# Crop Genetic Resources in Central America

CATIE/GTZ PROGRAM AT TURRIALBA,
COSTA RICA 1979

# Contents

## THE CATIE/GTZ CROP GENETIC RESOURCES PROGRAM AT TURRIALBA, COSTA RICA

# The CATIE/GTZ International Crop Genetic Resources Project at Turrialba, Costa Rica

### Background

The establishment of a gene bank for Central America and the Caribbean region at Turrialba, Costa Rica, was recommended during a Conference of Experts in Genetic Resources, which met at Beltsville, Md., USA in 1972.

To discuss the goals and organization of this gene bank, the "Centro Agronómico Tropical de Investigación y Enseñanza" (CATIE) and the Food and Agriculture Organization of the United Nations (FAO) organized a conference in December 1973. Experts from eleven countries of the region attended this meeting and discussed conservation, exploration, documentation and plant introduction in terms of regions and crops.

CATIE is a regional and independent research center. It is based on an agreement between IICA (Instituto Interamericano de Ciencias Agrícolas) and the governments of Costa Rica, Panama and Nicaragua, and other institutions. Its objectives are the execution and promotion of research and training in the field of agriculture.

In order to carry out the Genetic Resources Project, CATIE requested the technical cooperation of the Federal Republic of Germany. The Ministry of Economic Cooperation (BMZ) of the F. R. of Germany accepted this request, and entrusted the German Agency for Technical Cooperation, Ltd. (GTZ), with its execution. An agreement between CATIE and GTZ was signed on December 16, 1975, and the project started on July 1, 1976. The framework of this bilateral agreement includes cooperation with the Institute for Crop Science and Seed Research of the Research Center for Agriculture, Braunschweig-Völkenrode (FAL).

### Objectives

The main objectives of the project are the conservation, documentation and exchange of indigenous plant genetic material. This requires plant exploration activities and facilities for the conservation of genetic material. The latter, includes two cold rooms (+5°C and -20°C) for seed storage, and 24 hectares for living collections. Experiments on the storage of tropical crop seeds are being undertaken to improve maintenance of the genetic collections.

### Organization

CATIE contributes to the project land, buildings and administrative services. The Federal Republic of Germany provides the funding for three scientific personnel, their counterparts, running expenses, equipment and supplies, and a labour force. The scientific and technical personnel comprise

- Project leader, a botanist,
- Seed physiologist, in charge of the seed collections,
- Plant breeder, specialized in documentation,
- Horticulturist, in charge of maintenance of field collections.

The supporting personnel consists of assistants, office staff and a labour force.

# 1.
# Genetic Resources of Crop Plants

During the past twenty years increasing attention has been devoted to conservation of natural resources, because it is now obvious that many resources are disappearing rapidly and can never be replaced. Hitherto conservation of the genetic resources of cultivated plants has received less attention than has conservation of soils, water or forests, but nowadays, programmes of exploration and conservation of plant genetic resources are being undertaken at national, regional and world levels.

The risk of loss of plant genetic resources is greater in countries where agriculture has not yet been modernized. Primitive agricultural systems not only use a greater number of crops but also more varieties of them. This fact is easily appreciated by visiting rural markets to see the wide range of fruits and vegetables offered for sale and how they vary from place to place. The great number of crops available in developing regions is the result of many centuries of effort by a succession of simple cultivators, from the ones who first domesticated a wild plant to those who now carefully husband the seed from season to season. Through the ages, preservation, exchange and testing of the many crop varieties, and of learning how to grow them successfully and utilize the products efficiently, has resulted in the development of diverse local agricultural systems. Such ancient cropping systems are well adapted to local ecological conditions and produce a sufficient and correctly balanced diet for the community using them.

Another aspect of primitive agriculture, of fundamental importance to the conservation of crop gene resources, is the practice of sowing mixed seed. One sample of seed beans kept ready for sowing by an Indian farmer was found to contain six distinct varieties. At first sight this seems bad practice because the crop will not ripen evenly and the end product will be variable, but there is a good reason why the simple farmer sows mixed seed. In most cases the factor which determines whether a small farmer will reap a good or a poor harvest is attack by fungi, insects, or other parasites, which he cannot control because he lacks knowledge, equipment or suitable materials. In order to guarantee at least sufficient food to survive, the simple farmer must rely on natural genetic resistance of his crops to pests and diseases; that is to say he depends on some resistant plants surviving to yield a harvest. The different grades of resistance to pests and diseases exhibited by primitive crop varieties is of great importance for genetic improvement work. It is often to these primitive cultivars that the plant breeder must return when advanced varieties lose resistance because some new race of parasite has arisen.

