MALAYSIA:

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

(Leipzig,1996)

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Ministry of Agriculture

Kuala Lumpur, August 1995

Note by FAO

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CHAPTER 1
Introduction and Agricultural Sector

1.1 GENERAL

Located in the tropics, Malaysia consists of two major land masses, straddling across the South China Sea. Peninsular Malaysia is at the tip of mainland Southeast Asia while the states of Sabah and Sarawak are on the island of Borneo. The area of the country is 330,000 sq. km with the Peninsular having 138,000 sq. km and the remainder in East Malaysia.

Malaysia has an equatorial climate with fairly uniform temperatures throughout the year. In the lowlands, temperatures range from 32°C during the day to 22°C at night. Relative humidity is high (85-95 %), especially in the coastal areas. In the highlands, temperature can drop to 15°C. Rainfall is common throughout the year, averaging 200-250 cm a year. Most of the rain falls during the wet season which lasts from September to December in the west coast of the peninsular and from October to February on the east coast and Sabah and Sarawak.

The population is about 18 million, made up of a diverse mix of races - Malays, Chinese, Indians, Ibans, Kadazans and others. The Malays constitute the dominant race with about 50% of the population.

Malaysia covers a total of 33.06 million hectares of land, of which 7.15 million, 3.15 million and 4.45 million hectares are estimated to be suitable for agriculture in Peninsular Malaysia, Sabah and Sarawak respectively. The sector is dominated by plantation crops, of which oil palm (2.0 million ha) is the major crop, followed by rubber(1.8 million ha) and cocoa (0.4 million ha). Of the food crops, rice area is the most important followed by fruit and vegetable cultivation.

1.2 AGRICULTURE SECTOR

Traditionally, the agriculture sector had played the dominant role in Malaysia. However its contribution to the national economy has declined due to the rapid growth of the industrial and service sectors. Its contribution

towards the national Gross Domestic Product (GDP) has declined from 29% in 1970 to 14.8% in 1994 and is estimated to drop to 13% in the year 2000. From 66% and 29.7 % contribution to export earnings in 1960 and 1985 respectively, the agricultural sector contribution was only 14.6% in 1992. In 1960, agriculture employed 59% of the labour force but thirty four years later in 1994, it was 20% only.

Not withstanding its relative decline in contribution to the national economy, the agriculture sector continues to play a significant role in the development of the country. The importance of agriculture lies in the impact it still has on the rural economy. Despite the rural-urban population drift, rural areas will still have a considerable rural population well into the foreseeable future. Another reason for the continued interest in agriculture is its linkage to other sectors of the economy. In the transformation from an agrarian to industrial economy, the linkage is through the utilization of agricultural raw produce for processing to more finished forms.

Development policies and planning of the agriculture sector are guided by the National Agricultural Policy (NAP) (1992-2010) which aims at "a market-led, commercialized, efficient competitive and dynamic agricultural sector within the context of sustainable development". Under the NAP, it is postulated that the overall agricultural production base will unlikely to be substainally diversified in terms of range of crops and non-crop activities. The emphasis in food production in the NAP is given to crop commodities like rice, vegetables and fruits, and non-crop commodities like meat, dairy, poultry and fish. This emphasis is aimed at import substitution and potential for export. For industrial crop production, emphasis is on rubber, palm oil, cocoa, coconut, pepper, tobacco, floriculture and other crops. These crops will provide the raw materials whose output will be boosted by a concerted and planned development of the agro-based and downstream industries.

1.3 FORESTRY SECTOR

The basis and concept that underlined sustainable forest management is to set aside adequate natural forest lands, strategically located throughout the country to be managed under environmentally sound forest management practices.

In line with the concept of sustainable forest management, a total of 4.71†million hectares of forested land has been designated as the Permanent Forest Estate (PFE), to be managed in perpetuity. Within the PFE, a total of

1.90 million hectares is designated as Protection Forest, whereby the forests are conserved for soil, water protection, flood control and the protection of biodiversity and genetic resources. Apart from this, there are also national parks, wildlife reserves and sanctuaries, nature parks, bird sanctuaries and marine parks which have been established for conservation purposes.

The National Park or Taman Negara, covering an area of 0.43 million hectares of mainly virgin forests was gazetted as early as 1939. Besides these, efforts are also not spared to conserve various forest and ecological types in their original conditions, such as the Virgin Jungle Reserves (VJRs). These VJRs are established to serve as permanent nature reserves and natural arboreta, as controls for comparing harvested and silviculturally treated forests, and as undisturbed natural forests for general ecological and botanical studies. Since its inception in 1950, a total of 72 VJRs covering 21,478 hectares representing the major forest types have been established throughout Peninsular Malaysia. These VJRs are located within the Permanent Forest Estates.

Therefore conservation of forest genetic resources is always a priority in any forest management and harvesting plans. Nature conservation aims at protecting areas representing habitats and communities, whereas gene pools conservation are concerned with genetic diversity within species, which can only be surmised, but not identified. Hence genetic resources conservation will include both genetic and ecological variability. Nature conservation will therefore result in gene pool conservation of constituent species in *in situ* conservation.

CHAPTER 2
Indigenous Plant Genetic Resources

2.1 INDIGENOUS PLANT GENETIC RESOURCES

Like its neighbours in the Indo-Malayan region, Malaysia is very rich in biological resources. Its tropical rainforest is a unique heritage which has evolved over millions of years and is varied in flora and fauna. More than 14,500 species of flowering plants and about 1,500 genera are found, comprising over 2,500 tree species, 800 species of orchids, 500 species of ferns, 60 species of grasses and bamboos and myriads of others. Many of these indigenous species are used as natural resources for:

- food and beverages (fruits, vegetables, spices, edible oils, beverages, tubers, carbohydrates, sugars, alcohols and vinegar)
- timber, rattan, bamboo and fibre materials for shelter, weaving and thatching
- medicines and poisons
- natural dyes and tans
- gums, rubber, camphor and resins
- essential oils and aromatic oils, fuel and green manure
- feed and pasture
- smoking and chewing
- ornamentals
- ritual and ceremonial materials

However, hitherto, only about 300 species native to the country have been exploited and utilized. The remainder are still growing wild or semi-wild in various forest types and their economic potential has not been realised or investigated in greater detail. It is possible that many of them can be developed into economically important crops.

In Malaysia, the plant genetic resource programme is handled by the respective crop-based research institutes as part of the research activities in plant breeding. They are the Malaysian Agriculture Research and Development Institute (MARDI), Palm Oil Research Institute of Malaysia

(PORIM), Rubber Research Institute of Malaysia (RRIM), Malaysian Cocoa Board (MCB), Forest Research Institute of Malaysia (FRIM), National University of Malaysia (UKM), University of Malaya (UM) and the Agriculture University of Malaysia (UPM). In addition, the Department of Agriculture (DOA) and the Department of Forestry (DOF) of Peninsular Malaysia, Sabah and Sarawak are also involved with plant genetic resources activities, especially in crop/tree improvement programmes, conservation and seed/planting material production and distribution.

2.2 FOREST GENETIC RESOURCES

The forest genetic resources in Malaysia is very diverse. In Peninsular Malaysia alone, of the 8,000 flowering plants, a total of 2,650 are trees species, of which 408 species have been marketed in the international market under the Malaysian Grading Rules. The natural forests provide sanctuary for wildlife and maintain environmental stability, which are essential for the conservation of soil and water resources. They also form a large store house of untapped genetic resources useful for the improvement of indigenous forest produces such as timber, rattan, fruits and wildlife. Thus retention of the natural forests is essential to sustain the above objectives.

The Dipterocarp forests are of vital economic, as well as ecological importance to the country. They represent 70% of the total forested land and are characterized by the predominance of the family *Dipterocarpaceae* with many of the species of the genera *Anioptera, Dipterocarpus, Dryobalanops, Hopea, Parashorea and Shorea*.

Recognizing the need to retain sufficient natural forest cover to provide for sustainable timber production, as well as the conservation of biodiversity and the maintenance of essential ecological services, DOF has formulated various strategies for the long term sustainable forest genetic management of its forest resources. These include:

- Setting aside 4.71 million hectares of forested land as Permanent Forest Estate throughout the country, out of which 1.90 million hectares are Protection Forest and 2.81 million hectares are Production Forest.
- Protecting and safeguarding various forest and ecological types in their natural state through the establishment of Virgin Forest Reserves.
- Managing the forest resources more intensively on a sustained yield basis, and the establishment of plantation forests, which are expected to have the following beneficial effects:

- Conservation of the forest resources and maintenance of genetic diversity;
- Sustainability of the Permanent Forest Estate;
- Ensure environmental stability and quality;
- Reduce damage to the advanced growth;
- Minimise logging wastage;
- Induce optimum utilization of the forest resources; and
- Promote reinvestment in forest rehabilitation and forest plantation establishment.

2.3 OTHER WILD SPECIES AND RELATIVES OF CROP PLANTS

Fruits (including nuts and seeds)

Malaysia is unrivaled in terms of its diversity of tropical fruit and nut genetic resources. Many important cultivated fruit species are indigenous and have their relatives in the rain forest, particularly those from the large genera such as *Durio, Nephelium, Garcinia, Artocarpus, Langsium, Mangifera, Baccaurea, Citrus, Syzygium, Musa, Lansium, Salacca, Dialum, Canarium* and others. For instance there are well over 13 species of durian (*Durio*) and its relatives in Peninsular Malaysia. All except *D. zithbethinus* are wild. Likewise the mangoes are equally rich with 15 species, and only three or four of these are being utilised. Another is *Citrus* and its relatives which occur in abundance in Peninsular Malaysia as varieties and forms of species in the wild or under cultivation.

Of more than 500 fruit species found in the rain forest, about 100 species are edible and considered palatable to humans, but only a handful of them are cultivated. Besides the cultivated ones, there are a few wild and semi-wild fruits that have found their way into the market places, but may still be unheard of in other parts of the country. Examples of fruit species that have the potential for exploitation include *sukun (Artocarpus communis), salak (Salacca edulis), kuini (Mangifera odorata), pulasan (Nephelium ramboutan-ake), sentul (Sanoricum koetijape), bidara (Dimocarpus longana), tarap (Artocarpus odoratissimus), isau (Dimocarpus malesianus) and dabai (Canarium odontophyllum).*

There is expected to be very diverse genetic diversity in the wild range of indigenous fruits yet to be discovered as there are so many seedling trees in the wild or semi-wild conditions. Besides the imperative need to conserve as much as possible the indigenous fruit species, they are waiting their potentials to be exploited, namely as new fruit trees, as multi-purpose trees, as rootstocks and as sources of germplasm for breeding to improve the existing cultivated fruit crops.

