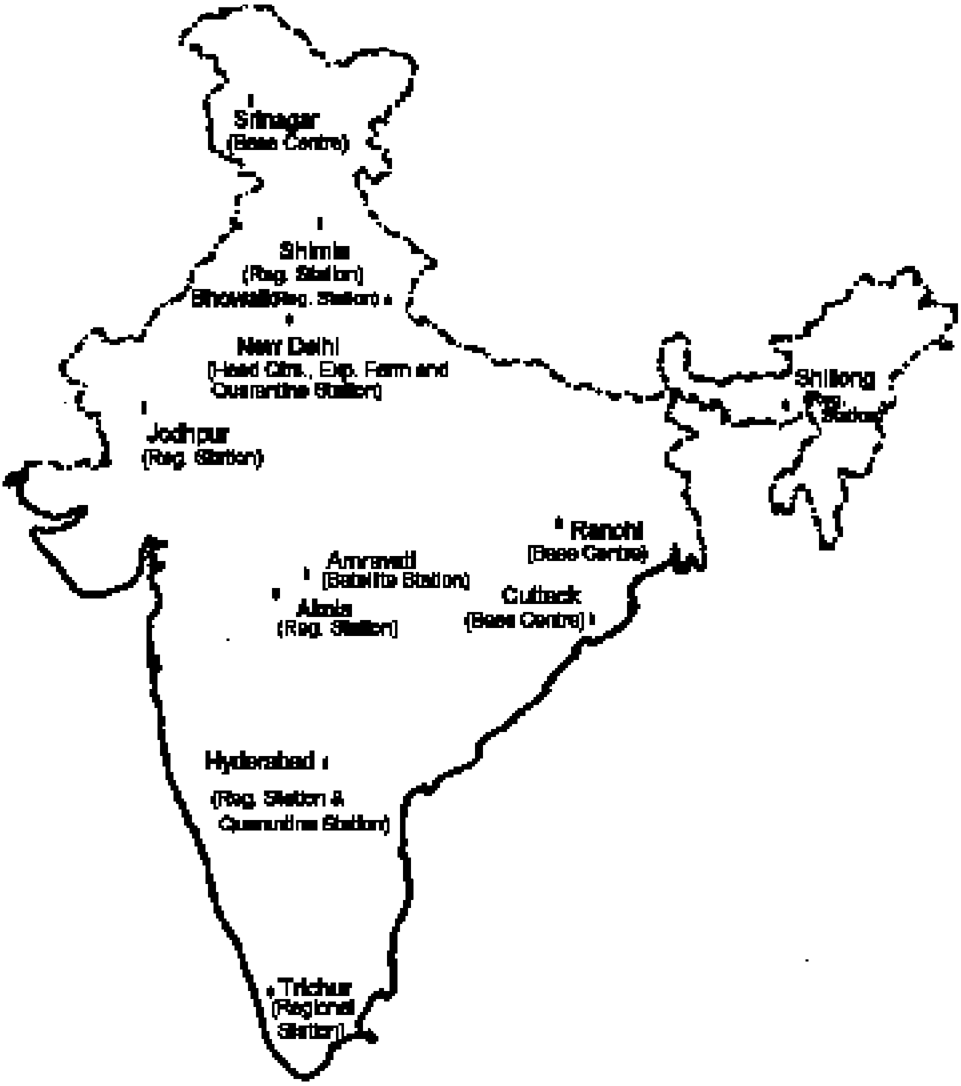
Sharma, S.D., Krishnamurti, A. and **Dhua, B.R.** 1987. Genetic diversity in rice and its utilisation. **In** Plant Genetic Resources : Indian Perspective (Eds. R.S. Paroda, R.K. Arora & K.P.S. Chandel) NBPGR, New Delhi, pp. 108-120.

Vasal, S.K. and **Taba, S.** 1987. Conservation and Utilization of maize genetic resources. **In** Plant Genetic Resources: Indian Perspective (Eds. R.S. Paroda, R.K. Arora & K.P.S. Chandel) NBPGR, New Delhi, pp. 91-107.

Zeven, A.C. and **de Wet, J.M.J.** 1982. Dictionary of Cultivated Plants and their Regions of Diversity. PUDOC, Wageningen, 259 p.

Zeven, A.C. and **Zhukovsky, P.M.** 1975. Dictionary of Cultivated Plants and their Centres of Diversity, PUDOC, Wageningen, 219 p.


1. ZIZYPHUS, CARISSA, CAPPARIS, CORDIA, GREWIA
2. MOMORDICA, CUCUMIS, CITRULLUS, SESAMUM
1. PYRUS, PRUNUS, SORBUS, RIBES
2. HORDEUM, ELYMUS, EREMOPYRUM, AVENA, AEGILOPS
3. ALLIUM, LEPIDIUM, CARUM, LINUM, CICER, CUCUMIS
1. PYRUS, PRUNUS, SORBUS, RUBUS, RIBES
I
V
IV
II
EMBLICA
LUFFA
EMBLICA
VI
VII
II, IV & VI SACCHARUM
1. ARTOCARPUS, GARCINIA, SYZYGIUM, DIOSPYROS, EUPHORBIA, MIMUSOPS, MANGIFERA, SPONDIAS, VITIS
2. CHIONACHNE, TRILOBACHNE, POLYTOCA, HYGRORYZA, ORYZA
3. VIGNA, ATYLOSIA, DOLICHOS, MUCUNA
4. ABELMOSCHUS, SOLANUM, LUFFA, CUCUMIS, MOMORDICA, TRICHOSANTHES
5. TUBEROUS TYPE
6. SESAMUM (IV)
7. CURCUMA, PIPER, MYRISTICA, CINNAMOMUM, ZINGIBER
ORYZA (MAX DIVERSITY)
1. CITRUS, MUSA, MANGIFERA, DOCYNIA, ELAEOCARPUS, MYRICA, MORUS, VITIS
2. COIX, DIGITARIA, ORYZA, VIGNA, CANAVALIA, MUCUNA
3. TUBEROUS TYPES
4. TRICHOSANTHES, MOMORDICA, CUCUMIS, SOLANUM, BRASSICAE, CORCHORUS
5. PIPER, AMOMUM, ALPINIA, CURCUMA, ZINGIBER
6. SACCHARUM


Srinagar
(Base Centre)
Shimla
(Reg. Station)
Bhowali (Reg. Station)
New Delhi
(Head Qtrs., Exp. Farm and
Quarantine Station)
Jodhpur
(Reg. Station)
Shillong
(Reg.
Station)
Ranchi
(Base Centre)
Amravati
(Satellite Station)
Akola
(Reg. Station)
Cuttack
(Base Centre)
Hyderabad
(Reg. Station &
Quarantine Station)
Trichur
(Regional
Station)