Many examples may be quoted where crossing an established crop variety with a primitive cultivar, or even with a wild species, has been used to obtain resistance to a new parasite. Thus a wild Mexican species of potato, which does not produce tubers but is resistant to blight, has been used to develop blight resistant potato varieties of major economic importance. Coffee growing, which is the major agricultural industry of Latin America, is continually threatened by coffee rust. New varieties being introduced to combat the disease derive their resistance from primitive varieties found in Ethiopia and Timor. Similarly modern tomato varieties resistant to bacterial wilt are the result of crossing non-resistant kinds with a wild tomato.

Out-crossing of established varieties with primitive cultivars is used, not only to secure disease resistance, but also to improve yields and product quality. A famous example occurred in the improvement of cotton, when a primitive cultivar found at Acala, near Oaxaca in Mexico, contributed to the development of high-yielding varieties suitable for the western part of North America. Recently, a major advance was made in the improvement of the African oil palm (*Elaeis guineensis*) by hybridizing it with a wild American species, the noli or palmiche (*E. oleifera*), which occurs naturally from Brasil to Costa Rica. The hybrid is shorter than the African parent, thus greatly facilitating the harvesting of the fruits which, themselves, yield oil of better quality. Many more examples could be quoted which illustrate the importance of preserving plant gene resources for future crop development.

The need for conservation of plant gene resources is particularly pressing in Latin America because of the rapid social changes occuring in the region. Perhaps the most important of these is change in the attitude of the people towards foreign crops. Consumption of these is regarded as a sign of social prestige and contributes to disregard, or even disuse, of the old native crops. It is worth noting, however, that in most cases, the adoption of a foreign crop does not improve the quality of the diet nor make the preparation of food cheaper or easier. With vegetables, it has been proved in several tropical areas that the adoption of temperate zone species in no way improves upon the quantity of vitamins and minerals already available from native kinds. Nevertheless, in Latin America, the prestige of the upper classes has been associated with the consumption of exotic crops and their use has been encouraged by commercial propaganda and by official campaigns of agricultural extension and nutritional improvement. This attitude may be contrasted with the keen interest shown in other parts of the world in the very crops which Central America is rejecting. Thus, the grain amaranths, which are today much less cultivated in Mexico and Guatemala than formerly, are now the subject of intensive breeding work in Australia and California for the remarkable protein content of the seeds.

The gradual replacement of primitive varieties of a crop by more advanced cultivars is also a potential source of genetic loss. The new varieties are less numerous and less variable than the ancient ones, but with suitable management, they give better yields and their introduction is an essential part of agricultural development. In parts of Asia and Africa, the change to modern cereal varieties has led to almost complete disuse of the old native cultivars. In Mexico and Central America fortunately, this danger is less imminent, partly because there are fewer intensive breeding projects, and partly because the indigenous farmers are extremely conservative. Nevertheless new varieties are being continually introduced and their use is officially encouraged. For this reason it is important that the indigenous cultivars of Central American crops should be studied and preserved before they disappear.

Finally, another factor which hinders conservation of indigenous genetic resources is the lack of well organized systems for managing seed supplies of local crops. It is often easier to obtain seed of a foreign crop, and information on how it should be grown, than seed of a local native one. Further, such research activities in the region more often concern with exotic crops than local ones. However, in some countries there is a growing tendency to improve and develop local indigenous crop plants as part of a cultural development, which it is hoped will lead to better feeding of the rural people and improve and diversify the national agricultural industry.

Interest in Central American plant genetic resources extends far beyond the political and geographical boundaries of the region. Central America has primitive cultivars of beans, maize, tomatoes, cotton, chilis, leguminous forage crops, pumpkins, cocoa and many others. Conservation of this wealth of genetic material and distribution of representative samples throughout the world, is of fundamental importance to plant breeders worldwide. On the other hand, Central America must depend on imported gene materials to improve such important crops as coffee, sugar cane, bananas, pasture grasses and others. The interdependence of all parts of the world upon one another for plant genetic resources makes their efficient preservation a matter of global importance.

