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Role of plant genetic resources in sustainable agriculture

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Abstract

Plant genetic resources are the backbone of agriculture which play a positive and unique role in the development of new cultivars including the restructuring of existing ones. Genotypes which could withstand better under abiotic and biotic pressures, are the keys for sustainable agriculture. Gene for such traits are often available in wild species and land races. Studies on genetic diversity of wild crop relatives have been carried out and there are 326 wild crop relatives in India. The informations needed to formulate a breeding plan for sustainable agriculture included in the present paper are genetic diversity, endagered plant species, species diversity and ecosystem stability, global floristic diversity in food plant, genetic resources in India, wild collections of major crops, plant genetic resources vis-à-vis crop breeding emphasis and conservation of plant genetic resources including new plant genetic resources. Till April, 2006, total number of accessions were 320,728 for different crops including cereals, millets and forages, pseudocereals, grain legumes, oilseeds, fiber crops, vegetables, fruits, medicinal and aromatic plants, species and condiments, agroforestry duplicate safely samples. These accessions were stored for long term storage in the National Gene Bank and may be utilized in future for developing the genotypes which could tolerate biotic and abiotic stresses.

Key words: Genetic resources, suistanable agriculture, species diversity, gene bank.

Introduction

The food grain demands by the year of 2020 is anticipated to be around 250 million tonnes, which means an extra 72 million tonnes of food grains are to be produced. This is both an opportunity and a challenge to geneticists and plant breeders to produce more when there is little possibility of any substantial increase in the cultivated land as well as water resources. It is in this context that the issue of sustainability becomes all the more relevant. In the recent past, there has been tremendous progress in agriculture under assured input situations, whereas the productivity in marginal land, rainfed areas, saline and waterlogged conditions have still remained low.

Crops such as coarse cereals, small millets, oilseeds, pulses, cotton etc. have much less area under irrigation than wheat and rice, and hence required technological advances that could enable quantum jumps in their productivity. Therefore more emphasis on research aiming at resistance to biotic and abiotic stresses is necessary. Plant genetic resources (PGR) are the backbone of agriculture which play a positive and unique role in the development of new cultivars, including restructuring the existing ones that are handicapped due to poor expression or lack of one or the other attributes. Plants, which could withstand better under biotic and abiotic pressures, are thus the keys for sustainability in agriculture. Genes for such traits are often available in wild species and landraces and have thus to be exploited fully to achieve desired objectives. Biotechnological approaches have enhanced the scope of locating and transferring useful genes from wild species.

There is a need for ecologically sound agricultural systems and judicious use of biodiversity in our approach to sustainability. Obviously, it is a stupendous task, which would require all-round efforts of not only collecting and preserving germplasm, but also evaluating it under appropriate stress conditions, and then to identify the desired genes in appropriate genetic background. Although existing potential of wild germplasm in India are tremendous, yet large areas are unexplored and untapped. A consortia approach would be desirable to augment, evaluate and sustainable use the wild plant species for improvement of cultivated crops. Germplasm enhancement is thus critical for sustainable agriculture in future and hence it would be necessary to meet these challenges successfully.

It is estimated that the Earth is home of approximately 240,000 species of plants of which only about 5,000 have been carefully studied (Anderson *et al.,* 1988). This rich diversity that has already captured human attention now contains a large array of useful plant genes. Though, as it is today, mankind, by and large, is dependent on 25 to 30 food plants, viz., wheat, rice, maize, barley, oats, sorghum, millets, soybean, beans, pea, chickpea, peanut, banana, citrus, tomato, sugarcane, cassava, potato, sweet potato, yams and five oilseed types and a few beverages (Harlan, 1975) and only three species viz. rice, wheat and maize provide 60 % food for the mankind.

Genetic diversity

Genetic diversity is defined as variations in the genetic composition of individual within or among species. India being one of the 12-mega biodiversity countries possesses rich genetic diversity. Studies on genetic diversity are not as yet very widespread and sharply focused. However, studies on genetic diversity of wild crop relatives and domesticated animals have been carried out. There are 326 wild crop relatives in India. Wild relatives of millets, wild relatives of wheat and barley have been located in the Western and North Eastern Himalayas.

Endanagered plant species

About 427 endangered plants species have been listed by the Botanical Survey of India in its publications on the floristic synthesis enumerated for Red Data book. This contributes to about 20 per cent of India's' total floristic wealth of higher plants. The array of biological resources including their genetic resources are renewable in nature or in similar ex-situ conservation with their proper management can support human needs indefinitely. Thus, is appropriate to treat these as the fundamental sources for sustainable development. Their perpetuation in the existing forms and to the extent feasible on existing basis is therefore, essential to suitable explore factors from such a big reservoir for tomorrow's need.

The availability evidences, however, indicate that human activities are eroding the prevalent biological resources and greatly reducing the biodiversity of the planet. Estimating the precise rate of loss, or even the current status of the species, is stupendous task because no monitoring system, whatsoever, systematic, is likely to match the huge diversity in its existing form. Thus, much of the basic information remains lacking, especially on the species rich tropics wild flora and a large fraction of its wild fauna are threatened with, many of the verge of extinction. This may not be surprising, while considering the fact that in the past few decades India has lost at least 50 per cent of its forest, polluted over 70 per cent of its water bodies, built or cultivated on much of its grasslands, and degraded many coastal areas. Further, to bio-prospecting this habitat, ill effects of destruction, hunting, over exploration and a host of other activities have together taken a heavy toll.

Species diversity and ecosystem stability

Diversity of genes within species increases its ability to adapt to adverse environmental conditions. When these varieties or populations of these species are destroyed, the genetic diversity within the species is diminished. In many cases, habitat destruction has narrowed the genetic variability of species lowering the ability to adapt to changed environmental conditions. The greater the variability of the species, the more is the ecosystem stability.

The survival and well being of the present day human population depends on several substances obtained from plants. The biodiversity in wild and domestic form is the source for most of humanity's food, medicine, clothing, housing, cultural diversity, intellectual and spiritual inspiration. It is believed that one-fourth of the known global diversity is in serious risk of extinction and calls for an integrated approach for conserving global biological diversity. Establishment of corridors with different nature for the possible migration of the species in response to climate change, etc. are the immediate steps to be taken for conserving the very precious biological diversity. Global network for gene banks, microbiological resources centres, and marine parks are also important. At the same time conservation must be coupled with socio-economic development especially in countries where population pressure threatens the national biotic resources.

World's floristic diversity in food plants

The genetic diversity in food plants consumed by man on a global basis is distributed/concentrated in twelve regions of diversity (Zeven and de Wet, 1982) with their wild related types also occurring here and/or more precisely in the different floristic regions of the world (Good, 1953). Phyto-geographically, such areas where the wild related types along with diversity of primitive cultivated types occur, is an important source of diverse, more useful germplasm. By and large, a wide range of environment (climate, soil, physiography) today holds an equally wide range of floristic wealth in the major biomes of the world (Good, 1953). It is estimated that among the 55 plant families which have contributed to the supply of domesticated species (Harlan, 1975), the Graminae family have contributed 29 cereals (and sugarcane), Leguminosae 41 crops (pulses, beans, tuberous types), Solanaceae 18 crops (fruits, vegetables, spices and one tuberous type), Cucurbitaceae 13 crops (pumpkin, squash, cucumber and varieties of gourds), Liliaceae 11 crops (edible bulbs), Umbelliferae 9 crops (salads, spices) and Araceae 8 crops. Among the cultivated plant diversity of 2,489 species distributed in different regions of the world (Zeven and de Wet, 1982) and belonging to 167 families, Graminae (379 species), Leguminosae (337 species), Rosaceae (158 species) and Solanaceae (115 species) are well represented. Tanaka (1976) deal with about 10,000 species of edible plants on a global basis while an earlier, more comprehensive treatment. Arora (1985) enumerated about 900 species of less known cultivated food plants on a world basis which include 141 species of tuberous and root crops, 218 of vegetables, 337 of fruits and 112 of seeds/nuts.

Plant genetic resources in india

Out of approximately 18,000 species of higher plants, about one third constitutes the useful plant wealth. This diversity includes 1,500 food plants. Based on plant-parts consumed, these genetic resources are represented by 375 species of fruits, 280 of vegetables, 80 of tuberous/root types, 60 each of edible flowers and seeds/nuts (Arora, 1991). Also, the

Indian region is one of the centres of diversity of cultivated plants, and Zeven and de Wet (1982) include 166 species in the 'Hindustani Centre'. The richness of landraces diversity is enormous and this contains sources of useful genes for tolerance to physiological and ecological stresses, diseases/pests etc. and good quality traits. Of particular interest are the wild progenitors and other wild relatives/related species of cultivated plants. About 326 such wild species have been enumerated for India, which occur in different phytogeographical and/or agro-ecological regions. Around 1,000 wild edible plants are widely exploited by native tribes (Arora and Nayar, 1984; Arora, 1991 and Paroda *et al.*,1998).

The species richness is classified under the following utility categories: cereals and millets-52 species, legumes-31, fruits107, vegetables-54, oilseeds-12, fibres-24, spices and condiments- 27 and others of miscellaneous use-26. Several less known crop domesticates of Indian origin have been reported, such as the legume root crop *Maughania vestita,* minor millet Digitaria *cruciata var. esculenta,* and the aromatic plant *Inula racemosa* (Arora, 1987). In addition, nearly 9,500 plant species of ethnobotanical uses have been reported from the country, of which around 7,500 are of ethno-medicinal importance (Paroda *et al.,* 1998)

World collections of major crops

There has been a far greater concern particularly in the last twenty-five years to collect widely the representative diversity in crop plants. The commendable efforts of the IARCs have been

Table 1. Germplasm holdings of IARCs (CGIAR Web-site Nov.2006)

IARCs	Holdings
CIAT (Centro Internacional de Agricultura Tropical, Colombia)	72,262
CIMMYT (International Maize and Wheat Improvement Center, Mexico)	120,527
CIP (International Potato Center, Peru)	15,061
ICARDA (International Centre for Agricultural Research in Dry Areas, Syria)	140,189
ICRISAT (International Crops Research Institute for the Semi-Arid Tropics, India)	114,865
IITA (International Institute of Tropical Agriculture, Nigeria)	27,596
ILRI (International Livestock Research Institute, Narobi, Kenya)	20,177
IRRI (International Rice Research Institute, Philippines)	108,043
WARDA (West Africa Rice Development Association, Cote d 'Ivoire)	14,759
AVRDC (The World Vegetable Center, Taiwan)	52,845
ICRAF (World Agro-forestry Centre, Kenya)	1,785
IPGRI/INIBAP (International Plant Genetic Institute)	1,250
Total	**689,349**

Table *2: Ex situ* holdings in major genebanks in the world

Country	Genebank	Holdings
India	National Bureau of Plant Genetic Resources	320,000
China	Institute of Crop Germplasm	300,000
USA	National Seed Storage Laboratory	268,000
Russia	N. I. Vavilov Institute	177,680
Japan	NIAR	146,091
Republic of Korea	Rural Development Administration	115,639
Canada	Plant Genetic Resources Centre	100,000
Germany	Institute of Plant Genetics and Crop Plant Research	103,000
Italy	Bari	55,806
Ethopia	Biodiversity Institute	54,000
Hungary	Institute for Agrobotany	45,833
Poland	Plant Breeding and Acclimatization Institute	44,883
Philippines	NPGRL	32,446
	Total	**1723,378**

*Holdings as on Nov.2006

instrumental in augmenting the genetic diversity of their mandate crops. Table 1 and 2 list the germplasm accessions assembled by the IARCs and other major genebanks in the world, which represent a sizeable part of the total world holdings for their respective crops. The IPGRI has substantially assisted the IARCs to collect germplasm, which is held in trust by the IARCs and in other PGR research activities. Since 1988, IPGRI and the concerned Genetic Resources Units of the IARCs meet regularly and discuss PGR issues of common interest in an Inter-Centre PGR Working Group to make collaborative efforts more directed to immediate and foreseeable needs, particularly of the developing countries. Besides, IPGRI linkages with the national PGR programmes have helped further in aligning a wide range of germplasm diversity from different regions based on germplasm collecting emphasis given to priority areas and crops on a, global basis (Arora *et al.,* 1991).

Plant genetic resources *vis-a-vis* crop breeding emphasis

Crop genetic resources are the results of conscious selection from the wide range of natural diversity. Subsequent crop evolution was the result of selection pressures on the variation originated by mutations and distributed by recombination. Selection pressures provided by crop management under complex production constraints and farmers' preferences, led to the distribution of the variation among types that differed from place to place, with each type characterised by high level of adaptation to a given environment.

Recent crop evolution was due to modern plant breeding that began when it became evident that landraces were incapable of responding to the improvements in farming systems and that more reactive materials were therefore necessary. Selection occurred first among and within landraces, and then in variation originated by crossbreeding. Farmers adopted the new high yielding varieties over large areas, thereby rendering the crops more uniform and exposed to the risk of severe attacks by diseases and pests. The introduction of a limited range of resistance into a few elite and widespread varieties produced the need to rescue crops from an impending danger of failure, as resistance became ineffective against an array of rapidly evolving pests and parasites. As a consequence, today most of the breeding aims are to maintain already achieved yield levels.

In addition, whenever a valuable characteristic is obtained, it is used by numerous breeders, further narrowing the genetic bases of crops. Seed market competition makes in additional contribution in this direction, since it induces breeders to use competitor varieties as reference. Sometimes these constitute the base material to which one or few desirable properties are introduced and a new variety is obtained. Although legally different, it is substantially similar to its predecessor, and therefore capable of occupying the same market. Consumers, with their precise requirements and specific preferences, also contributed to reduce genetic variability in farmers' crops. In this way plant breeding has narrowed the genetic basis of crops to its success. In all advanced agriculture, a few excellent varieties, all related to each other, tend to cover vast areas and to exclude most of the others (Simmonds, 1979).

The need for responding to improvements in cropping practices and market requests, and the urgency of meeting the food demand of populations in developing countries, forced plant breeders to concentrate their efforts on environments with unlimited resources, particularly water supply, and selecting biotypes reacting to increasing levels of exogenous inputs. Generally, modern varieties have low interspecific competitive ability but improved disease resistance and better sink/source ratio.

Ever since agriculture began around 10,000 years ago; the cultivated plants have been exposed to selection pressure, both biotic and abiotic. It is well realised now that many useful traits of importance to breeding research are hidden in the enormous biological wealth. Also, such diversity in recent years has been screened/studied for crop improvement purposes and primitive cultivars incorporated in breeding promising selections or varieties, as in rice, tomato, potato, wheat, sugarcane and many other crops (Brown *et al.,* 1989).

The discovery of dwarfing genes of wheat and rice from the primitive landraces from Japan and China triggered the so-called 'Green Revolution', which enabled this world to feed its increasing population. The process of selection has continued with emphasis to breed diverse types for different agro-climates and agro-ecosystems to combat biological stresses, which continue replacing the old with new varieties adapted to local conditions. In rice, for example, results at IRRI brought out IR 8, which gave way to IR 20, which was succeeded by IR 26 and then IR 36. The late 1970's IR 36 was the world's most popular rice, but by 1980 it was found susceptible to a new strain of brown plant hopper. In the meantime, IRRI had developed yet another variety, IR 56 (Anderson *et al,* 1988). Similarly, equally rewarding has been the efforts of the plant breeders and associated scientists in other IARCs in developing promising varieties, i.e., CIMNYT-wheat, maize, barley, CIP-potato, sweet potato, CIAT-*Phaseolus* beans, cassava, forages, IITA-yams, cassava, rice, maize, cowpea, ICARDA-wheat, barley, chickpea, lentil, faba bean, medic/forage legumes, ICRISAT sorghum, pearl millet, pigeon pea, chickpea, groundnut, AVRDC- tomato, mung bean, sweet potato, soybean and *Capsicum*.

In wheat, high yielding Indian dwarf varieties, suiting consumers' preferences, helped India achieve the 'Green Revolution'. Presently, a range of varieties is available for all wheat growing states for different agronomic situations, i.e., timely or late sown irrigated conditions, timely sown rainfed conditions or salt-affected soils. Similarly, a range of varieties resistant to different diseases and pests is available. As in wheat, rice improvement programmes got a fillip with the introduction of dwarf rices. Starting with the release of IR8, a number of dwarf varieties even suiting relatively different ecosystems like rainfed lowlands semi-deep water and rainfed uplands have been evolved. Even early maturing varieties (70 days) and high yielding 'basmati' type varieties have been developed.

Besides the extent of research inputs and adoption of improved technologies in rice and wheat, which contributed to huge food grain reserves, very significant national contributions have also been made towards yield increases in several crops especially sugarcane, cotton, tobacco, potato, sorghum, maize, pearl millet, etc. The noble canes developed through wide crosses in the 1940s at the Sugarcane Breeding Institute, Coimbatore are a classic example. Ever since, a number of superior canes were bred and many of those have been released in India and in more than a dozen countries abroad. India is the first in the world to commercialise hybrid cotton. H-4 was the first such intra- specific hybrid. This was followed by other inter-specific hybrids such as Varalakshmi, DHC 32, etc. Here, it is worth mentioning that cotton hybrids have become quite popular in the rainfed regions.

India is also the first country to produce hybrid castor and hybrid pigeon pea and the advances made in hybrid maize are in no way less significant than elsewhere in the world. The release and cultivation of hybrid/composites in maize has led to a substantial increase in maize productivity. In castor, the production in the country has more than doubled with more rapid spread of hybrids. Hybrids in various crops have also given the required confidence to the farmers and are widely accepted for cultivation even in marginal conditions under rainfed agriculture. Unlike in many other countries, hybrid technology has become quite successful even under less-endowed environments.

There are several such significant achievements in different crops relating to breeding crops either genetically higher in productivity or possessing resistance to various biotic and abiotic stresses (ICAR, 1989 and Paroda, 1989, 1991). However, the fact remains that despite limited availability of quality seeds of improved varieties and hybrids, the compound growth rate of various crops/commodities during the last 50 years has been fairly impressive and more than 3000 varieties of various crops has been developed in India (Table 3).

Table 3. Varieties notified in India under the Seeds Act up to 2002

Crop / Commodity	Number
Paddy	578
Wheat	228
Sorghum	142
Maize	156
Pearl millet	109
Other Coarse grain & Small millets	125
Pulses	556
Oilseeds	426
Forage Crops	109
Fibre Crops	235
Vegetables	395
TOTAL	**3059**

Role of landraces in sustainable agriculture

The role of landraces is often conceived as donor of specific useful genes for improvement of HYVs. Such vision is far too restrictive and diminutive, as compared with the great potential they retain for further progress of many agricultural areas, especially those exhibiting unpredictable, unfavourable conditions.

Limiting factors can occur with different intensity, at different times across the growing season, and for a variable period of time. In Mediterranean environments, for example, limitations can derive either from low temperatures in winter, dry spells at any time during the growing season, fogs during pollination and seed setting, high temperatures, lack of water, and hot winds during grain-filling or, more frequently, from different combinations of these factors. Yield increases and stability, under these circumstances, cannot be derived from single traits, whatever their complexity, but rather from different combinations of traits, and within each combination the role of individual traits can change with the type, intensity and timing of the stress.

Landraces or primitive cultivars, evolved under farmers' selection over millennia in the area, are composed by many different genotypes, each of which possess a slightly different expression of traits and is better adapted to slightly different conditions or combination of conditions than others. This variability, with some genotypes at their best and some others differently sacrificed, assures the stability of the population. It appears that selection pressure, under millennia of cultivation, was not able to identify a trait conferring superior performance or a genotype, A consequence of the above facts is that the interest in these populations primarily lies in the possibility of understanding mechanisms enhancing stability in unpredictable environments both as far as the genetic structure and the adaptive role of specific traits are concerned, and not as a source of single gene. Biotechnology can play an important role in these studies as it follows the dissection of complex characters through the use of molecular markers.

A second consequence is that selection of pure lines to be released as varieties for these environments may not represent the best strategy in the long run; rather long-term, sustainable improvements would produce a population of genotypes representing different combinations of traits. Evidence indicates the possibility of selecting from landraces individual genotypes showing good stability in the short run (Ceccarelli, 1990). Various proportions of these lines might provide the opportunity to combine individual with population buffering, while the different proportions with which the lines are combined would allow the provision of different varieties for different agro-ecological conditions. Traditional farmers show a great ability to benefit from differences between available planting materials.

Multipurpose crops

Landraces are highly valuable for farming systems in many and semi-arid countries, because of their attitude to multipurpose production. In West Asia and North Africa (WANA) countries, for example, where sheep flocks represent a basic economic component, barley and wheat landraces provide both grain and straw, the latter representing the only available feed supply capable of ensuring the survival of animals during the summer period. With some exceptions of multipurpose trees, little attention has been paid so far to multipurpose crops, for germplasm collection and evaluation, as well as investigations on suitable agronomic practices and cropping systems.

The sustainability issue

The above problems have triggered a debate about the sustainability of present agriculture. There are numerous definitions of sustainability in agriculture, almost all of them amenable to one or more of the three main conceptual approaches: economic, ecologic, and agroecological. From an economic viewpoint, agriculture is sustainable if it can satisfy the growing demand for agricultural commodities on terms increasingly favourable; the reduction of the real price of a commodity is an indication that production is proceeding along a sustainable road for consumers but not for farmers, while rising prices reflect difficulties and, ultimately, lack of sustainability. From an ecological point of view, agriculture is sustainable if it respects the biophysical capital that has become constituted (or is renewable) over a long period of time, so that it does not cause impoverishment, pollution, or alteration of ecological equilibrium. According to this approach, the present size of the world population at present-day consumption rates is not consistent with the available natural resources. The third approach considers present-day agriculture not only as an assault on nature, but also on the rural people and the rural communities, and therefore looks forward to a revitalisation and strengthening of rural culture in an integrated, holistic approach to the physical and cultural dimensions of production and consumption.

In recent years, the concept of sustainability has tended to spread beyond the confines of agriculture, to include the entire development process. The debate has given rise to the definition proposed by the World Commission on Environment and development (1987): *"sustainable development is the development that meets the need of the present without compromising the ability of future generations to meet their own needs"***.** It is followed by CGIAR definition: *The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the natural resource base and avoiding environmental degradation"*

The capacity of sustainable increases in agricultural production would therefore depend on new ecologically sustainable technologies and production systems, and on the resources available towards this goal. In some cases, the adjustments, however individually sustainable, are unlikely to ensure general sustainability, particularly in less favourable environments unless due regard is given also to the resource base. If the resource base, as soil, biological diversity, etc., is allowed to deteriorate in both quantity and quality, the maintenance of present production, future production potential, and a range of production options become more difficult. The problems here are more fundamental, since they can hardly be separated into independent research trusts, and are heavily affected by constraints unrelated to research. In addition they require a longer-term commitment, and the opening of research fronts.

Options towards agricultural sustainability

Sustainable agriculture refers to the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the natural resource base and avoiding environmental degradation (Cohen *et al*., 1991). It stresses greater efficiency of resource use and a balance with prevalent environment to achieve sustainability. It aims at the optimum use of our total resource base so that the maximum possible production could be harnessed without jeopardising the long-term capacity of the valuable resources. This is, no doubt, a difficult task especially when the land suitable to agriculture is gradually diminishing and cultivation on marginal/low productivity lands is the only alternative left. Exploitation of such unsuitable situations obviously leads to further deterioration in their potential, which goes against the basic principles of sustainability in agriculture, i.e., continuity in production on a long-term basis without allowing any degradation of the overall environment. Understandably a systems approach of appropriately allocating the resources to an array of options like crop cultivation, pasture development/ animal husbandry, forestry, etc., would be the desired solution. Thus, the efforts in progress and isolation, since researches aiming at better resource management are equally relevant, particularly for stress prone, rainfed and ecologically imbalance environments. Elsewhere, approaches such as 'Alternate Farming', 'Organic Farming', and 'Natural Farming' are now being advocated to achieve sustainable agriculture.

A critical analysis on conservation and sustainable agricultural development has been earlier presented by Swaminathan (1986) stressing the following points to promote ecological sustainability, i.e., Conservation of genetic resources, genetic evaluation and utilisation, integrated pest management, soil resources, water conservation and care and minimising pollution hazards. The options open to us in this context and the important strategies that could go a long way to attain our goals towards sustainability.

The role of genetic diversity

The conservation of genetic resources, initiated about thirty years ago, constitutes one of these new fronts, but has hitherto suffered from major handicaps. First, it was not fully appreciated *by* the stronger movements for conserving general biological diversity, and therefore proved incapable of inserting itself as a qualifying part of these movements. Second, it essentially projected its interests towards the future needs of agriculture, without underscoring its potential and even indispensability, for the present. It must be clear that genetic resources are of vital importance not only for future food security, but also for present-day agriculture. Moreover, direct short-term benefits stemming from their use are instrumental in attracting the support necessary to their conservation.

Conservation of genetic resources

As agriculture is becoming more and more intensified and location specific, crop improvement objectives are also becoming more and more complex. To meet these objectives, it is necessary to conserve available genetic variability and further collect, augment and enhance it. The conservation of genetic resources is to be viewed particularly in the face of their genetic erosion and eventual wipe-out. On one side, with the modernisation in agriculture, the expansion of a relatively small number of improved cultivars to large tracts of land leads to the elimination of vast diversity in primitive landraces of different crop plants. On the other hand, the development in all spheres of life is leading to acute scarcity of land and water. These factors are forcing changes in the land use and agriculture practices, resulting in disappearance of habitats, which harbour wild progenitors and weedy forms of our basic food plants. Thus, the basic building blocks of modern crop cultivars have been threatened. This is particularly worrying in the present times when agriculture is becoming more and more intensified and location-specific, and plant breeding objectives are becoming more and more complex. It cannot be overlooked that diversity in races of diseases and pests is, also more in the tropical environments, and the situation gets accentuated further with the change in cropping patterns and increase in the cropping intensity. This emphasises the importance of conservation and use of germplasm diversity for desired sustainable agriculture in the world. . Plants can adapt themselves to adverse conditions and still form the very basis of producing required biomass that sustains the world population today.

Conservation of genetic resources can be carried in two forms, namely *in situ and ex situ. In situ* conservation demands the establishment of nature or biosphere reserves, national parks, or special legislation to protect endangered species. The Department of Environment and Forests have taken this in a big way. *Ex sit*u conservation means storing germplasm in a gene bank. This method is more practical and facilitates conservation of large germplasm collections. For this, ongoing efforts have been further intensified not only to collect and introduce available genetic variability but also to evaluate and enhance it for proper utilisation in genetic improvement programmes. Concerted efforts for the creation of modern facilities for conservation of these resources have been undertaken by creating the National Gene Bank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, and also the centres for National Active Germplasm Sites (NAGS) at 56 places so that valuable germplasm resources can be appropriately stored and maintained, and consequently effectively utilised in the crop improvement programmes in the country. (Rana and Arora, 1991). Up to April 2006, total numbers of 320,728 accessions of different crop(s) were stored for long-term storage in the National Gene Bank.

New plant resources (under-utilized crops)

New plant resources need to be exploited in order to meet the growing needs of the human society, which incidentally has depended only on a small fraction of plant wealth as stated earlier. Accordingly, many of the under- utilised plants have a potential for improving Indian agriculture in diversified agro- ecological niches, and have great potential for exploitation in view of the value of their economic products for use as food, fodder, medicine, energy and industrial purposes (Bhag Mal and Joshi, 1991). Their role assumes particular importance in harnessing production from lands hitherto unsuitable for major crops. Some of the exotic crops which have been found most promising for exploitation are guayule *(Parthenium argentatum),* jojoba *(Simmondsia chinensis)* as sources for industrial rubber and oil respectively in arid situations, *Atriplex* spp, as forage resource for salt-affected soils and *(Leucaena leucocephala)* as a fodder tree source for semi-arid rainfed situations. Likewise, many of the indigenous plant species such as rice bean *(Vigna umbellata) and* their introduction from other countries are promising sources for undertaking production for suitable situations.

Table 4: Ex-situ conservation of germplasm in National Genebank at NBPGR (As on 30th April 2006)

Crop Group	Accessions stored in National Genebank
Cereals	129,896
Millets and Forages	46,267
Pseudo cereals	4,856
Grain Legumes	50,401
Oilseeds	44,021
Fiber Crops	9,227
Vegetables	19,742
Fruits	204
Medicinal and Aromatic Plants	4,001
Spices and Condiments	1,136
Agro-forestry	742
Duplicate Safety Samples	10,235
Total	**320,728***

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