For instance in Sarawak, the *nyekak (Durio kutejensus*) and *durian kuning (D. graveolens)* have fruits that can be developed as unique durians from the state. Other *Durio* species hold promise as rootstock for the commercial durian (*D. zibethinus*). *Mangifera pajang* and *M. odorata* have good quality fruits while *M. aquea* have fruits of good flavour and are juicy, having potential for making mango nectar. Fruits of *Canarium odontophyllum, Dimocarpus spp., Artocarpus spp., Lansium spp., Dialum spp.,* and *Baccaurea spp.* have good eating quality. At present all the indigenous fruits are still available in the wild and are in no real danger of genetic erosion.

Rice

Several local wild rice species include *Oryza rufipogon, O. officinalis, O ridleyi and O. meyeriana*. In view of their potential as sources of genes encoding tolerance or resistance to stresses, wild rice species are now receiving increasing attention in genetic resource programmes.

Vegetables

The indigenous vegetable species are mostly grown wild in their natural habitat. Lately some effort have been made to grow them on a commercial scale. These species include *pucuk manis (Stenochlaena palustris), pucuk paku hijau (Athyrium esculentum), pegaga (Centella asiatica), Ceylon spinach (Basella rubra), kesum (Polygon minus), selom (Oenanthe javanica),* some Solanaceous species such as *Solanum nigrum, S. tuberosum, S. ferox*, and some *Amaranthus* species. Some of these wild species, particularly the *Solanum* species, are of commercial value as some of them have been found to be resistant to Fusarium wilt.

Spices

Piper nigrum which is an introduced species with no wild relatives in Malaysia. However, there are a number of local *Piper* species such as *Piper sarmentousum, P. porphyrophyllum* and *P. vestinum* which are used in the traditional medicines. With its specked foliage of two colours, *P. porphyrophyllum* has the potential to be developed into an ornamental

plant. Also found in Malaysia are *P. colubrinum* and *P. betle* which can be sources of resistance to *Phytophthora capsici*.

Coconut

Malaysia is located within the center of diversity of *Cocos nucifera* and extensive variation has been observed among its morphological traits such as palm height, vigour, nut size, nut colour and endosperm structure. In Malaysia, three basic types are found namely the Malayan Tall, Malayan Dwarf and Specific Variants.

Orchids

There are about 1,500 wild species in Malaysia. These rare and endangered orchid species were found in the hills/ mountains, forest/jungles, along rivers and also swampy areas. MARDI has set up a germplasm collection of the Malaysian orchid species. Some of these collection have been identified as species belonging to *Dendrobium, Eria, Liparis, Coelogyne, Bulbophyllum, Phalaenopsis, Calanthe, Plocoglottis, Cymbidium, Renanthera, Appendicula, Bromheadia, Thrixspremum, Agrostophyllum, Aerides, Ludisia, Dipodium, Oberonia, Vanilla, Acriopsis, Spathoglottis, Grammatophyllum, Paphiopedillum, Arachnis* and *Vanda*. DOA Sabah also collects and maintains indigenous orchids of Sabah and also some rare species from Borneo.

Rattan

Malaysia records up to 106 rattan species and currently five are commercially important including *Calamus caesius, C. trachycoleus, C. ornatus, C. scipionum*, *C. manan* and *C. optimus*.

Bamboos

From the 58 species of bamboo found in South-East Asia, about 50 species in 10 genera are recorded in Malaysia. Only 13 species are being utilized either by industries or by cottage industry. These include species of *Bambusa, Dendrocalamus, Giantochloa* and *Schizostachyum*. There are still potential species left unexploited in the wild. Most of the species are found in the wild especially in logged-over forests and along riverine areas fringing the forest.

Medicinal Plants

In Malaysia, traditional medicine is looked upon as an alternative or supplement to modern medicines. In the remote areas where modern facilities are not readily available, traditional medicine is the primary health care.

Many indigenous plants are used as medicine. Many are known to have diuretic hypotensive, symatholytic tranquilizing, anti-neoplastic, anti-protozoan, insecticidal, aphrodisiac and anti-tumor properties. They have not been developed commercially but are believed to be sources of useful plant products. Among the more important medicinal plants in Sarawak include *Blumea balsamifera, Costus speciosus, Derris elliptica, Elephanatopus scaber* and *E. tomentosus, Eurycoma longifolia, Physallis minima, Piper sarmentosum, Leonurus sibiricus, Orthosiphon aristatus, Hedyotis corymbosa* and *H. diffusa*.

At present, indigenous medicinal plants are still available in the wild and not in imminent danger of genetic erosion. However steps need to be taken to conserve them. In Sabah, an ethnobotanical garden has been set up to conserve and for research the native plants important in the local communities. Likewise in Sarawak, DOA also maintains a small collection of medicinal plants commonly used by Sarawak people in the Bintulu Agricultural Park in addition to the *ex situ* collection by DOF. Currently there is a joint effort between DOF Sarawak, Universiti Malaysia Sarawak and an organization in the United States to develop useful drugs from *Calophyllum lanigerum*, known as bintagor tree locally.

2.4 LANDRACES AND OLD CULTIVARS

Fruits

Generally the old cultivars or landraces of fruits are fast disappearing in view of better quality varieties of fruits being introduced. This is especially so with rambutan. As many of the old varieties are low in yield or possess poor quality fruits, their cultivation is discouraged.

Rice

Traditional varieties or landraces and old cultivars of crop plants are found mainly with rice and certain field/food crops like sweet potato and okra. In Sabah and Sarawak, the rice farmers are the more common users of traditional varieties which are still maintained by them. In these two states, traditional varieties of rice have not been replaced by modern high yielding varieties except for a small acreage, unlike Peninsular Malaysia where the granary areas are planted mostly with new varieties. In Sabah and Sarawak, most of the rice land is still much rainfed and upland.

The farmers' selections are far superior in terms of taste, texture and fragrance compared to the recommended improved varieties. Hence many old cultivars and landraces are still maintained and cultivated by farmers in Sabah and Sarawak. The Sarawak government does not discourage this as the rice lands are generally unimproved and traditional varieties thrive better than improved varieties. In Sabah, there are at least 40 traditional varieties or landraces being maintained by farmers for their dryland rice and another 40 have been listed for irrigated rice. DOA Sabah maintains over 1000 collections of rice. In Sarawak, there is an endless list of old varieties still cultivated throughout the state but some of the well known old varieties are Biris, Adan, Rotan and Wangi. The recent reform in pricing of super grade rice has spurred a keen interest in the cultivation of good quality traditional rice in Sarawak.

Vegetables

The production of vegetables in Malaysia is largely dependent on imported seeds from abroad especially those of Brassicaceae, Alliacea and Compositae. For families such as Solanceae, Cucurbitae, Leguminacea, Malvacea and Convulvalaceae, farmers are planting improved varieties, although some land races are still being planted as a result of preference or tradition. For example, whilst imported varieties of *Capsicum annuum* are grown, lately some farmers are growing cultivars that have been developed locally through selection of landraces. For *Capsicum frutescen, Solanum melongena, Momodica* and *Luffa*, old cultivars are still popular. For the traditional salad vegetables (ulam-ulam), no improved variety has been reported.

Spices

Clove (*Syzgium aromaticum*), cardamon (*Elettaria cardamomum*), Cinnamon (*Cinnamomum javanicum* and *C. iners*) and nutmeg (*Myristica fragrans*) are grown scattered and in limited areas by farmers for domestic use and localised market. Quality of these spices are lower than the accepted quality of world spices market. Conservation is by repeated planting in these farms.

Field Crops

Currently most of the cassava planted for the starch industry comprises of one commercial variety - Black Twig. For the less significant edible root market, some traditional varieties like Pulut, Putih and Melaka are grown. Very few, if any, of the old landraces are still maintained by farmers. Similarly for cocoyam, despite a diversity of types/varieties, only two seem to dominate the market. Many of the landraces have been abandoned, and some still exist in a semi-wild state, along irrigation canals or drains, but even these are rapidly disappearing.

However, for sweet potato, many of the landraces are still by maintained by pockets of small farmers, probably as backyard or home garden crops. This situation is very prevalent in Sabah and Sarawak. Because of the short term nature of the crop and the ease of propagation (through tubers or vine cuttings), there seems to be a rapid switch to new varieties if these are obviously better than existing ones.

Orchids

Presently there are many commercial orchid hybrids being grown as a result of hybridization of orchid species. In the past, many of the Malaysian orchid species were used by orchid breeders worldwide. They included species of *Paphiopedillum, Vanda, Arachnis, Renanthera, Phalaenopsis* and *Dendrobium.*

CHAPTER 3
National Conservation Activities

3.1 *IN SITU* CONSERVATION ACTIVITIES

To protect and conserve the diversity of natural plant resources in Malaysia, a number of *in situ* and *ex situ* measures have been undertaken. The *in situ* measures include the maintenance of plants in their original habitats, through the network of protected areas such as National and State Parks, Wildlife Santuaries, Wildlife Reserves and Virgin Jungle Reserves. Competition for land utilization under present land-use policies makes *in situ* conservation efforts important.

In general, the prevailing laws are adequate with regard to the conservation of protected areas. As part of the conservation strategy, DOF has established Protection Forests, Virgin Jungle Reserves and Genetic Resource Areas (GRA). In 1988, a total of 1,563,180.9 hectares of land in Malaysia has been designated as *in situ* conservation areas (Table 1).

Conservation of forest genetic resources in Malaysia is a dynamic component in sustainable forest management. In addition to encouraging natural regeneration through silvicultural practices, GRAs are also established to integrate genetic management into existing forest management plans. GRAs are used as source-pedigreed population for seeds and seedlings for reforestation programme and to date, 5,517 hectares of GRA in Ulu Sedili Forest Reserve, Johor have been established for such purposes.

DOA Sabah is also involved with *in situ* conservation where an 100 ha area of fully regenerated forest at the Agriculture Research Station at Ulu Dusun, Sandakan is occupied by both timber and a very high density of wild fruit and nut species. It has been proposed as a Totally Protected Area under the Sabah Conservation Strategy.

Table 1 In situ conservation areas in Malaysia by locality

Locality	Class of area*	Area (ha)
Johore	WLS, VJR, SRP	171,752.3
Kedah	VJR, SRP	4,372.7
Kelantan	VJR, SRP, NP	106,080.0
Malacca	VJR	152.3
Negeri Sembilan	VJR, SRP	3,886.2
Pahang	SRP, VJR, WLS, NP, PF	376,841.7
Penang	VJR	419.0
Perak	WLS, VJR, SRP, WLS	8,673.4
Sabah	VJR, SRP, WLS, RF	538,342.2
Sarawak	NP, WLS, ABRO, WL.RC	253,767.4
Selangor	TRF, VJR, SRP, WLS	13,024.0
Terangganu	SRP, VJR, NP	85,660.2
Total		**1,563,180.9**

ABRO = Aboretum **NP = National Park** **RF = Research Forest** **SRP = Species Reserve Plot**

TRF = Teaching and Research Forest **VJR = Virgin Jungle Reserve** **WLS = Wildlife Sanctuary** **WL.RC = Wildlife Research Center**

3.2 *EX-SITU* COLLECTIONS

For plant genetic resources, *ex situ* conservation facilitates scientists to access, study, distribute and use them in relation to their development as crops or in relation to their utilization for crop improvement. *Ex situ* conservation maintains species outside their original habitats in facilities. In Malaysia, *ex situ* conservation activities of various plant genetic resources are carried out in aboreta, seed genebanks, field genebanks, and *in vitro* genebanks or under cryopreservation (Table 2).

The most established and common form of *ex situ* forest genetic resource collections in Malaysia is through the establishment of plants in aboreta. These can be found in both the aboreta and in research institutions. In Peninsular Malaysia, the major aboreta are found in FRIM, Rimba Ilmu in Universiti Malaya, Medicinal Plant Garden in UPM, Taman Pantun in UKM, MARDI Orchid Collection and the Penang Botanical Garden. In Sabah, *ex situ* collection centers include the Kinabalu Park, Poring, Sepilok Aboretum, Tenom Orchid Center and Agriculture Research Station. In

Sarawak, the Botanic Garden in Semonggok is the main center. With the exception of the aboreta in FRIM, most of the other collections are small in size.

Based on a survey in 1988, it was estimated that 38,255 accessions of plant genetic material were in the *ex situ* collection of various institutions in Malaysia, inclusive of both indigenous and introduced plant species (Table 3).

These national collections of forest species consist mainly of indigenous tree species with or without commercial value. Some of the families represented in these collections are *Alangiaceae, Anacardiaceae, Apocynaceae, Annoaceae, Araucariaceae, Bombacaceae, Burseraceae, Celastraceae, Dilleniaceae, Dipterocarpaceae, Ebenaceae, Euphorbiaceae, Fagaceae, Guttiferae, Lauraceae, Lecythidaceae, Leguminosae, Loganiaceae, Meliaceae, Moraceae, Myristicaceae, Myrsinaceae, Rhizophoraceae, Rubiaceae, Rutaceae, Sapindaceae, Sapotaceae, Thymeleaceae and Verbenaceae*. Only selected species of these families have been planted, most of which were collected at random either as seed or wilding materials from the forests. Some exotic materials such as *Acacia mangium, Gmelina arborea, Khaya aivoriensis* and *Paraserianthes falcataria* have been planted. Large proportion of these species are replicated elsewhere.

Table 2 Facilities for ex situ plant conservation in Malaysia

Type of facility	Plant species
Aboreta	Medicinal plants Citrus Timber species Ornamentals
Seed genebank	Rice
Field genebanks	Rubber Oil palm Cocoa Durian Mangosteen Langsat Rambutan Banana Orchids
In vitro genebanks/Cryopreservation	Cassava Sweet potato Potato

Table 3 Ex situ germplasm collection in Malaysia based on a survey in 1988

Commodity grouping	Type of accession	Status	Number of accessions
Latex Producing Plants	Species, genotypes, clone	Plants	10,746
Cereals	Species, cultivar, Seed lot, composite	Plants, Seeds	7,142
Vegetable Oils and Fats	Cultivar, clone, species, half-sibs, full-sibs	Plants	4,958
Edible Fruits and Nuts	Clone, species, cultivar, genotype, variety	Plants	3,036
Timber Trees	Species, cultivar, races, clone	Plants	2,865
Vegetables	Variety, clone, cultivar, species, seed lot, clone-cultivar	Plants, Seeds	2,564
Root and Tuber Plants	Species, cultivar, clone-cultivar, landraces, clone-hybrids	Plants	2,483
Ornamental Plants	Species, cultivar, hybrid	Plants	1,058
Pulses	Cultivar, seed lot, ecotype, species, cultivar-hybrid	Seeds, Plants	702
Spices and Condiments	Species, clone, cultivar, seed lot, ecotype, variety, cultivar-seed lot/clone	Plants, Seeds	652
Plants producing Sugars, Alcohols or Acids	Species, cultivar, clone	Plants	406
Rattan	Species	Plants	367
Plants used for Beverages	Species, clone, hybrid, cultivar, seed lot, clone-seed lot, clone-individual	Plants, Seeds	275
Other useful Plants	Species, cultivar	Plants	137
Medicinal Plants	Species	Plants	231
Plants used for Smoking	Seed lot	Plants, seeds	10
Fibre Plants	Species, clone-seed lot	Plants	50
Feed Plants including forage and Pasture Plants	Ecotype, species, cultivar	Seeds, Plants	35
Sago and Related Starch Producing Plants	Clone, Suckers, species	Plants	34
Dye Producing Plants	Species	Seeds, Plants	20

Commodity grouping	Type of accession	Status	Number of accessions
Tannin Producing Plants	Species	Plants	5
Bamboos	Species	Plants	20
Resin Producing Plants	Species	Plants	9
Balsam Producing Plants	Species	Plants	1
Wax Producing Plants	Species	Plants	2
Aromatic Woods	Species	Plants	1
Plants Producing Poisons, including insecticides	Species	Plants	10
Plants used for making mats	Species	Plants	19
Plants for packing/thatching	Species	Plants	10
Essential Oil Plants	Species, variety, clone	Plants	11
Shade and Cover Plants,including mulches	Species, ecotype, hybrid line, cultivar	Seeds, Plants	79
Fuel Plants: Charcoal/Firewood	Species	Plants	46
Lower Plants	Species, clone	Plants	23
Plants used for Chewing	Species, variety	Plants	15
Other local plants (Scientific names unknown)	Species	Plants	220
Total			**38,255**

3.3 CONSERVATION ACTIVITIES FOR CROP SPECIES

Fruits

Various research bodies in the country have collected and maintained indigenous fruit trees, either *in situ* or *ex situ* or both. The living collections of fruit genetic resources are held either *in situ* or *ex situ* or both. Overall, the various institutions have together a collection of 200 species with over 4,700 accessions *ex situ* (Table 4). The various institutions that provide for *in situ* conservation of fruits include FRIM, Forest Research Center in Sepilok, Sabah and DOA, Sabah.

Fruit aboreta has also been established in agricultural parks in various parts of the country as a conservation measure as well to serve agrotourism purposes. These fruit aboreta can be found in:

- Forest Research Institute of Malaysia, Kepong, Selangor
- Malaysian Agricultural Park, Bukit Seri Cahaya, Shah Alam, Selangor
- Sekayu Agricultural Park, Terengganu, and
- Sungei Sebiew Agricultural Park, Bintulu, Sarawak

In Sarawak, the fruit germplasm collections are kept in two research stations, the Agriculture Research Center, Semongok, and Kebuloh Station and also in two agricultural stations Tarat and Layar. The earliest collection, based in Tarat, began in the 1960's and consisted of local, indigenous as well as exotic materials. They were planted mainly for evaluation of newly introduced fruit clones and fruit types and to provide sources for propagation. Indigenous materials with potential for commercialisation were kept in Layar.

Table 4 Living collections of fruit genetic resources held by various institutions in Malaysia

Institution	Location	Number of species	Number of accessions
Department of Agriculture, Peninsular	Serdang Agricultural Park Bkt. Seri Cahaya Ulu Paka	54	1,000
Department of Agriculture, Sabah	Kundasang Tenom Ulu Dusun (also *in situ*)	95	418
Department of Agriculture, Sarawak	Semongok Sg. Sebiew Agric. Park Tarat	38	310
Forest Research Center, Sabah	Sepilok (*in situ*)	14	133
Forest Research Institute of Malaysia	Pasoh (*in situ*) Kepong	54	200
Malaysian Agricultural Research Institute	Bukit Tangga Cameron Highlands Jeram Pasu Jerangau Kemaman Kuala Kangsar Kluang Pontian Serdang	100	2,230
Agricultural University of Malaysia	Serdang	36	239
University of Malaya	Kuala Lumpur	71	207
Total			**4,737**

Germplasm materials are used mainly for evaluation and collection of agronomic characters by research officers of the DOA Sarawak. The germplasm collection can be rated as fairly good and selections are made based mainly on desirable characters such as fruit quality. Collections are normally planned during the fruit ripening season.

In Sabah, about 33 families of fruit plants (including nut trees and spices) with about 300 to 400 species are currently maintained. There are approximately 3,000 accessions, including those cultivated varieties. Some of these species may be lost in the future as land development progresses towards a mono-culture type of agriculture. Hence the *ex situ* conservation by DOA

Sabah is being used as a means to at least preserve some of the more useful species.

Rice

Although rice germplasm collection started before 1950, it was only in 1960 that the collection was properly coordinated when the Department of Agriculture Headquarters pooled 200 accessions from the various experimental stations. A systematic documentation was undertaken with the formation of MARDI in 1970 and a catalogue listing 1,029 accessions published, containing basic data like maturity, plant form and growth, grain characteristics and resistance to pests and diseases.

At present at the national level, the total rice germplasm collection stands at 8,621 accessions including several local wild rice species (*Oryza rufipogon, O. officinalis, O. ridleyi* and *O. meyeriana*). All these accessions are conserved *ex situ* in MARDI's Genebank Rice Research Center in Seberang Perai. About one half of this collection comprises of indigenous varieties which had been collected from remote areas nation-wide.

There is also some rice germplasm collection and conservation in the states of Sabah and Sarawak. In Sarawak, rice conservation work began in the 1960's. There is a germplasm collection in the Agricultural Centre, Semongok with 1,169 accessions in the collection. Currently there are also 860 introduced varieties in the collection. Likewise in Sabah, the Department of Agriculture Sabah maintains over 1,000 collections of three rice species.

The traditional rice varieties in the national collection are increasing being used in the rice breeding programme in Malaysia as sources of pest/ disease resistance, adaptability to local conditions and as sources for good grain. However in Sabah only a small percentage of samples are used each year mainly for the purpose of breeding and varietal evaluation. These mainly involve the varieties which possess good eating quality traits. Apart from MARDI and DOA Sarawak, from time to time, the Sabah collection gets requests from IRRI for certain traits for evaluation.