World centres of genetic diversity among cultivated plants.

## DEFINITION OF GENETIC RESOURCES

The terms "**Genetic Resources**" or "**Germplasm**" are often thought to refer only to material used for genetic improvement of cultivated crop plants. Actually they should be used in a much wider sense and include:

**1. Primitive cultivars** (**Cultivar** is synonymous with **variety** so far as domesticated plants are concerned). This is a variety of a cultivated species selected and maintained by farmers which has not been subjected to intensive plant breeding. The great majority of crops grown in Central America: beans, maize, fruits and vegetables are primitive cultivars. The term primitive cultivar, or primitive variety, does not usually imply low yield, inferior quality or poor disease resistance. Indeed, in the most advanced countries, many crops planted are primitive cultivars developed simply through prolonged selection of naturally occurring variations.

**2. Advanced cultivars.** A variety resulting from an intensive programme of selection, hybridization or induced mutation carried out with specific objectives in mind (mutations are changes in the genetic structure of the plant which may occur naturally or be induced artificially). The specific objectives of genetic improvement programmes are numerous, and may include increasing the yield or quality of the produce, shortening the growing period of the crop, improving resistance to drought or disease, etc. Such advanced cultivars are usually less variable than primitive selections, and usually need more exactly controlled growing conditions.

### Clones

Cultivars or varieties, whether primitive or advanced, which are propagated vegetatively, are called **clones.** Biologically they are parts of a single plant multiplied many times.

**3. Wild populations.** Fruits and other products are collected and utilized from many species of wild plants. Populations of these species may be a) **wild types** descended naturally and directly from the same ancestors as those from which the cultivated varieties have been selected; this is the case in some fruits like red zapote (*Pouteria* sp.), sapodilla (*Manilkara zapota*) and others which may still be found wild in the woods, b) **weeds** which are descended, like their crop relatives, from a common ancestor which may by now have disappeared; such plants have not undergone deliberate selection by farmers but have evolved spontaneously to grow in sites resulting from human disturbance. Thus in Central America there are populations of wild tomatoes which grow on roadsides and field margins.

**4. Wild relatives.** Are wild species of the same genus than the crop plant or from allied genera, which are closely related, and may be crossed with them to produce hybrid cultivars giving better yields or greater resistance to disease. The use of wild relatives to improve potatoes, tomatoes, and oil palm has already been mentioned, and there are many more. The conservation of these wild relatives is as important as the preservation of primitive cultivars and fundamental to future plant breeding programmes.

**5. Genetic lines.** In advanced breeding programmes geneticists develop specialized populations of plants, such as true-breeding **pure lines** of maize and other crops, or populations which show male sterility. These populations are not themselves used for crop production, but are essential stages and components used to produce new advanced cultivars. These too need careful conservation, but are not yet important in the Central American region.

# 2.
# Central America as a Reservoir of Plant Genetic Resources

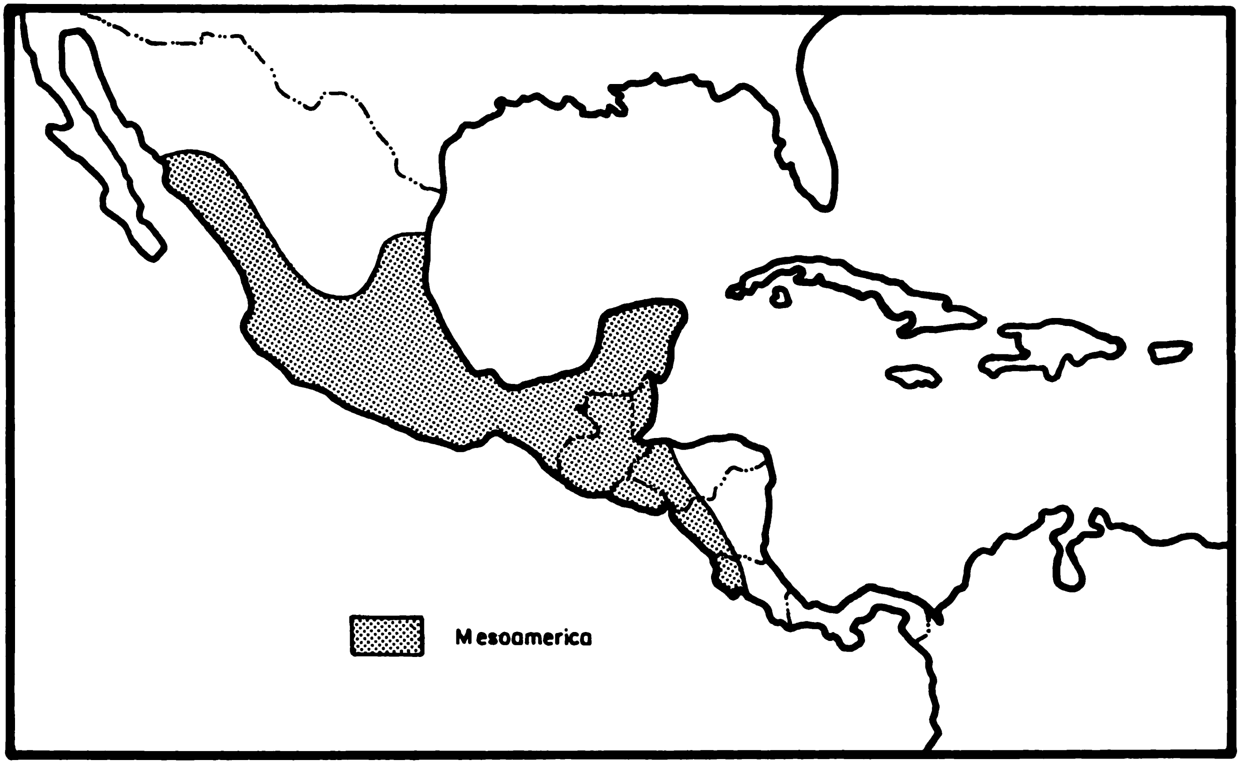
Vavilov considered Mexico and Central America as one of the most important centres of plant genetic diversity in the world.

The region does not have clearly defined natural boundaries, although most geographers regard Central America as lying between the Tehuantepec isthmus in Mexico and Atrato in Panama. A more restricted area, recognized by anthropologists, is "Mesoamerica", extending from the watershed between the Panuco and Santiago Valleys in the middle of Mexico, to the north east of Costa Rica. However, the distribution of Central American crops varies depending upon species and many of them occur both north and south of the limits given above. Central America comprises a mosaic of varied ecological conditions, from the semi-desert of northern Mexico to zones of dense Amazonian vegetation in Costa Rica. The mountainous terrain of the region is the principal cause of this remarkable diversity of ecological conditions and corresponding diversity of vegetation. The main mountain ranges run from north to south and reach an altitude of 4000 m. They thus interrupt the westerly flow of rain-bearing winds and produce great local variation of temperature and rainfall. Further, volcanic activity along the Pacific coast has emphazised the mountainous nature of the region and has given rise to a variety of deep fertile soils. The region also enjoys a wide range of climate; it borders the semi-tropical belt in the north and extends to the stormy high-rainfall Caribbean zone in the south. Between the two lies a complete gamut of ecological niches.

The natural flora of the area is also extremely rich and diverse in species because Central America was the meeting place of two ancient floras once separated by the sea. The northern component originating in North America predominates as far south as Nicaragua; southwards elements of the Amazonian flora prevail.

To this complex picture of varied climatic, geological and floristic variation must be added the effects of prolonged human activity. Mesoamerica was one of the original centres of agricultural development in the world. That is to say, ancient inhabitants of the region independently domesticated plants and animals, learnt to cultivate the soil and developed systems of crop management and a complete technology for food production. The earliest traces of agriculture in Mesoamerica date back 9000 years and were found at Tehuacan in the middle of Mexico. This site has conditions particularly suitable for the preservation of organic remains, but there may well have been even older settlements of which no trace survives.

In Mesoamerica, as in other original centres of agriculture —the Fertile Crescent of the Middle East and south east Asia— the collection of wild plants slowly led to the domestication of crops such as maize, beans, pumpkins and cocoa, to mention only those which have achieved world importance. Initial domestication, followed by many generations of empirical selection by farmers, changed the wild types to primitive cultivars and slowly increased yields. The series of maize cobs discovered at Tehuacan demonstrates more clearly than for any other crop how the useful part of a plant can be thus improved. The oldest cobs, from the deepest levels of excavation, measure a few centimeters in length while the most recent, from upper levels, are comparable with maize varieties cultivated in the region today. This process took 5000 years to accomplish and shows that the American indian was able, through selection of local types and through hybridization which occurred when




Central America and neighbouring lands, showing the nuclear area "Mesoamerica" (shaded).

he brought together types from different districts, to convert a plant of pitifully small yield into one of the most important cereal crops in the world today.

Table 1 lists the main crop species originating from the Central American region and, even though many of them are not well known outside the region, they are important components of the daily diet and of regional trading. There were also some crops which used to be used but have now disappeared for historical reasons, as has happened in other areas. Seed of **Setaria**, a species of grass, has been found in the earliest levels at Tehuacan, when the people practiced food gathering and the very earliest stages of agriculture. These seeds were apparently used for food but are not found in higher levels, possibly because they were replaced by maize. More recently indigo *(Indigofera suffruticosa)*, was an important product of several Central American countries but has now almost disappeared. It was replaced throughout the world by cheaper, synthetic aniline dies.

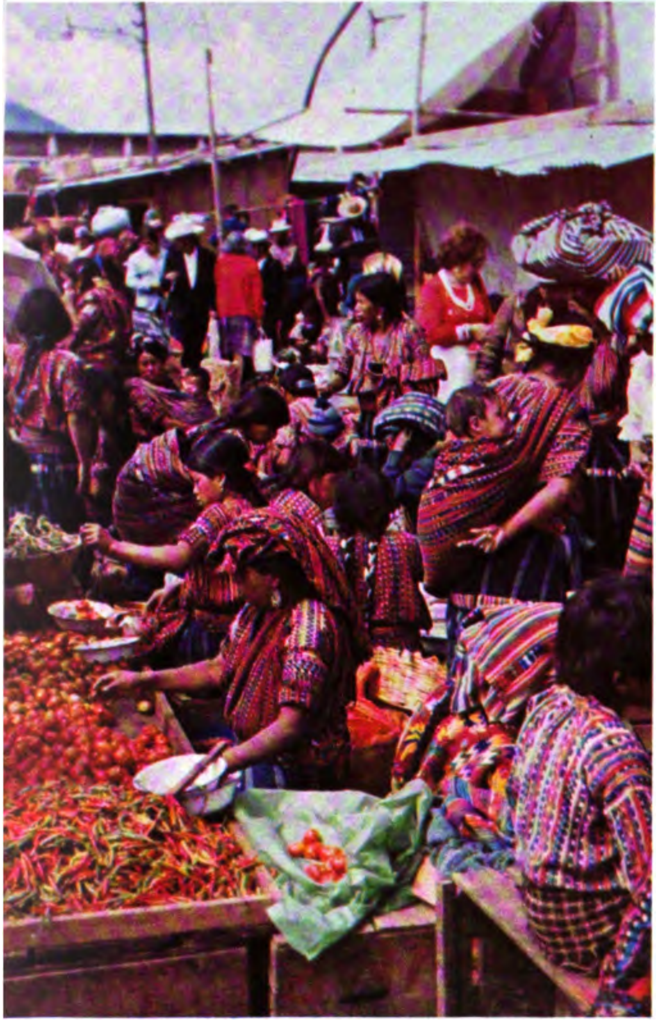
Mexico and Central America exhibit all stages of man's utilization of plants. Food gathering from wild plants, the stage before domestication, is still practiced and in northern Mexico an intermediate stage occurs. There, the fruits of certain species of cactus are collected from the countryside, while the same species are planted around homesteads so that it is impossible to distinguish the wild fruits from cultivated ones. Another simple method of utilization is to permit wild plants to grow in the fields. Thus tomatoes are weeds which are deliberately left to grow in cultivated areas and around houses, encouraging their reproduction. When clearing forest, fruit trees such as zapote (*Pouteria* spp.), zunzas *(Licania platypus)*, *Inga* spp., sapodilla (*Manilkara zapota*) and others, are deliberately left to provide shade and fruits in season. On the Pacific slope of Mesoamerica mixed kinds of fruit trees are deliberately planted round dwellings to give both shade and fruit. The same system is widely practiced in India, south east Asia and parts of Africa, and fruit trees used to cover a considerable proportion of the settled land in Mesoamerica today, however these orchards are being continually reduced to provide land for commercial crops, cattle farms and new houses.

Some Central American genetic resources are not only unique to the region but are also found only in small parts of it. