(Ed. George Kosby). Catholicate College, Pathanamthitta.

MANAGEMENT OF PLANT GENETIC RESOURCES

Y.Annamma Varghese
Rubber Research Institute of India,
Kottayam 686009, Kerala

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1.INTRODUCTION

Plant genetic resources (PGR) constitute a broad spectrum of diverse gene pools representing land races, primitive cultivars, and varieties of traditional agricultural as well as wild and weedy varieties of crop plants, which are maintained in the form of plants, seeds, tissues etc. These are the basic raw materials for all crop improvement programmes The great wealth of genetic diversity currently available holds vast potential. However the genetic resources are non renewable and are among the most essential of the world's natural resources. It is essential that these will be conserved, at the species level, gene pool or ecosystem level, for the use of present and future generations.

1.1 Why PGR matter?

Plant wealth is vital for development of human society and the key for food security and to eradicate poverty. Plants provide feed for livestock. Plants protect the environment, increase soil fertility through the addition of organic matter, prevent soil erosion and prevent desertification. Green plants absorb atmospheric carbon during the process of photosynthesis, thus keeping the environment clean.

Genetic diversity is essential for- sustainable use of PGR i.e. for adaptation of species for changing biotic/abiotic stresses, the genetic base should be broad enough. However, in modern agriculture the genetic diversity is under threat due to the wide spread cultivation of a limited number of high yielding varieties. This is leading to loss of land races and also depletion of the original gene pool. Moreover, the ever-increasing destruction of forest lands for agricultural purposes and urbanization etc. result in depletion of wild habitats leading to gradual elimination of wild species and weedy relatives. It is estimated that up to 5% of species may disappear in the next 25 years.

Scientific and sustainable management of all available genetic resources to meet the world's developmental needs is of prime importance today. Since the state of our future environment is largely unknown, no body knows which genes will be required in the future. Therefore genetic resources have to be collected, studied and conserved for future use before they disappear for ever.

The various concerns regarding genetic conservation include the following aspects. How to set up and maintain major collections, contents and scope of collection, places to be explored, place of maintenance, basic methods to be adopted, choice of information system and methods of utilization.

2 Centres of Diversity

2.1 Primary centers of diversity

The genetic diversity of cultivated plants is not randomly distributed throughout the world, but concentrated in specific regions known as centers of diversity. Pioneering work on conservation of Plant Genetic Resources and Genetic Diversity was done by the Russian school of plant collection lead by Nikolai Ivanovich Vavilov, the Russian Botanist and Geneticist par excellence. In the 1920s Vavilov identified areas with similar physiographic characteristics where there was maximum variability for the major cultivated species and recognized eight main centers of origin. These primary Centers of Diversity are China,India, Middle Asia, Near East, Mediterranean, Ethiopia, Central America, Mexico and South America (Peru, Equdor, Bolivia,Chily,Brazil, Paraguay).

Primary centres of diversity

Sl.No.	Centres	Major Crops	Cultivated Species
1.	China	11	136
2.	India	15	117
3.	Middle Asia	15	42
4.	Near East	20	83
5.	Mediterranean	6	84
6.	Ethiopia	15	38
7.	Central America Mexico	9	49
8.	South America		
	(Peru, Equdor Bolivia)	7	45
	Chily	1	4
	Brazil, Paraguay)	6	13

Later (1962), Zhukovsky, a colleague of Vavilov identified some more centers as the mega gene centers of Crop Plant Diversity and a number of micro gene centers of wild growing species related to our crop plants, where the cultigens first originated.(Esquinas-Alcasar,1993).

The 12 Mega Centres of Crop Plant Diversity

1 Chinese-Japanese Region
2. Indochinese-Indonesian Region
3. Australian Region
4. Hindustani Region
5. Central Asian Region
6. Near Eastern Region
7. Mediterranean Region
8. African Region
9. European-Siberian Region
10. South American Region
11. Central American and Mexican Region
. Northern Region

The Hindustani region is the centre of origin of many major crops like rice, little millet; black gram, green gram, moth bean, rice bean, Dolichos bean, pigeon pea, cowpea, chickpea, horse gram, egg plant, okra, cucumber, leafy mustard, rat's tail radish, taros and yams; Citrus, banana, mango, sun hemp, tree cotton; Sesame, ginger, turmeric, cardamom, areca nut, sugarcane, black pepper, indigo and jute (Dhillon and Saxena, 2003). The Indian Gene Centre is extremely rich in bio diversity. It possesses 11.9 per cent of world flora with 5,725 endemic species belonging to about 141 endemic genera and over 47 families of higher plants (Nayar, 1980). Among the domesticated species, about 167 crop species (including 25 major and minor crop species have originated and/ or developed diversity in this part of the world and further, over 320 species of crop plant relatives are also known to occur here (Arora, 1991).