Sarawak has a very good collection of rice germplasm and they are representative of the diversity existing in the field. The collection is adequately maintained to an acceptable standard as far as the storage facilities are concerned. Collections activities are planned according to divisions within the state and priority is given to areas where development is more rapid or where hydroelectric dams has been proposed. Collection trips are mainly planned for rice only and sometimes specifically for certain traits like grain quality but during such trips other varieties and cultivars are also collected. Collections are usually well planned with collections done at road sides, markets and

villages in the remote areas. Collection trips are very costly in Sarawak as interior Sarawak is only accessible by foot and rivers.

Vegetables

Conservation activities for vegetables are conducted by MARDI and DOA in Peninsular, Sabah and Sarawak. In Sabah, plants used as native vegetables, are also grown and conserved in the 433 ha Sabah Museum Ethnobotanical Gardens by the Sabah Museum Department. In MARDI, wild vegetables and "ulam" species are collected from time to time and maintained as the Vegetable Museum in its station in Jalan Kebun for conservation and observation. Serious efforts began in 1980 to collect genetic material of vegetables from all over the country simultaneously with the vegetable survey. Special efforts were made to collect *Solanum* species in 1984-1985. At present, apart from the living collection, the vegetable genetic resources are kept in a medium term genebank stationed in Jalan Kebun. The collection includes indigenous, local and exotic materials which are utilised as active collection and breeders' working collection.

There is an active programme by the Research Branch of DOA Sarawak to collect seeds of the major vegetable families. Special effort is made on the collection of terong Dayak (*Solanum* sp.) and cucumber of native origins. Seeds of kepayang (*Pangium edule*) and pumpkins are also collected. More than fifty various species and landraces of *Solanum*, cucurbits, brassicas and legumes have been collected for field observation.

In Sabah, a total of about 50 species and approximately 500 accessions are maintained for field and food crops. The most current work on traditional cultivars are okra for vegetables and sweet potatoes for root/tuber crops.

Spices

There is no formal national plant resources collection or national genebank for spice crops, except for the pepper collection in Sarawak. However on-farm maintenance of limited resource collection is carried out in MARDI's Kluang Research Station as listed below:

Crop/Spice	No. of accessions
All spice (*Pimenta divica*)	3
Betle leaf (Piper betle)	1
Clove (Syzgium aromaticum)	5
Cinnamon (*Cinnamomum javanicum*)	3
Cinnamon (*C. burmanii*)	2
Cinnamon (*C. iners*)	1

Crop/Spice	No. of accessions
Cinnamon (*C. verum*)	1
Cardamon (*Elettaria fragrans*)	8
Nutmeg (*Myristica fragrans*)	4
Pepper (*Piper nigrum*)	15
Pepper (*P. colubrinum*)	1
Vanilla (*Vanilla fragrans*)	1

To date the record for the number of pepper germplasm accessions collected from Sarawak stands at 117 and 259 for *Piper nigrum* and *Piper* species respectively. Both seeds and cuttings are collected. Because pepper is a recalcitrant species, the collection is maintained as living plants at the research center. Many accessions collected as cuttings did not survive. Thus, only 36 accessions of *P. nigrum* and 46 accessions of *Piper* species are still living. All varieties of pepper and about 10% of *Piper* species collected are used in the varietal improvement programme. Cryopreservation techniques for germplasm maintenance is being studied.

Field crops

MARDI maintains a living collection of cassava, sweet potato and cocoyam. These are supplemented by living collections maintained in the Malaysian Agriculture University (UPM), DOA Sabah (sweet potato and cassava) and DOA Sarawak (sweet potato). Unfortunately at MARDI, the breeder doubles as germplasm curator which does not make for efficient germplasm maintenance and characterization. In addition, there are no special fund for this purpose.

For the root crops, most of the live collections comprise materials collected locally. Some of the cassava accessions have very high starch content in their roots and others high protein content in the leaves (but are low yielding). Likewise there are among the sweet potato accessions with high dry matter content in the roots, and some with resistance to scab. However there is no preferential treatment for these valuable genetic resources. The MARDI collections of cassava, sweet potato and cocoyam are valuable because of the diversity they cover. Many of the landraces collected in the past may no longer be found *in situ*. The sweet potato accessions in particular, were very systematically collected from all the states of Peninsular Malaysia as well as from Sabah and Sarawak.

The germplasm collections are maintained from year to year with little active usage since there are insufficient resources to indulge in active hybridization programmes for the three root crops locally. New sources of variation are being introduced from Consultative Group on International Agricultural

Research (CGIAR) centers (Center for Tropical Agriculture (CIAT) for cassava, International Potato Center (CIP)/Asian Vegetable Research and Development Center (AVDRC) for sweet potato) as well as other agencies (National Agriculture Research Center (NARC), North Carolina State University for sweet potato).

There is no specific *ex situ* conservation program for maize germplasm and soya bean in Malaysia. Only a small amount of PGR collection materials are being stored in the short-term facilities in MARDI's Rice Genebank.

Beverage Crops

There is no formal national genebank or genetic resource collection for coffee. However conservation of germplasm from local areas as well as from abroad are maintained as a living collection in MARDI's Kluang Research Station. At present, the coffee germplasm collection consist of 296 accessions (187 *Coffea liberica*, 177 *C. robusta*, 32 *C. arabica*). These germplasms are used by the breeder in the selection programme for improved materials.

For cocoa, prior to the setting up of the Malaysian Cocoa Board (MCB) in 1989, various government agencies and plantations were involved in maintaining cocoa genetic materials. At present there are over 800 clones of cocoa held in various organizations in Malaysia. Since 1991, MCB has been undertaking to collect and establish all available cocoa genetic materials including imported and locally selected clones in MCB's regional research stations.

Orchids

The *ex situ* orchid species genetic resources collection are kept in MARDI Station, Serdang. The collection of indigenous species began in 1976 and there is still active collection trips, especially to unexploited areas such as Belum Forest Reserve and tentatively to Bakun, Sarawak. A small orchid species collection is maintained in the Orchid Garden in the Sri Cahaya Agriculture Park as well as in MARDI Station in Cameron Highlands.

More than 400 species of lowland wild orchids are also being maintained by Sabah DOA in the Tenom Orchid Center (TOC). Apart from carrying out collection, the TOC is also helping in conservation activities of orchid species through collection and culture of seeds/seedlings of endangered species and re-introducing them into the wild habitat. For example, *Paphiopedilum rothschildianum* was reintroduced in the Kinabalu Park in 1987.

Coconut

MARDI has a programme on the prospection and collection of the coconut. The present living collection occupies 41.5 ha of land in MARDI's Cocoa and Coconut Center in Hilir Perak. It consists of five Tall types of *Cocos nucifera* introduced from Fiji, Sri Lanka, West Africa, Philippines, 38 local Tall types from local sources, six Dwarf types collected locally and from Fiji, Philippines and Indonesia. The main users of the genetic materials are the breeders and other researchers. In Sabah, the coconut germplasm collection consists of 32 accessions, being maintained at the Agricultural Research Station in Ulu Dusun, Sandakan.

Banana

Germplasm collection of banana in MARDI began in 1973 and now has over 200 cultivars, mainly collected from local sources. It consist of both wild and edible cultivars. Some preliminary evaluation of the accessions are being carried out at various locations in the country with respect to yield, fruit quality and disease resistance.

Illipe Nuts

Plants germinated from seeds of several species of *Shorea* collected have been maintained as a conservation measure. They include *Shorea macrophylla, S. splendida, S. stenoptera, S. pinaga, S. palembanica, S. horea seminis* and *S. hemsleyana*.

Rattan

Currently 48 accessions of the various rattan species have been collected since 1989 and established at a germplasm plot in Semongok Agricultural Research Centre. The collection consists of *Calamus manan, C. caesius, C. trachycoleus, C. optimus, C. scipionum, C. ornatus* and *C. javensis.* The growth characterization will be monitored over the years as part of the research and development work in addition to serve as a conservation measure.

Rubber

Rubber, an important industrial crop in Malaysia, has a narrow genetic base as most of the present plantings are derived from a small collection of 22†seedlings brought from Brazil around 1876. This situation is further exacerbated by the planting of a few selected, high yielding clones. To prevent the possibility of a genetic calamity in the near future, RRIM embarked on an ongoing programme by introducing materials from the centers of diversity.

These are the 1951-52 Importation, the 1966 Importation and the 1981 Prospection.

The 1981 Prospection carried out by International Rubber Research and Development Board (IRRDB) resulted in a collection totalling 64,736 seeds and 1,522 m budwood from 194 presumably high yielding ortet trees. In compliance with the International Code of Plant Collection, 50% were retained in Brazil while the balance was distributed to Malaysia (35%) and Ivory Coast (15%) for conservation, evaluation, utilization and also redistribution to other IRRDB countries.

Oil Palm

The genetic base upon which the breeding populations have established for oil palm, another important industrial crop in Malaysia, is extremely narrow as it originated from the four seedlings planted in the Botanic Garden in Bogor in 1884. Efforts to broaden the genetic base received a boost in 1973 when MARDI and Nigerian Institute for Agriculture Research (NIFOR) collaborated in large scale prospection in Nigeria. The present germplasm collection in Malaysia consists of *Elaeis guineensis* and *E. oleifera* from various parts of Africa and tropical Central and South America.

3.4 STORAGE FACILITIES

Rice

Apart from living collections, seed banks are meant for field crops including rice. Storage facilities for seeds are with the research institutions or universities. Among the most comprehensive is that for the national rice germplasm collection which is kept in the MARDI's Genebank in Seberang Perai. Duplicates of Sabah's and Sarawak's rice varieties are kept in their respective state facilities which are sufficient for short to medium term storage only.

MARDI's Rice Genebank is located within the compound of its Rice Research Center. It was completed and became operational in 1988. It is a one-storey building with a total floor space of 305 sq. m. The facility is divided into cold rooms, preparatory room, processing, computer room, scientist /curator's room, seed laboratory, control room and a room to accommodate reserve water tank.

Currently the primary aim of the Genebank is conservation of rice germplasm. However, it is also providing short-term storage space for temporary storage of seeds of maize, groundnut, soyabean and vegetables for research purposes. Storage is for short-term, medium-term and long-term with longevity of seeds expected at 3-5 years, 15 years and 30 years respectively. The short-term storage facilities are maintained at 19-21°C and R.H. 50-60% whilst medium-term storage consists of rice seeds in plastic bottles kept at 3-4°C and 35-40% R.H. For long term storage, deep freezers (-10°C) and freezer cabinets (-20°C) are used.

In Sabah these seeds are stored under cold room conditions at the Agricultural Research Center, Tuaran and the Agriculture Research Station, Tenom. The cold rooms operate at a temperature of 7°C ± 2°C and at a relative humidity of 50 to 60% ± 5%. The seeds are stored in plastic containers for small samples and in partially sealed polythene bags or sacks for bulk storage. Most of the materials collected are under short to medium term storage as DOA Sabah does not have the facilities for long term storage. With the very limited storage facilities available, there are no duplication of the materials for safety reasons.

In Sarawak, the rice germplasm (threshed seeds) collection is stored in glass jars containing silica gel and sealed with wax in a cool room where the temperature is maintained at 16°C using air conditioning units. This storage system is short term in nature and seeds are kept for 3-5 years.

Vegetables and Field Crops

As mentioned earlier, germplasm of crops like vegetables, maize, soyabean and groundnuts are kept as seeds in MARDI's Rice Genebank facilities in Seberang Perai for short term storage purposes. However for vegetable seeds, medium term genebank facilities in MARDI Jalan Kebun are also used for storage. There the vegetable seeds are kept in plastic packets placed in plastic containers in a cool room where temperatures are maintained at 10 to 16°C. This system is able to maintain the viability of the seeds up to six months to six years depending on the crop species.

For tuber and other crops which require vegetative propagation, living collections are maintained. The cassava germplasm is duplicated and kept in MARDI Peat Research Station. Part of the cassava and sweet potato germplasm collections are duplicated and kept for safe keeping in CIAT and AVDRC. Many of the Sabah and Sarawak accessions of sweet potato collected in 1989-90 are duplicated in their respective Department of Agriculture and in National Institute for Agriculture Research (NIAR), Japan.

The storage approach for *ex situ* collections is a fairly new approach for Forest Genetic Resources. Very few of Malaysian forest genetic resources are being maintained this way, as the technology to store recalcitrant seeds has yet to be developed fully. Storage facilities when present, for example like in the Forest Research Center in Sepilok run by DOF Sabah, walk-in cold rooms are used for seed storage of selected species.

3.5 DOCUMENTATION

Readily available and effective dissemination of information derived from empirical studies, initial seed increase/rejuvenation and characterization/evaluation will to a large degree determine the extent to which a genetic resource collection is used by researchers and other interested scientists. In Malaysia, documentation on plant genetic resources usually comes in the form of individual papers or reports, departmental or agency annual reports, special reports, log books, catalogues, proceedings of symposia or conferences and publications of books. In recent years however, there has been attempts to computerise documentation amongst the various agencies to facilitate management and utilization of data on their respective plant genetic resource collections.

In 1988, the Malaysian National Committee on Plant Genetic Resources collated the existing information of the status of the plant genetic resources in the country by conducting a nation-wide survey. The directory produced in 1991 as a result of this survey listed both the *in situ* conservation areas and the *ex situ* living collections held in various institutions.

The diversity of the plant genetic resources in Malaysia is also documented by the following publications:

1. Wayside Trees of Malaya (in two volumes) by Corner (1988)
2. Tree Flora of Malaya (Volumes 1-4) by Whitmore (1972,1973), by Ng (1979, 1989)
3. Endemic Trees of the Malay Peninsula by Ng (1990)
4. Genetic Resources of Under-Utilised Plants in Malaysia by Zakri (1989)

The genetic diversity of the lesser known fruit species in Sabah and Sarawak has also been well documented by Lam (1993), Wong (1993), Voon *et. al.*

(1992) and Serudin (1993). The project carried out by PROSEA (Plant Resources of South East Asia) has also published several publications on plant genetic resources in the region. So far, the PROSEA publications are on pulses, edible fruits and nuts, dye and tannin-producing plants, forages, timber trees, vegetables and rattans. PROSEA also published a basic checklist of the plant genetic resources of South-East Asia.

It is expected that the current on-going Tree Flora of Sabah and Sabah Project which started in 1991 as a collaborative project between FRIM, DOF Sabah and DOF Sarawak will yield a comprehensive taxonomic account of the tree flora of Sabah and Sarawak by the year 2000.

PROSEA has developed a documentation system for information storage and retrieval called SAPRIS (South East Asia Plant Resources Information System). SAPRIS consists of six databases:

1. Baselist: primarily a checklist of more than 6200 plant species
2. Catalog: references to secondary literature
3. Prephase: references to literature from South East Asia
4. Organym: references to institutions and their research activities
5. Personym: references to specialists, and
6. Textfile: all PROSEA publications and additional information

For MARDI's rice germplasm collection, MARDI has come out with the MARDI Germplasm Management System (MARDIGEN) which was developed using Dbase 3 Plus Programme to facilitate two sub-systems, namely Documentation and Data Management, and Seed Inventory. The user oriented database is designed to meet several expectations, *vis-à-vis* its terminology which are based upon genetic and biological principles, ease of data input and editing, and facilitate data storage and retrieval.

For MARDI's collection of cocoa and coconut germplasm, all accessions are also documented using GMS software introduced by IPGRI. Agronomic evaluation is integrated into the documentation system. Passport data, characterization data, evaluation data and breeder's records are kept with the samples. About 90% and 30% of the cocoa and coconut samples respectively have been documented. In addition for cocoa, MCB is actively participating in the International Cocoa Germplasm Data Base (ICGDB) and the newly formed Cocoa Breeders Association for Genetic Improvement of Cocoa (INGENIC). MCB also has linkages with the International Cocoa Genebank Trinidad (ICGT), United States Department of Agriculture (USDA) Miami and Mayaquez, CATIE Costa Rica and Reading University, United Kingdom.

In Sabah, documentation, as far as possible, is in written form such as on index cards or in log books. Computerization of the documentation system has not been started yet although the IPGRI software on Genebank Management System has been acquired recently but no training has been conducted. Training in documentation is very much needed.

In Sarawak, only basic documentation of the fruit germplasm has been done. The data consists mainly of agronomic assessments of fruit and yield. Passport data of collections made on fruit quality is also available. However, due to the lack of taxonomic expertise, these materials have not been fully utilized.

Various trials on a number of local and native vegetable species appear in the Research Branch Annual Reports of Sabah and Sarawak. A book on fruits and vegetables of Sarawak was published by DOA Sarawak in 1990. No computerized data storage is being used at present in Sarawak, although the DOA has acquired the GMS software from IPGRI recently.

In Sarawak, passport data are available also for rattan and illipe nut species. Collection of other data for these plant genetic materials are in progress. For rice, documentation consists of storage in a catalogue. At present, only about 10% of the collection have agronomic evaluation information integrated into the catalogue. The rest only have passport, indigenous and breeders' records. For pepper, 50% of the varieties collected are fully documented with plant descriptor and agronomic evaluation information.

3.6 EVALUATION, CHARACTERIZATION AND REGENERATION

Characterization for germplasm of the major crops like cocoa, coconut, rice and oil palm also include breeders' records (pedigree records). For the other crops, since not much breeding has been done, only accession records and simple characterization records are being kept. Here manpower constraint is a major set-back. Ethnobotanical usage of crops, in particular the wild species of fruits and nuts have been researched into and some documentation has been done.

Many characterization of crops is based on "self-designed" formats and does not necessary follow those of IPGRI (IBPGR) descriptors. This is because characterization was done very much earlier on and the formats were tailored to the needs of the breeders/department, before the internationally recognised descriptors were introduced.

The evaluation process of the major crops are through field performance trials (both breeding and agronomic). Evaluation trials are done on the major crops and potential species whereby improved and/or new varieties are usually recommended for general planting.

Fruits

Evaluation of the fruit germplasm is based mainly on yield, quality of product and basic agronomic characters like plant height and other growth parameters. Few characterization of vegetative characters have been attempted due to a lack of staff and expertise. The evaluations are done using modifications of IBPGR descriptors and other sources. In the selection of superior clones of fruit trees, farmers' information on clone identification, clone name , locality of clone as well as records of yield and fruit qualities are recorded.

Regeneration of accessions are made if the materials are of potential for commercial use. This is conducted to obtain sufficient plants for replicated varietal/clonal evaluation at one or two sites. Facilities for regeneration are fairly adequate. Certain fruits like *Canarium odontophyllum* and *Mangifera pajang* have been found to be difficult to regenerate through vegetative means. It is felt that a more thorough approach to this problem would yield better results.

Rice

For initial seed multiplication and characterization, the seed samples are planted in the field in plots of 60 hills per variety. Systematic characterization of 45 morpho-agronomic traits are carried out in the field and in the laboratory. The materials are also subjected to systematic screening procedures and are evaluated for reactions to GEU traits such as diseases and pests, grain quality traits such as amylose and consistency.

About 10% of the collection maintained in Sarawak have been evaluated and characterised according to international standards, i.e. IRRI Descriptors for Rice. This evaluation and characterization exercise is carried out at the Research Center by the Rice Research Officer. The set of collection maintained by IRRI have been evaluated and characterized. However due to the lack of trained personnel, characterization using molecular biology tools has not been attempted. All data pertaining to characterization and evaluation are stored in a catalogue and can be made available for users, when necessary.

The aim of regeneration in rice is to replenish stocks of an accession by growing the accession under suitable conditions. Regeneration is performed

when the viability of a seed stock falls below an acceptable level. At the MARDI Genebank, viability test for rice seed is monitored stored in medium-term by testing a number of randomly selected accessions each year after 3†years and 5 years of storage for *japonica* and *indica* varieties respectively. Fifty seeds of each accessions are tested and the accessions are rejuvenated from the medium storage when the viability drops to 80%. Regeneration is also carried out when the amount of seed is 50 gm or below.

Vegetables

For vegetables, evaluation of materials is mainly based on basic agronomic characters, disease resistance and yield performance at multilocations especially for those of exotic origin. Intensive evaluation and characterization are made only on the more important species such as *Capsicum* spp. The evaluations are made using modifications of IPGR descriptors where applicable. Many local vegetables are not being evaluated and characterized due to manpower and other resource constraints.

Some of the desirable species or varieties which proved promising are multiplied for further detailed work. No large scale regenerations are carried out for distribution unless the varieties are proven to be good. Materials which proved to be poor yielders are normally discarded.

Field crops

Morphological characterization of cassava and sweet potato have been completed. This has been carried out by the breeder working on the two crops. The characterization of cassava germplasm adopted the descriptors of Rogers and Fleming while the sweet potato were characterized by descriptors used by NARC Japan, which is adapted from the IBPGR descriptors.

Only part of the germplasms for cassava (about 70%) and sweet potato (about 20%) have been evaluated for important agronomic traits. Evaluation was carried at the location of the genebank, but in the case of cassava, some evaluation was carried out at MARDI's Vegetable Research Center Jalan Kebun which is located on drained peat.

There is some evaluation for biochemical data (e.g. leaf protein and leaf and root cyanide contents in cassava), physiological data (e.g. leaf life in cassava), disease and pest susceptibility (e.g. *Cercospora* leaf spot and bacterial blight in cassava, weevil in sweet potato). There was some attempt at fingerprinting of sweet potato using esterase patterns.

Accessions of maize are mostly evaluated for yield and agronomic characteristics but are not characterized with other taxonomic characteristics.

Regeneration is done after the seeds have been in storage for 4-5 years or when seeds of an accession is required for research purpose. Regeneration procedures are adequate to maintain genetic integrity of an accession. At least 3,000-5,000 plants of an accession are planted in a regeneration cycle to avoid genetic drift.

Pepper

A plant descriptor was developed by the International Pepper Community (IPC) with contributions from scientists from India, Indonesia and Malaysia in 1981. Member countries collected all the necessary information on 10†varieties of pepper based on this descriptor. However recently a group of Indian scientists submitted a more detailed descriptor to IPGRI for acceptance. Apparently, IPGRI is not aware of what IPC had accomplished earlier. Presently, 50% of the pepper varieties have been fully documented using the IPC descriptor and the information published in the IPC report.

Due to the wide and frequently continuous range of variations in vegetative characters, the use of morphological characteristics in classification of *Piper* had created many new and unnecessary taxa and adding to the confusion within the genus. It is difficult to distinguish and verify the names of the cultivars of *Piper nigrum*. Effort is being made to use some of the molecular biology techniques like Polymerase Chain Reaction-Rapid Amplified Polymorphic DNA (PCR-RAPD) and izozymes for pepper germplasm identification.

Germplasm of *Piper* species are maintained as living plants in the field. Visual and preliminary assessment on some of the desirable agronomic characteristics is done by experienced personnel. Preliminary evaluation of specific traits like chemical quality, resistance/tolerance to pests and diseases can also be done using plants in germplasm plots.

Pepper germplasm is propagated vegetatively. Thus regeneration produce true to type with no or little danger to genetic drift. Regeneration is done for evaluation in more detail and for the continuation of germplasm maintenance.

Beverage crops

For coffee, evaluation and characterization of accessions is carried out by the breeder as part of the breeding and selection programme. Data is documented. Characterization for certain agronomic traits such as yield berry and bean size, resistance/susceptibility to berry and twig borer, and morphological characters are in progress. Materials that show potential are cloned for further replicated trials in research plots.

For cocoa, evaluation and characterization of the germplasm samples are carried out by a breeder using a modified IPGRI descriptors. The evaluation includes disease and pest susceptibility, production potential, quality of beans and adaptability.

Orchids

Evaluation of the orchid species in the germplasm collection is based mainly on the suitability either as potted or hanging plant, or as parents in the breeding programme. The orchid species can also be further evaluated as indoor or outdoor landscape plants. For each species, a detailed morphological data is collected and documented together with notation of special characteristics for future reference and use in breeding work. However due to lack of taxonomic expertise, identification of some of the orchids species is still not confirmed.

The orchid species germplasm are propagated vegetatively by dividing pseudobulbs or cuttings. However as this procedure is time consuming, mass propagation of a species is often done through selfing. The seed culture of orchid species is tedious procedure as it has been found that some of the Malaysian species take a very long time to germinate in the culture flasks.

Coconut

Evaluation and characterization of genetic resources collection is also based on a modified IPGR descriptors. Evaluation is carried out on yield ability, nut quality, agronomy, disease and pest susceptibility. Characterization is done on plant phenotype and nut characteristics. Only varieties that have potential are regenerated using the hand pollinated seed nut under the supervision of a qualified breeder.

Rubber

The germplasm collection from the 1981 Prospection are being evaluated for important economic characteristics. These characteristics include yield, vigour, branching habit, field resistance to leaf disease, dwarf and/or semi dwarf character, rubber timber characteristics, special viscosity rubber and other technological properties which may be of good marketable value. In addition other characters such as drought resistance, tolerance to wind, ability to thrive well under low nutritional status and difficult soil conditions will also be sought.

Oil palm

Oil palm genetic materials collected are established as field genebanks. They are evaluated so that elite materials can be identified. The descriptors for oil palm developed by IPGRI are used to record information such as weights of bunch, fruits and nuts, palm height etc. Progeny testing of elite materials is done with the cooperation of the industry to study their combining abilities. Apart from high yields, slow height increment are traits sought for. Biochemical and molecular screening using isoenzyme, Restricted Fragment Length Polymorphism (RFLP) and RAPD techniques are being used to study diversity amongst the population collected. Experimentation is being carried out to conserve oil palm germplasm using *in vitro* methods such as cryopreservation of seeds and embryos.

Forest species

Selection for elite characters for the purpose of tree improvement and characterisation are not conducted for these collections. However most of the collections are being monitored and evaluated for their growth performance in the field. The collections are most frequently obtained direct from the forests through regular phenological reports, rural villages and markets as seeds. Most of the samples were obtained randomly or by chance, such as when the botanist encounters a fruiting tree in the forest. Occasionally they are collected as wildings.

At present, only species with commercial value are being utilized as source plants for seeds and cutting materials. Trees belonging to the families of *Burseraceae, Dipterocarps, Euphorbiaceae* and *Leguminosae* are most heavily utilised at this moment. These national collections are meant primarily for research purposes and not for large scale plant production.

3.7 FOREST GENETIC RESOURCES

The Third Forestry Inventory of Malaysia carried out during the period 1991-1993 was designed to:

- Define the extent and location of forested areas of Peninsular Malaysia
- Classify the forest areas by broad volume types
- Provide stand and stock tables by forest types

- Classify volumes, and
- Stocking of rattan, bamboos and palms

For virgin forest, the gross volume per hectare of species of diameter 30 cm and above varies between 150 - 270 mm^3 between 10.4 and 15.5%. For logged-over forest, gross volumes are between 169 and 173m^3/ha.

In addition to the above, the forest of Malaysia can be classified into the major forest types:

- Upper Montane Forests
- Lower Montane Forests
- Upper Dipterocarp Forests
- Hill Dipterocarp Forests
- Lowland Dipterocarp Forests
- Heath Forests
- Beach Forests
- Peat Swamp Forests
- Freshwater Alluvial Swamp Forests
- Riparian Fringes, and
- Marine Alluvial (Mangrove) Swamp Forests

The hill dipterocarp forests are located on more difficult terrain and are characterised by uneven stocking, lack of natural regeneration on the forest floor before logging, and uncertain seedling regeneration after logging because of irregular seedfall from potential mother trees, which sometimes can occur at intervals of several years. Reforestation programmes would require a large amount of seedlings yearly. Thus there is a need to develop other sources of planting material in addition to wildings and seeds. The dipterocarp species are known to have irregular flowering habits and are very localised. It is important to obtain information on the flowering and fruiting habits of preferred species found in the vicinity of a nursery, as this will facilitate seed collection and the eventual raising of seedlings. While great stride has been achieved in producing planting stocks for species such as *Acacia mangium, Bambusa spp., Clamus spp., Dyera costulata, Endosepermum malaccense and Gonystylus spp.*, through tissue culture, more research is being carried out to mass produce such seedlings. This holds true for cuttings of *Dyrea costulata, Endospermum malaccense, Hopea odorata, Khaya ivorensis, Shorea leprosula,*

S. parvifolia and *S. platyclados*. Thus there is much potential for raising planting stocks through cuttings.

CHAPTER 4
In-Country Uses of Plant Genetic Resources

4.1 IN-COUNTRY USES OF PLANT GENETIC RESOURCE COLLECTIONS

Local plant genetic resources are a part of the biological diversity that constitutes a national heritage that can be managed and utilised for commercial and economic purposes. The most valuable indigenous forest genetic resources currently in use and in demand are the timber and non-timber species such as bamboo, rattan and medicinal plants. The role of indigenous plant genetic resources as sources of pharmacological products has been enhanced recently due to interest in other alternative forms of medicine. In this respect, local indigenous knowledge and utilization of these plants in cultural practices, either as food or medicine or shelter, are possible keys to their potential value.

Of importance too are the fruit trees and ornamental plant genetic resources. They serve as reservoirs of genetic material that can be moved into crops for commercialisation through breeding techniques. Breeders in need of new traits can utilize these resources to further improve an existing crop, like incorporating disease resistance, drought tolerance etc. Crop stocks may eventually decline in value if they are confronted with new environmental stresses to which they cannot be made resistant for the lack of genes from relatives.

As for materials collected (both local and exotic) and kept *ex situ*, they are used for breeding work or for evaluation of the species or kept for future breeding and evaluation programmes. Among the major crops involved include rubber, oil palm, rice, cocoa and coconut. The breeding programmes adopted by the various research institutions in Malaysia are aimed at crop improvement through yield, quality and pest and disease tolerance/resistance.

4.2 CROP IMPROVEMENT PROGRAMMES AND SEED DISTRIBUTION

The main objectives of the country's crop improvement programme are as follows:

- To produce genetically improved materials for increased productivity, diversified end-product/use of crop, meeting national food/feed needs and import substitution.
- To mass-propagate the materials for planting purposes, and
- To set up seed/planting material production areas.

The main work conducted on PGR in the various commodity-based research institutions in the country is and will be the continuation of programmes on progenies, produced from hybridization of materials/varieties in their respective germplasm collections. In addition, work will also be continued on adapting imported germplasm for local needs in order to improve on productivity. If required, specific traits will be introduced. For instance, the absence of good high yielding varieties with resistance to diseases is still a constraint in the production of vegetables in the country. Hence there is the need to look for germplasm with this trait.

Likewise the genetic resources collection present in Malaysia will be also a source for overseas scientists as they have traits required in breeding or crop improvement programmes. Institutions like IRRI have obtained rice varieties from Sarawak where the quality of native rice varieties is considered to be a premium in the market.

The practices used to achieve the above aims include conventional breeding, biotechnology, tissue culture and seed production and storage. Associated with the breeding programmes will be activities on agronomic practices and requirements with the improved materials. In Malaysia both the government and the private sectors are involved in crop improvement and seed distribution programmes. For crops like rice, vegetables, corn, groundnut, fruits and other food crops, government research institutions like MARDI and local universities come out with breeder and/or foundation seeds or planting materials. In these cases, the Department of Agriculture subsequently undertakes the production and distribution of seeds/planting materials. For industrial crops that include rubber, oil palm, coconut and cocoa, both private and government agencies are involved with crop improvement and seed/planting material distribution.

Using rice as an example, the rice germplasm (both local and imported) being conserved in MARDI's Genebank is being utilised by local breeders to

produce improved rice varieties. MARDI produces the foundation seed stock of the improved varieties, after which DOA will produce registered as well as certified seeds for distribution to rice farmers in the country.

4.3 FOREST TREE IMPROVEMENT PROGRAMMES AND SEED DISTRIBUTION

The main objective of the programmes is to increase the growth and standing volume of timber in all species. Like for the agricultural crops, practices used include conventional selection and breeding, biotechnology, tissue culture and seed production and storage. The national breeding activities are currently focussed on commercial indigenous species such as *Dryobalanops aromatica, Dryea costulata, Endospermum malaccense, Shorea parvifolia, S. leprosula* and *Hopea* spp., while exotic species include *Acacia mangium, Hevea brasiliensis, Khya ivorensis* and *Tectona grandis*, aiming towards increased production and export opportunities. In view of the heart rot problem in *A. mangium*, attempts are being made to hybridise *A. mangium* with *A. auriculiformis* to obtain the resistant gene.

Malaysia is currently developing the necessary tropical timber improvement technologies which include, amongst others, identifying elite materials using DNA studies, mass-propagating these materials through tissue culture and to extent seed viability through long-term storage. The agencies involved are DOF Peninsular Malaysia (government agency), FRIM (statutory body), Sime Darby, Guthries and Sabah Softwoods and Sabah Forest Industries (private sector). A large proportion of the initial trees come directly from the forests. The subsequent resources are derived from seed production orchards, and seedlings and clonal seed orchards.

The amount and quality of scientifically bred plant materials, currently being undertaken in the country is not adequate to meet national needs. The technologies developed for use in tree improvement are still low in comparison with the technologies developed for agricultural crops. In addition, tree species are perennial crops and improved varieties take many decades to produce the desired results. The progeny cycle is thus very much reduced. Pest and disease resistant trees for selected species have yet to be developed to overcome the outbreak of pests and diseases in forest plantations. Constraints such as the lack of manpower, facilities, technology and financial resources for large-scale production of planting materials also exist.

The planting materials for forest species comes in the form of seeds, seedlings, cuttings and mass-propagated materials. These planting materials and advisory services are made directly available to the semi-commercial and commercial plantations. The adoption projects and joint ventures with private landowners have also been set up for *Tectona grandis* (teak). Many of the plantation managers are not involved in tree improvement and variety evaluation activities. The only major constraint they face is the availability of planting materials either in the form of seeds, seedlings, cuttings or mass-propagated materials.

Similar efforts are also being attempted for bamboo and rattans. As for medicinal plants, all of their genetic resources are stored *in situ* in the forests. Peninsular Malaysia has yet to embark on the improvement programme of selected medicinal plant species. However, many collections have been collected by government agencies, research institutions and local enterprises, including foreign institutions and screened for their pharmacological and therapeutic properties. The importance of the Malaysian forests in holding such genetic resources is enhanced by the recent discovery of an anti-HIV component in *Calophyllum langerum*.

4.4 USE OF FOREST GENETIC RESOURCES

Apart from the timber species, other forest genetic resources being widely used for improvement are those relatives of ornamental plants and fruit trees. Wild relatives are constantly being collected and regenerated by private nurseries and industries, and institutions such as MARDI and DOA using the *ex situ* techniques. These wild relatives/species provide the genetic materials required for crop improvement.

The use of the genetic resources of selected timber species such as *Dryobalanops aromatica, Hopea adorata, Shorea leprosula* and *Shorea parvifolia* (under the grouping of *Dipterocarps)* have become increasingly important in the past decade as Peninsular Malaysia attempt to improve its degraded forest areas. The non-dipterocarps such as *Azadirachta excelsa, Bambusa spp., Calamus caesius, Calamus manan, Dyera costulata* and *Endospermum malaccensis* are also being used extensively. Introduced species such as *Acacia arborea, Paraserianthes falcataria* and *Tectona grandis* are some of the well-known fast-growing exotic species used in reforestation activities.

While DOFs of Peninsular Malaysia, Sabah and Sarawak are involved in reforestation activities, there are several large and established private

enterprises which are involved in the production of timber for both local and export markets. The request for services generally covers the field of planting materials, silviculture practices, harvesting technology and wood-processing technology.

Large proportion of the elite genetic resources for the above-mentioned species comes from the collections established and produced by research-based agencies. The genetic resources of other timber species are being collected and documented. There is no national genebank or centre established for such purposes. Field genebanks are, in fact, the virgin forests found in Malaysia.

4.5 BENEFITS DERIVED FROM USE OF FOREST GENETIC RESOURCES

The export volume and value of timber-based products such as saw log, sawn timber and plywood for 1993 are the highest compared to all other primary commodities. In 1993, forestry products contributed 65% of the total export volume of primary commodities. Similarly, it contributed 10.19% of the total export value from primary commodities. Clearly, the timber genetic resources are the most valuable forest resource at present.

The genetic resources of medicinal plants are used on a research basis. Collaboration with local and foreign research institutions (e.g. the National Cancer Institute, U.S.A.) in the screening and development of medicinal compounds are currently underway.

4.6 BENEFITS DERIVED FROM THE USE OF PLANT GENETIC RESOURCES

As plant genetic resources collections are mostly evaluated for their yielding ability and agronomic characteristics to find out if any of them possess a superior characteristic that could be used for crop improvement, the development and availability of improved varieties of crops to farmers for better yields form a major objective for the continued conservation of plant genetic resources. Another benefit would be the introduction of new crops through the exploitation and promotion of indigenous fruits or vegetables.

For example, 28 modern rice varieties have been released in Malaysia. These new improved varieties have significantly contributed to the total rice

production in the country. Corn is another example whereby several accessions obtained from other countries were found to be adaptable and have been used to improve local maize varieties. MARDI has been able to release improved varieties of vegetables (chilli, tomato, French bean, long bean, okra, brinjal), root crops (sweet potato, cassava) and fruit clones to farmers in Malaysia as a result of the breeding programme. Likewise RRIM and MCB have made available improved rubber and cocoa clones to Malaysian growers of these crops.

CHAPTER 5
National Goals, Policies, Programmes and Legislation

5.1 NATIONAL GOALS AND PROGRAMMES

Whilst various agencies carry out activities related to plant genetic resources on an institutional or joint-institutional basis, these activities are coordinated by the National Committee on Biological Diversity with representation from various ministries, departments and institutions involved with research, development and utilization of plant genetic resources in the country. A technical committee has been formed to guide this national committee on technical matters. The national programmes take into cognizance the national goal which is to transform Malaysia into a world's center of excellence in the conservation, research and utilization of tropical biological diversity by the year 2020.

5.2 POLICIES

At present there is no national policy directed specifically on the conservation and utilization of plant genetic resources. As the conservation and sustainable utilization of plant genetic resources will be affected profoundly by development activities in the various economic sectors, Malaysia has incorporated such considerations into its policy statements and developments plans. These policies and development plans relevant to biological diversity of plants include:

- The National Forestry Policy 1978 Amendment 1993
- The National Agricultural Policy (1992-2010)
- The National Mineral Policy
- The Five-year Development Plans
- The Second Outline Perspective Plan (1991-2000)

In addition to the above policies, three other policies at the national level are in the process of formulation. Proposed are the National Conservation

Strategy, the National Environment Policy and the National Policy On Biological Diversity. The first two proposed policies are addressed at the conservation of all natural resources and protection of the environment in Malaysia while the proposed National Policy on Biological Diversity covers the biological resources of plants and animals specifically. The proposed National Policy on Biological Diversity aims at conserving the country's diverse biological resources and ensuring that its components are utilized in a sustainable manner for the continued progress and socio-economic development of the nation.

Hence programmes and activities on plant genetic resources in the country will be guided by the objectives of the National Policy on Biological Diversity once it is finalised and adopted. Among its proposed objectives include:

- Optimising economic benefits from sustainable utilization of the components of biological diversity.
- Ensuring long-term food security for the nation.
- Maintaining and improving environment stability for proper functioning of ecological systems.
- Ensuring preservation of the unique biological heritage of the nation for the benefit of present and future generations.
- Enhancing scientific and technological knowledge and educational, social cultural and aesthetic values of biological diversity.

5.3 LEGISLATION

Much of the legislation on biological diversity is sector based, for example the National Forestry Act 1984 Amendment 1993 deals with the management and utilization of forests alone. Plant species endangered due to habitat destruction are not protected by way of an Endangered Species Act. However, there are efforts underway to come up with litigation and non litigation measures to protect the nation genetic resources either through the strengthening of existing legislation/regulations and/or formulating new legislation/regulations.

The new development in the field of genetic engineering resulted the introduction of various GMOS (genetically modified organisms-plants) into the environment. This has necessitate the nation to take precautionary measures such as formulating biosafety legislation/regulations to ensure that

the release of such organisms/plants do not undermine the safety of the populations and threaten food production of the country.

Of relevance to biological diversity in Malaysia are the legislations listed in Table 5. Some are federal legislations and some are state enactments which means that not all legislations enacted will apply to the whole of Peninsular Malaysia, Sabah and Sarawak.

5.4 TRADE, COMMERCIAL AND OTHER INTERNATIONAL AGREEMENTS

Malaysia has signed and ratified the Trade-Related Intellectual Property Rights (TRIPS) under the Uruguay Round of GATT (WTO). Under this agreement, Malaysia is obliged to confer protection to varieties of plants within the next ten years. With the assistance of the International Union On Plant Variety Protection (UPOV) Secretariat, a national seminar on plant variety protection was held in December 1994 to explain the nature and rationale of protection.

Table 5 Partial list of legislations that are of relevance to biological diversity conservation and management in Malaysia

Coverage	Legislation
Federal	Environment Quality Act 1974 Fisheries Act 1985 Pesticides Act 1974 Plant Quarantine Act 1976 Customs (Prohibition of Exports) (Amendment)(No. 4) Order 1993
Peninsular	Water Enactment 1920 Aboriginal Peoples Act 1960 Land Conservation Act 1960 National Land Code 1965 Protection of Wildlife Act 1972 National Parks Act 1980 National Forestry Act 1984 Amendment 1993
Sabah	Parks Enactment 1984 Forest Enactment (Amendment) 1992 Fauna Conservation Ordinance 1963
Sarawak	National Parks Ordinance 1956 Wildlife Protection Ordinance 1958 Forest Ordinance 1954

Malaysia is also a signatory to the Convention of International Trade on Endangered Species of Wild Fauna and Flora (CITES) and a member of the International Union for the Conservation of Nature and Natural Resources (IUCN). Under CITES, Malaysia has obligations to control the trade of flora and fauna between countries. An obligation under IUCN is the establishment of protected area systems for the conservation of habitats and ecosystems.

Malaysia is also a signatory to the Ramsar Convention on the Conservation of Wetlands. A Ramsar site has been identified at Tasek Bera in the State of Pahang.

CHAPTER 6
International Collaboration

In relation to plant genetic resources and biodiversity as a whole, Malaysia has been involved prominently in the international arena. The Langkawi Declaration on the Environment and Development of 1989 of the Heads of Government of Commonwealth countries marks a significant step in this direction. With the ratification of the Convention on Biological Diversity on the 24th June 1994, Malaysia is obliged to develop national strategies, plans or programmes for the conservation and sustainable utilization of its biological resources. Hence where possible and appropriate, these features are integrated into sectoral or cross sectoral plans, programmes and policies.

In addition to the Convention on Biological Diversity, Malaysian scientists and other scientists in the region met in 1992 and produced the Manila Declaration which calls for the ethical collection and utilization of Asian biological resources. A code of ethics in biological prospecting was drawn up. Subsequently a meeting in Malaysia produced the Melaka Accord which called for actions to be implemented with the region to control the movement of plant genetic materials.

Malaysia has been an active member of the International Board for Plant Genetic Resources Regional Committee for South-East Asia (IBPGR/RECSEA) since its establishment in mid-1978. Through IBPGR/RECSEA, Malaysia has participated in a highly successful cooperative programme in plant genetic resources with Indonesia, Papua New Guinea, Philippines and Thailand. National institutions like MARDI and PORIM have participated in the programme. Malaysia is also a member of the Commission on Plant Genetic Resources (CPGR) established under FAO.

IPGRI provided funds to MARDI to establish a medium-term seed storage facility and for the collection of coconut germplasm. PORIM and RRIM have a sizeable collection of oil palm and rubber germplasm funded by IPGRI and the International Rubber Research and Development Board (IRRDB). Germplasm collection and conservation of minor and under-utilised crops are also undertaken by several local universities through the assistance of some international funding agencies. Winged bean germplasm were collected by UKM with financial assistance from IPGRI, the International Council for Development of Underutilised Plants (ICDUP) and the International Federation of Scientists (IFS), and also by UPM with assistance from the Asia Foundation and ICDUP. The IFS awarded grants to UPM and UKM for long bean and edible aroids germplasm collection respectively. Sine 1984,

IPGRI has involved several Malaysian scientists in a regional collection mission of the genetic resources of *Citrus* species and related genera.

At present, the PROSEA project is an example of a cooperation programme at a regional level to gather, document and exchange information on plant genetic resources among countries in the region. As a result of this collaboration, Malaysia scientists have been able to contribute to the publications of PROSEA.

Other international collaboration on plant genetic resources that Malaysian institutions have taken part are listed in Table 6.

Table 6 List of some of the international collaboration on Plant Genetic Resources in which Malaysian Institutions are involved

Crop	Local institution	Collaborators	Activity
Groundnut	MARDI	ICRISAT, FAO, AVDRC	Varietal Testing
Cocoa	MARDI, MCB	International Cocoa Genebank (Trinidad), IPGRI, Reading Univ.	Collection, Documentation
Soyabean	MARDI, DOA Sabah	AVDRC	Varietal Testing
Rattan	Sabah Forestry Dept, FRIM, Luasong Forest Center	EC, Kew Garden, CIRAD-Foret	Conservation, genetic improvement, provenance progeny trials
Tobacco	MARDI	Tobacco Research (Zimbabwe), USDA	Exchange germplasm
Rice	MARDI, DOA Sarawak, DOA Sabah	IRRI	Variety testing, line testing, exchange germplasm
Pepper	DOA Sarawak	International Pepper Community	Descriptors development Varietal testing
Vegetables	MARDI, DOA Sabah, DOA Sarawak	AVDRC	Varietal testing, Adaptability testing
Pulses	MARDI, DOA Sabah	ICRISAT	Varietal testing

Crop	Local institution	Collaborators	Activity
Sweet potato	MARDI, DOA Sabah	AVDRC, NARC, CPI, TARS (Puerto Rico)	Germplasm collection Varietal testing
Alternate crops	DOA Sabah	Weimea Botanic Garden and Aboreteum (Hawaii)	Germplasm exchange
Fruits	DOA Sabah	Rare Fruit Council International	Germplasm exchange
Maize	MARDI, DOA Sabah	CYMMYT	Varietal testing

CHAPTER 7
National Needs and Opportunities

In relation to the plant genetic resources in the country, Malaysia has to play the role of conserving and using its indigenous genetic resources on a sustainable basis, and at the same time has to broaden the genetic base of the major economic exotic crops like rubber, oil palm, pepper and cocoa. Malaysia has to take the lead role to preserve the genetic resources of these crops because of their importance to the economic well-being of the country. The conservation and sustainable utilization of indigenous plant resources will help in crop improvement and diversification in the agriculture and forestry sectors.

Effective management of plant genetic resources as a component of the biological diversity of the country will be streamlined with the objectives of the proposed National Policy on Biological Diversity. The conservation and sustainable utilization of plant genetic resources will be guided by the strategies for biological diversity as a whole. These strategies are as follows:

- Develop and establish Malaysia as a centre of excellence in industrial research in tropical biological diversity.
- Improve the scientific knowledge base through
  - Inventorisation and documentation of the biological diversity in Malaysia
  - Undertaking studies to assess its direct and indirect values, and
  - Identification the potential threats to biological diversity loss and how they can be encountered.
- Enhance sustainable utilization of the components of biological diversity through the encouragement of the optimum use of the components of biological diversity, including the use of biotechnology.
- Strengthen the institutional framework for biological diversity management through the establishment and reinforcement of mechanisms for planning, administration and management of biological diversity.
- Strengthen and integrate conservation programmes through increased efforts.
- Integrate biological diversity considerations into sectoral planning strategies by ensuring that all major sectorial planning and development activities incorporate considerations of biological diversity management.

- Enhance skills, capabilities and competence by producing a pool of trained, informed and committed manpower in the field of biological diversity.
- Encourage private sector participation through stimulating private sector participation in biological diversity conservation, exploration and sustainable utilization.
- Review legislation to reflect biological diversity needs through reviewing and updating existing legislations to reflect biological diversity needs and introducing new legislation where appropriate.
- Minimise effects of human activities on biological diversity by taking measures to reduce the adverse effects of human activities on biological diversity.
- Enhance institutional and public awareness by promoting and encouraging the understanding and participation of the public for the effective conservation and protection of biological diversity.
- Promote international cooperation and collaboration in order to enhance national efforts in biological diversity conservation and management.
- Exchange of information by promoting and encouraging the exchange of information on biological diversity at local and international levels.
- Establish funding mechanisms by identifying and establishing appropriate funding mechanisms for biological conservation and management.

CHAPTER 8
Proposals for a Global Plan of Action

A global plan of action for the effective conservation and sustainable utilization of plant genetic resources found in sovereign states of the world should be focussed at the following:

- Development of centers of excellence in industrial research, especially for tropical plant genetic resources.
- Improving the scientific knowledge on plant genetic resources.
- Enhancing sustainable utilization of plant genetic resources.
- Strengthening institutional framework for management of plant genetic resources.
- Strengthening and integrating conservation programmes.
- Integrating plant genetic resources consideration into international development programmes.
- Enhancing skills, capabilities and competence of developing countries to effectively manage their plant genetic resources.
- Development of methodology and national emergency response systems to evaluate long term hazards and threats to plant genetic resources.
- Enhancing institutional and public awareness to plant genetic resources.
- Promotion and strengthening of international and regional scientific and technical cooperation and collaboration.
- Facilitation of exchange of information relevant to the conservation and sustainable use of plant genetic resources, taking into account the special needs of developing countries.
- Establishment of funding mechanisms at the international level for the effective management of plant genetic resources in developing countries.
- Protection and compensation for the utilization of the technology, knowledge, know-how and practices of indigenous and local communities relevant for the conservation and sustainable use of plant genetic resources.
- Development and promotion of improved strategies and technologies for the conservation and sustainable use of plant genetic resources.
- Development or enforcement of plant biotechnology and biosafety regulations, norms and standards.

- Ensuring equitable sharing of benefits arising from the use of plant genetic resources and the technology, knowledge, know-how and practices of indigenous people and local communities.

Acknowledgment

This country report was made possible through the invaluable assistance and cooperation from various agencies and their officers in Malaysia. The Ministry of Agriculture wishes to thank the Ministry of Foreign Affairs, the Ministry of Science, Technology and Environment, the Ministry of Primary Industries, the Economic Planning Unit of the Prime Minister's Department, the Sabah Department of Agriculture, the Sarawak Department of Agriculture, the Department of Agriculture, Kuala Lumpur, the Department of Forestry, Kuala Lumpur, the Sabah Department of Forestry, the Sarawak Department of Forestry, MARDI, FRIM, RRIM, PORIM, LKM, Universiti Kebangsaan Malaysia, Universiti Pertanian Malaysia, Universiti Malaysia Sarawak, Sabah Museum Department.

Special mention should be made of the direct contributions made by several officers from these various agencies. Special thanks are due to the following:

Chan Han Hee
Department of Agriculture, K. Lumpur

Mohamad Osman
Malaysian Agriculture Research and Development Institute

Chin Tuck Yuan
Forestry Department, Peninsular Malaysia

Francis K.Y Liew
Department of Agriculture, Sabah

Joseph Pounis Guntavid
Museum Department, Sabah

William Wong
Department of Agriculture, Sabah

Annuar Haji Mohammad
Forestry Department, Sabah

Shim Phyau Soon
Sabah Forestry Development Authority

Tay Eng Bok
Malaysia Cocoa Board

Lee Ming Tong
Malaysian Cocoa Board

Kelvin Lamin
Malaysian Cocoa Board

Rita Manurung
Department of Agriculture, Sarawak

Sim Soon Liang
Department of Agriculture, Sarawak

Voon Boon Hoe
Department of Agriculture, Sarawak

Teo Gien Kheng
Department of Agriculture, Sarawak

Lai Kui Fong
Department of Agriculture, Sarawak

Chai Chen Chong
Department of Agriculture, Sarawak

Lee Hua Seng
Forestry Department, Sarawak

Wong Lock Jam
Malaysian Agriculture Research and Development Institute

Zainal Abidin
Malaysian Agriculture Research and Development Institute

Abdullah Md. Zain
Malaysian Agriculture Research and Development Institute

Fadelah Abdul Aziz
Malaysian Agriculture Research and Development Institute

Joy Varguhese
Malaysian Agriculture Research and Development Institute

Muhamad Ghawas Maarof
Malaysian Agriculture Research and Development Institute

Tan Swee Lian
Malaysian Agriculture Research and Development Institute

Sapiyah Sabali
Malaysian Agriculture Research and Development Institute

Musa Yaacob
Malaysian Agriculture Research and Development Institute

Ong Seng Huat
Rubber Research Institute of Malaysia

Mohd. Rafie Haji Yusop
Palm Oil Research Institute of Malaysia

Lilian Chua
Forest Research Institute of Malaysia