2.2. Secondary Centres of Diversity

Many species from the primary centre shift to distant lands, which are the secondary centers of diversity. Many valuable forms found in these centers and the local land races are a major part of secondary centers of crop diversity. The traditional management of agro bio diversity during the pre industrial agriculture resembles the natural ecosystems.

3.Classification of Plant Genetic Resources

PGR can be broadly classified in to two viz. cultivated species. and wild spp.

3.1 Cultivated Species

The cultivated species include commercial varieties, land races, breeding lines, special genetic stocks etc

3.1.1.Commercial varieties:

These are standardised and commercialised varieties or cultivars developed mostly by professional plant breeders. Many of them give rise to high production under intensive cultivation system and are -in general genetically uniform - leading to high genetic vulnerability to pests and diseases.

3.1.2. Land races

Also known as folk crop varieties: these are traditional local varieties evolved over centuries. There is a-large diversity between and within these varieties which being adapted to survive in unfavourable conditions have low but stable levels of production due to the presence of many desirable traits and are therefore, characteristic of subsistence agriculture.

3.1.3 Breeding lines:

These are the material obtained by plant breeders as intermediate products and used for development of high yielding commercial cultivars. These, in general originate from a small number of varieties or populations and hence of narrow genetic base.

3.1.4.Special genetic stocks:

These include other genetic combinations like genic, chromosomal or genomic mutants, naturally or artificially produced and add to the genetic variability.

Among the cultivated species, the commercial varieties including the obsolete ones have been and continue to be used for development of newer varieties and are generally well distributed in the collection while the land races did not receive proper attention. However, in the recent years the traditional local varieties, have been given great attention due to two reasons 1.the abundance of potentially useful genetic variation they contain. in already co adapted gene complexes and 2. the speed with which they disappear when replaced by commercial cultivars.

3.2. Wild species

3.2.1. For direct use:

These are wild species consumed by man uses but not planted or cultivated. In the wild species, genetic erosion occur selectively, against the most valuable material, since the best plants are consumed first. An example is Durio spp. growing in Malaysia and Indonesia where the local people pull down the most productive trees to collect their fruits leading to loss of the elite genotype. Similarly in the case of timber spp., the best ones are cut down first, thus drastic selection operating against the plants with the most desirable traits.

3.2.2. For indirect use:

These are wild species related to cultivated plants and possessing beneficial characters that can be transferred to their cultivated relatives. Such transfer is achieved through sexual crossings when sexually compatible while in case of sexual incompatibility, somatic hybridisation or genetic engineering may be resorted to introduce desirable characters in to cultivated species.

3.3.3.Potentially utilizable:

These wild species, which are not used currently, have characteristics or composition, which are of potential use in future. This is the case with some quick growing wild species, for which the present energy crisis has opened up wide prospects of utilization. Similarly, many wild species have higher contents of medicinal substances than in the traditional varieties.

4. Conservation of PGR

The conservation of genetic resources goes far beyond the preservation of the species. The objective must be to conserve sufficient diversity within each species to ensure that its genetic potential will be fully available in the future. PGR can be conserved both *in situ* and *ex-situ* and the two should be considered complimentary and not antagonistic.

4.1. *In situ* conservation

Also known as on-site/ dynamic conservation for which there is legal protection of the area and habitat in which the species grows. This is the preferred method for wild species, which maintains evolutionary dynamics of the species.

Conservation of PGR on-farm, home garden etc also comes under this method.

4.2. *Ex-situ* conservation

Also known as off-site/ static method of conservation, which implies conservation of representative samples of species in germplasm banks as seeds, shoots, *in vitro* culture, plants or in botanical gardens. Ex situ conservation is mainly used for cultivated species. The main advantages are that the material is available in relatively small space under intensive care and are easily available to the breeder. On the other hand, natural selection and adaptation to local habitat ceases, which is the major disadvantage of *ex situ* conservation of PGR.

According to Swaminathan (2002), an integrated gene management system in vogue today, consists of three systems of conservation viz. *in situ* conservation, ex-*situ* preservation and *in situ* on farm conservation. In the case of *in situ* and *ex situ* conservation, public funds are provided to establish biosphere reserves, protected areas, botanical gardens, gene banks etc. However in the case of *in situ* on farm conservation of agro biodiversity, rural people conserve land races or folk varieties for public good at their own cost. There fore, the need to develop a framework for promoting benefit sharing under the different conditions of conservation was stressed by Swaminathan (1995,1996 and2002)

Activities related to the *Ex-situ* conservation of PGR include collection, conservation, characterization, evaluation, documentation, utilization and exchange.

5. Exploration and Collection

Plant genetic resources available to humans are being eroded rapidly due to various reasons like introduction of new high yielding and uniform varieties, deforestation, developmental activities, urbanisation and change in agricultural practices. Hence there is an urgent need to try and assemble whatever genetic diversity is still available, either from farmers field or from nature.

. Seed material will be collected for most species although in some cases it may be bulbs, tubers, cuttings, whole plants, pollen grains or even *in vitro* tissues depending on the characteristics of the species and the manner in which the material is to be collected. The collection team should have a clear vision of what they want to collect.(Esquinas-Alcasar,1993) Tactics and procedures for collecting have been elaborated by Frankel and Bennet (1970), Chang (1985) and Arora (1981). A breeder will usually look for useful agronomic characters (selective sampling), where as the population geneticist may try to collect randomly (random sampling). A targeted collection is for immediate use for research purposes while rescue collecting is done when there is a threat of damage of *in-situ* conservation. The rest of the collection is meant for gap filling for future use (national/regional/global/conservation responsibility).

5.1 Core collection

The concept of core collection, aimed at management for accessions in large gene banks, was first proposed by Frankel and Brown (1984). A core collection consists of a core set of accessions representing maximum diversity of a species with minimum redundancy. A core with ca. 10% of accessions (minimum 3000 accessions) contains around 70% alleles of the whole collection (Brown 1989). Along with the core collection one reserve collection representing the whole collection should also be maintained for future use.

6. Characterization, evaluation and documentation

Systematic characterisation and evaluation is essential for proper utilisation of the PGR. Characterisation and evaluation may serve two functions. Firstly, many of the characters recorded on individual accessions have diagnostic value and will help gene bank curators to keep track of an accession and check its genetic integrity over years. The second function is related to its use for documenting the extent of variability from broad gene pools for use in crop improvement programmes. Usually, highly heritable, easily scorable and frequently observed morphological characters are used as descriptors for characterization. In recent years, digital imaging is also done for direct storage of various descriptors of accessions in computer database. Molecular markers are being extensively used for germplasm characterisation and evaluation.

Evaluation of germplasm resources is generally done in two stages viz. preliminary evaluation and further evaluation. Preliminary evaluation consists of-recording limited number of desirable agronomic traits including vegetative characters, inflorescence, fruit and seed characters, and tolerance to diseases, pests and abiotic stresses. Further characterization and evaluation consists of recording of potential agronomic characters for specific objectives in specific circumstances like productivity, tolerance to stress factors, resistance to diseases and pests, quality parameters etc.

Documentation of the database generated is another important area. Data base management includes entry, compilation, classification, storage, retrieval and dissemination of information. Computerization of the database is done using special softwares developed for the purpose. It is also important to maintain both hard copy as well as e-copies in a systematic manner for future reference and utilization of information documented. The Germplasm Resources Information Network (GRIN) of USDA (http://www.ars-grin.gov) provides extensive information about a large number of crops for easy retrieval of information to users.

7.Utilization of PGR

Conventionally, there are various steps for the utilization of PGR. Useful sources of donor germplasm need to be identified first. The next step is introgression or incorporation of useful genes to cultivated varieties followed by further breeding, screening and selection of desirable recombinants. Finally multiplication and large scale testing of the selections is done which will lead to release of new varieties.

7.1. Biotechnological approaches in PGR utilization

Biotechnological approaches play a major role in the management and utilization of genetic resources. Molecular markers is very useful for identification of useful sources of donor germplasm. Transfer of useful genes to cultivated base can be achieved through various *in vitro* methods like *in vitro* fertilization and embryo rescue (eg.cotton, rice, barley, wheat), and para sexual hybridisation through protoplast fusion. Production of cytoplasmic hybrids through somatic fusion helps transfer of both somatic and cytoplasmic genes from diverse sources.

Direct gene transfer is possible through electroporation of DNA, particle gun technique, agrobacterium mediated transfer (eg. Transfer of Bt gene for imparting resistance to lepidopteran insects). In the area of further breeding, screening and selection of desirable recombinants, soma clonal variants add to the genetic diversity. Tissue culture technique is useful to shorten breeding cycle a, in the case of early flowering in poplars and *in vitro* flowering in bamboo. Anther /ovule culture and *in vitro* screening are other areas of application of *in vitro* techniques in PGR management. Though some of these techniques have been perfected in a few crop species., commercial application of many of these techniques is yet to be achieved.

7.1.1 Molecular techniques for increased use of PGR

DNA marker technology is a potential technique for managing the large collections of germplasm. Four areas of germplasm characterization and evaluation in which molecular markers can be used were identified as I) identification of genotypes including duplicate accessions,2) fingerprinting of accessions 3) analysis of genetic diversity in collections or natural stands and 4) assembling a core collection (Dodds and Watanbe,1990).

Molecular markers are useful for analysis of the extent and distribution of genetic diversity in Germplasm, estimation of genetic distance data for identification of diverse sub population, for establishment of a core and working collection and also for implementation of a preservation strategy. Thus molecular markers help monitoring plant material and assisting in germplasm collection and management in organizing genetic diversity and establishing the genetic relationships among the accessions, early and rapid characterization of germplasm from collection trips, assisting in the construction of core collections, assessing genetic distances to guide the use of genetic resources and also for tracing taxonomic /phylogenetic relationships of the cultivated varieties. Molecular markers have much potential in improving the use of wild species for identification of different sources of interested genes in the genome through marker-assisted selection (MAS)

The two types of DNA Based Molecular Markers are RFLP (Restriction Fragment Length Polymorphism) based markers viz. RFLP and AFLP and PCR (Polymerase Chain Reaction) based markers viz. PCR, RAPD and SSRs. PCR primers are specific primers of short oligonucleotide sequences complementary to the flanking sequences of the gene to be amplified, while in RAPD instead of specific primers random primers, normally decamer primers are used. Single Nucleotide Poly morphism(SNPs) belong to new generation markers. Microsatellites or Simple Sequence Repeats (SSRs) are a new class of potential marker system. Microsatellites are robust and reliable markers of 1-6 bp tandem repeats of nucleotides and well distributed in the genome.

Amplification Fragment Length Polymorphism (AFLP) is both a restriction and amplification based marker.

8. National / International Plant Genetic Resources Institutes

National Bureau of Plant Genetic Resources (NBPGR) Delhi is the nodal organization for collection, quarantine, conservation, evaluation, documentation and exchange of plant genetic resources. The NBPGR is under the Indian Council of Agricultural Research, Dept. of Agricultural Research & Education, Ministry of Agriculture, and Govt. of India. The Bureau has12 regional stations/base centers for carrying out the PGR activities in India. Under the Indian National Plant Genetic Resources System (INPGRS) operated by the NBPGR there is a national seed repository (base collections), national facility for plant tissue culture repository, cryo- preservation facility and a chain of clonal repositories(Field Gene banks) of different crops located at different places.

8.1 Major Divisions and Stations of NBPGR

The five major Divisions of NBPGR include

1. Plant Exploration and collection for collection of PGR through region and crop specific explorations.
2. Plant Quarantine facility ensures that insect pests, pathogens and weeds do not enter the country along with the import material and also carry out post quarantine inspection.
3. Germplasm Exchange Division is responsible for introduction, exchange and distribution of germplasm.
4. Germplasm Conservation Division is responsible for conservation of PGR and
5. Germplasm Evaluation Division undertakes and co ordinates evaluation of PGR. NBPGR Stations and Centers located in different places include

The Regional Stations at Delhi, Akola, (Maharashtra), Bhowali (UP), Jodhpur(Rajasthan).Shillong (Meghalaya), Shimla (Himachal.Pradesh) and Thrissur (Kerala)

There are two Exploration Base centers at Cuttack (Orissa) and Ranchi (Bihar) and a Satellite Station- at Amaravati (Maharashtra)

There are two Plant Quarantine Stations at Delhi and Hyderabad

The NBPGR Regional Station – Thrissur is responsible for collection of crop diversity from Kerala, Tamil Nadu and Karnataka. The mandate includes maintenance, characterisation and preliminary evaluation of paddy, cassava, dioscorea, colocasia,, amorphophalus, ginger, turmeric, pepper, banana, jack fruit, bitter gourd etc.

8.2 *In situ* conservatories in India

The seven biogeographical regions and the corresponding biosphere reserves in India are given below.

Biogeographic Region	Biosphere Reserve
1. Himalayan High lands	Nanda devi (U.P)
2. Burma Monsoon forests	Knokrek (Meghalaya)
3. Bengalian	Manas (Assam)
4. Rain forests	Sunderbans, W.Bengal
5. Coromandal	Gulf of Mannar, TN
6. Malabar rain forests	Nilgris, Karnataka, Kerala, TN
7. Andaman and Great Nicobar	Great Nicoboar (A&N islands)

9. International Plant Genetic Resources Institute (IPGRI)

The IPGRI located in Rome, Italy has the mission to encourage, support and undertake activities to improve the management of PGR worldwide with the broad objectives to help eradicate poverty, increase food security and protect the environment.

9.1 IPGRI Programmes

There are three major programmes undertaken by the IPGRI

1. The plant genetic resources programme, which supports national, regional and international systems to conserve and use PGR.
2. The International Network for the Improvement of Banana and Plantain (INIBAP). This is an elaborate network in order to increase and sustain productivity of bananas and plantains grown on smallholdings.
3. The CGIAR genetic resources support programmes

Under this programme advice and service is provided to the institutions under the Consultative Group of international Agricultural Research (CGIAR) in the area of genetic resources policy.

IPGR Projects

Currently there are 20 multi-disciplinary IPGRI projects that are regional or global in scope providing support to PGR programmes and regional networks in different regions viz.

1. Americas
2. Asia, the Pacific and Oceania
3. Europe
4. Sub-Saharan Africa
5. Central & West Asia and North Africa
6. Global capacity-building and institutional support
7. Global forest genetic resources strategies
8. Promoting sustainable conservation and use of coconut genetic resources
9. Locating and monitoring genetic diversity
10 *Ex situ* conservation technologies and strategies
11 *In situ* conservation of crop plants and their wild relatives
12 Linking conservation and use
13 Livelihoods and Institutions : Social, cultural and economic aspects of agro biodiversity
14 Information management and services
15 Public awareness and impact assessment
16 Musa genetic resources management
17 Musa germplasm improvement
18 Musa information and communication
19 Support to regional Musa programmes
20 CGIAR genetic resources support programme

9.2 Regional Networks

The four Regional net works of IPGRI are

1. Regional Network for Conservation and Utilization of Plant Genetic Resources in East Asia - EA-PGR (1991) Members: China, Japan, Republic of Korea, Democratic People's Republic of Korea and Mongolia.

2. Regional Cooperation in Southeast Asia for Plant Genetic Resources-Southeast Asia - (1993) Members: Indonesia, Malaysia, the Philippines, Papua New Guinea, Thailand, Singapore and Vietnam.

3. The South Asia Network on Plant Genetic Resources (SANPGR) (1990). Bangladesh, Bhutan, India, Nepal, Maldives and Sri Lanka .

4. The Pacific Agricultural Plant Genetic Resources Network PAPGREN (2001). Cook Islands, Fiji, Kiribati, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu.

Under the United States Department of Agriculture (USDA), the National Plant Germplasm System (NPGS) is responsible for the management of PGR in the US. USDA has four Regional Plant Introduction Stations viz.: Western (Pullman), North Central (Ames, Iowa), Southern (Texas) and North Eastern (Geneva, New York) which, stores thousands of plant species and varieties. In addition to NPGS, national seed storage Laboratory located at Colorado provides long-term seed storage facility and maintains-back up for all the four regional stations.

10. Natural Rubber- A Specific case of Management of wild germplasm

10.1 Importance of Natural Rubber

The para rubber tree of commerce, *Hevea brasiliensis* (Willd ex. Adr.de Juss.) Muell.Arg, produces around 98% of the world's natural rubber (NR), an industrial raw material of strategic importance. In India, around 35,000 products are made out of NR and world over; NR is used in about 50,000 products.

The cultivation of rubber is the chief means of livelihood for millions of people in many rubber-growing countries of the Far East, who depend directly or indirectly on wages or profits received from the production of plantation rubber. Natural rubber forms the raw material for a very large number of articles useful to man.

10.2 Origin and distribution

Hevea brasiliensis comes under the genus *Hevea*, family Euphorbiaceae. There are 10 more species in the genus *Hevea* viz. *H. benthamiana, H.camergoana, H.camporum, H. guianensis, H. microphylla, H. nitida, H. paludosa, H. pauciflora, H. rigidifolia,* and *H.spruceana.*

The genus *Hevea* occupies the whole of the Amazon river basin in Brazil also extending towards south and north covering parts of Brazil, Bolivia, Peru, Colombia, Ecuador, Venezuela, French Guyana, Surinam and Guyana. *Hevea brasiliensis* extends about half of the range of the genus, mainly occupying the region south of the Amazon, extending to Acre, Matto Grosso and Parana areas of Brazil, parts of Bolivia, Peru, north of the Amazon to the west of Manaus as far as the extreme south of Colombia.

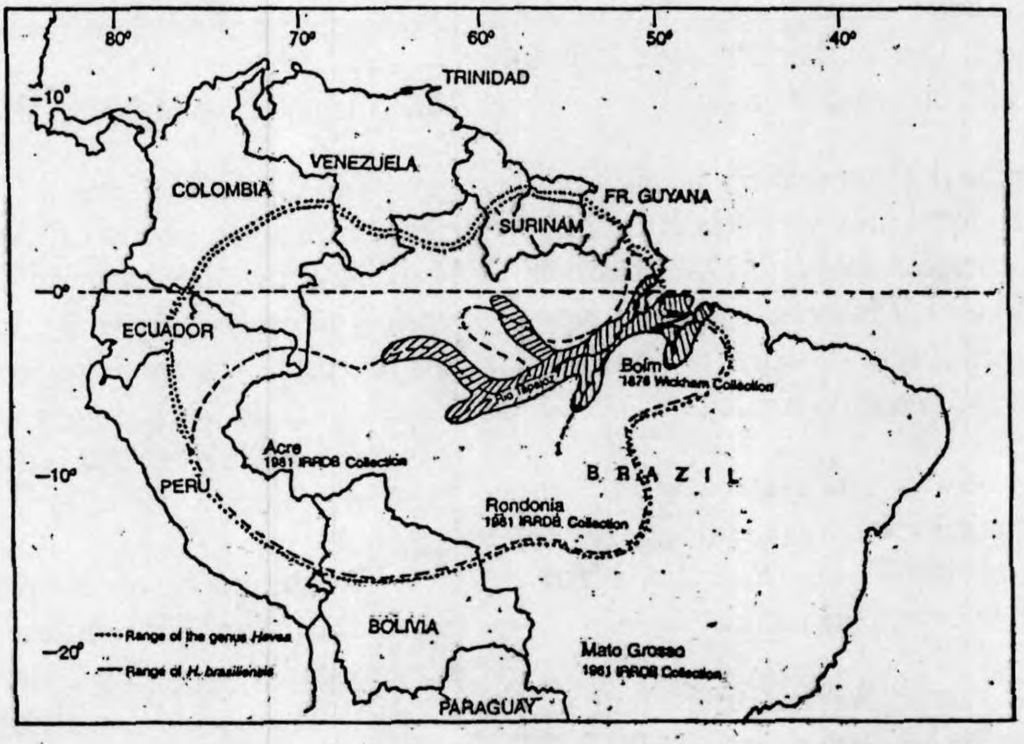


Figure 1. Distribution of the genus *Hevea*

The entire development of rubber plantations in the East is attributed to the famous Wickham collection (Lane, 1953; Wycherly, 1968; Dean, 1987). Wickham collected 70,000 seeds of *H. brasiliensis* from near Boim on the Rio Tapajoz and from the well-drained undulating country towards the Rio Madeira. About 2,700 of these seedlings were raised at Kew, England, and 1919 of them were dispatched during 1876, mainly to Sri Lanka; a few went to Malaysia, Singapore and Indonesia (Baulkwill, 1989; Dean, 1987). In India, rubber was first received in 1878, from Sri Lanka. This original collection known as 'the Wickham base' has contributed to the entire present day plantation in the east.

The species is now grown mainly in the tropical regions of Asia, Africa and America in countries like Malaysia, Indonesia, India, Sri Lanka, Thailand, China, Philippines, Vietnam, Kampuchea, Burma, Bangladesh, Singapore, Nigeria, Cameroon, Central Africa, the Ivory coast, Ghana, Zaire, Liberia, Brazil and Mexico. However the major share of total production comes from tropical Asia.

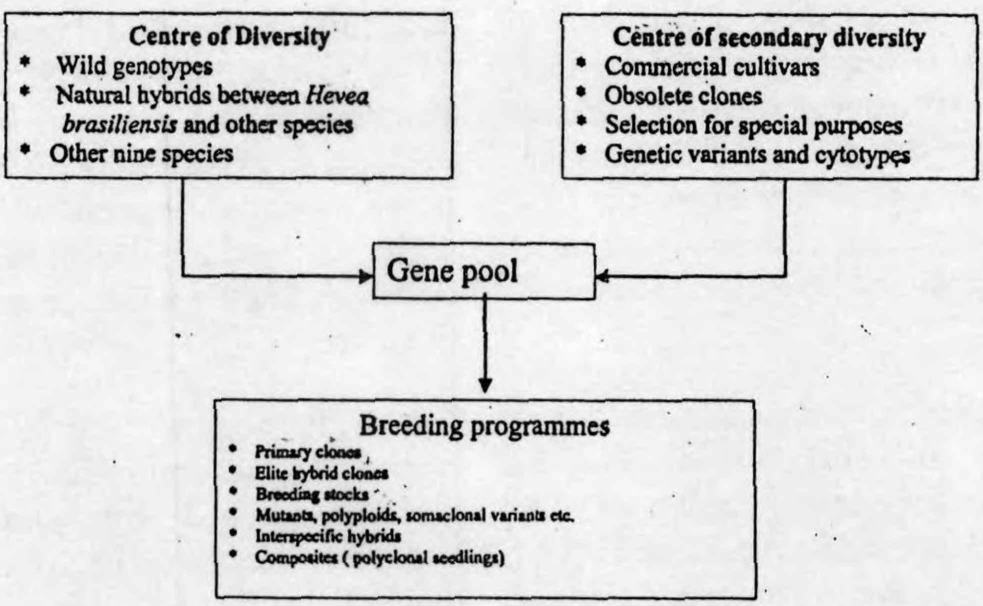
In India the traditional rubber-growing region is confined to the state of Kerala and Kanayakumari district of Tamil Nadu. Rubber cultivation was later extended to non-traditional areas in the country. Currently rubber is grown in Kerala, Tamil Nadu, Karnataka, Tripura, Assam, Meghalaya, Mizoram, Manipur, Nagaland, the Andaman and Nicobar Islands, Goa and Maharashtra. Besides, the crop has also been introduced in the states of West Bengal, Orissa, Andhra Pradesh and Madhya Pradesh. However, Kerala enjoys the monopoly with 85 per cent of the cultivated area in India.

10.3 Genetic Resources in *Hevea*

10.3.1 Sources of germplasm

The spectrum of *Hevea* germplasm can broadly be grouped into those belonging to the primary center of diversity and those in secondary centers. The primary center of diversity not only accommodates the wild genotypes of the genus but also the naturally occurring hybrids, morphotypes and variants. Commercial cultivars, selections and genetic variants form the genetic resources in the secondary centers.

Spectrum of germplasm of *Hevea brasiliensis*



Source: Varghese *et al* 1992

Commercial cultivation is very often restricted to high yielding cultivars, which may become obsolete when newly improved ones are released. As such, it is not unlikely that the older materials disappear in course of time. These are valuable genetic materials and most of the countries where *H. brasiliensis* is an introduced crop, the variants, selections and obsolete cultivars are maintained as an insurance against gene erosion.

10.3.2 Introduction of clones

Introduction or exchange of available clones among the rubber growing countries in the early years constituted the original breeding pool in each country. Recent introductions under bilateral and multilateral clone exchange programs organized by the International Rubber Research and Development Board (IRRDB) and Association of Natural Rubber Producing Countries (ANRPC) are confined to potential clones of good performance. Thus popular clones evolved in different countries are being introduced to member countries and evaluated under the local agro climatic conditions and promising selections recommended for large scale planting.

Under the bilateral clones exchange programme, India has obtained clones developed in China, Indonesia, Ivory Coast, Liberia, Malaysia, South America , Sri Lanka and Thailand. Clones developed in India were supplied to China, Ivory Coat, Malaysia, Sri Lanka and Thailand. A total of 127 clones introduced into India from other countries form the exotic component of the original gene pool in India (George, 2000).

10.3.3 Need for broadening the genetic base

The genetic base of *Hevea* in the South East Asian countries is very narrow, limited to a few seedlings originally collected by Sir Henry Wickham in 1876 from Brazil referred to as the 'Wickham gene pool. From this original material with an average yield of 200-300kg/ha/yr, rubber breeders could achieve substantial improvement in yield to about 3000kg/ha/yr through hybridization and selection over the past few decades.On the other hand, rigorous selection practiced mainly for yield alone and hybridization programmes utilizing the best clones in a generation as parents for the next generation, further narrowed down the genetic base. (Simmonds, 1989; Tan,1987; Varghese, 1992). Similarly, wide adoption of clonal propagation by budding has resulted in extensive areas being brought under a limited number of high yielding clones leading to a sort of monoculture situation.

There are already indications of erosion of genes controlling resistance to diseases caused by *Oidium* and *Gloesporium* in the original Wickham material (Wycherley, 1977). South American Leaf Blight (SALB) caused by *Mycrocyclus ulei*, the most devastating disease of rubber presently confined to the tropical Americas, demands breeding and selection of SALB resistant clones in Asian countries.

Besides, rubber cultivation has been extended to potential non-traditional and marginal areas confronted with extremes of climate and moisture stresses and hence development of location specific clones is a priority area. Since the existing germplasm of *Hevea* has a narrow genetic base, breeders all over the world recognised the urgency for broadening of the original narrow genetic base of rubber by introduction of fresh wild germplasm. Wild germplasm has been identified as a repository of genes conferring resistance to various biotic and abiotic stresses.

10.3.4 Fresh Germplasm- The 1981 Collection

Considering the urgent need for broadening the genetic base, fresh wild germplasm has been collected from the center of diversity in Brazil, in a joint expedition of the International Rubber Research and Development Board (IRRDB) and Brazilian Government, in 1981. The team collected 64,736 seeds (Ong *et al.*, 1983) and budwood from 194 presumably high yielding mother trees (ortets) from the states of Acre, Mato Grosso and Rondonia (Ong *et al.*, 1983). Ecological differences between these states offer chances for the selection of materials suitable for diverse situations.

The seeds and budwoods collected were despatched to the primary nursery at Manaus in Brazil, where 50% of the entire seed collection was retained, as per the agreement with Brazil. Of the remaining seeds, 75% was sent to the Asian multiplication and distribution center at Malaysia, and 25% to the African Center at Ivory Coast. From the seedlings raised at these centers, budwood were distributed to member countries.

In India, this new germplasm was imported from Malaysia during the period 1984 to 1990 and established at the RRII Central Experimental Station in South Kerala and in the two North-Eastern regional research stations at Guwahati and Agartala. In India, currently, a total of 4548 accessions including 90 ortet clones received from the Malaysian center, have been established in traditional and non-traditional areas (Varghese *et al.*, 2002).

10.3.5 Conservation

Conservation of genetic resources of *Hevea* in perpetuity is an urgent need of the time. Both *in situ* conservation of genotypes in their original habitats and *ex situ* conservation in special nurseries or fields are feasible in *Hevea,* of which the latter is widely adopted due to practical considerations. In India, *ex situ* conservation of the wild germplasm is done in field nurseries known as conservation nurseries at a spacing of 1m x 1m, inter-planted with suitable controls ensuring proper identity.

The germplasm collection, maintained in the field as 'active collection' for regeneration, multiplication, distribution and characterization, are exposed to natural calamities as well as pest and disease outbreaks. From this a 'core collection' or a condensed assembly of germplasm should be identified and established for efficient conservation as well as for elimination of redundancy in large collections. Finally a 'working population' to suit short term needs of individual breeders and breeding programs can be established for current use. (Varghese, 1992).

10.3.6 Characterization and Evaluation

Characterization, evaluation and documentation precede utilization of wild germplasm. The 1981 germplasm collection conserved in the different Rubber Research Institutes is subjected to characterization and evaluation aimed at selection of the potential accessions for utilization in genetic studies and crop improvement programs. With the objective of characterization of the wild *Hevea* germplasm, a descriptor has been prepared for the first time in India. The descriptor includes passport data, plant type description at juvenile phase and data on relevant quantitative and qualitative characters expressed in subsequent phases of growth. Abraham *et al.*, (1994) reported morphological characterization of the wild germplasm at the juvenile phase.

Field evaluation of the wild germplasm is done in statistically laid out trials employing simple lattice /augmented design in two stages *viz.* a preliminary evaluation, where the accessions are evaluated for agro- morphological and anatomical characters, and a further evaluation, where selections from the preliminary evaluations are subjected to a more detailed study. So far over 1000 accessions have been subjected to 16 preliminary evaluation trials in 5 different locations both in the traditional and non-traditional areas and 102 accessions in two further evaluation trials at two locations.

In India, several preliminary studies (Varghese *et al.*,1989; Abraham *et al.*, 1992, 1995; Abraham, 2001; Mercy *et al.*, 1993, 1995; Mercy, 2001; Madhavan *et al.*, 1993, 1996; Reghu *et al.*, 1996; Rao and Reghu, 2000 and Sanjith 2003) on characterization, variability estimates, character associations and genetic divergence in the wild germplasm of *H. brasiliensis*, have been reported in different sets of wild germplasm accessions. These studies revealed wide variability and significant genetic differences among the accessions for most of the agro morphologic traits, bark structural characters and juvenile yield indicating the scope for selection of accessions with desirable characters. There were several individual accessions with values higher than that of the control clone for several growth characters like girth, height, number of leaves, number of leaf whorls, and bark anatomical characters like bark thickness, number of latex vessel rows, density and diameter of latex vessels. Moderate estimates of phenotypic and genotypic coefficients of variation with high estimates of broad sense heritability were recorded for most of the agro-morphological and bark anatomical characters and juvenile yield studied indicating the highly heritable nature of these characters. Genetic divergence studies in wild germplasm assume great importance in the context of their utilization in hybridization programs.

10.3.7 Documentation

Comprehensive information describing the plant material must be collected and stored in order to meet the demands of current as well as future users of the plant genetic resources. Being the national agency dealing with *Hevea* germplasm research activities, the Rubber Research Institute of India maintains a National Accession Register with all the basic data. The database is also being computerised for easy storage and retrieval. Preparation of a herbarium of the wild accessions is in progress.

10.3.8 Screening for resistance to biotic stresses

In the case of the emergence of a virulent strain of a particular pathogen in favorable environmental conditions, the disease will spread and cause serious damage, if sufficient genetic variability for tolerance to diseases is not available in the population. Wild germplasm being a rich source of genes conferring resistance to diseases, screening of the accessions for major diseases is a priority area of germplasm research. In India, field/laboratory screening of the wild genotypes, for resistance to *Phytophthora, Odium and Corynespora* leaf diseases has revealed wide variability among the wild accessions indicating the scope for selection of sources of resistance.

10.3.9 Screening for resistance to abiotic stress

Screening of wild accessions for drought and cold are in progress in the drought prone area at Dapchari in Maharahtra state and in a cold prone area at Nagrakata, in the sub Himalayan West Bengal respectively. Early performance of the wild accessions in these locations is quite encouraging in identification of a good number of potential wild accessions tolerant to drought and cold climates. Mato Grosso accessions were in general superior for drought tolerance compared to those from Acre and Rondonia.

10.3.10 Screening for timber- latex traits

The contribution of rubber wood products to rubber industry is in the increase with the rising demand of timber for wood based industries. Identification of desirable genotypes for qualitative and quantitative timber traits has been recognized as a priority area since rubber wood has been accepted as an alternate source of commercial hardwood. Screening of the wild genotypes for timber-latex traits has been envisaged and initiated in India. Among the three provenances, accessions from Acre were observed to be more vigorous with long, straight trunks and less branching, which is a desirable feature for timber clones.

10.3.11 Hybridisation incorporating wild germplasm

Incorporation of superior wild accessions as one of the parents in Wickham x Amazonian hybridization programs has been initiated, in various rubber research institutes all over the world including India. The hybrid progenies are under field evaluation. The potential of the wild accessions of rubber, to serve as parents in crop improvement programs has been well understood now.

There is no doubt that the wild *Hevea* germplasm is an- untapped source of many valuable genes. It is the best raw material for realizing the current objectives-and future demands of the industry. Combining conventional and biotechnological methods it will be possible to achieve yield stability and sustainability in Natural Rubber.

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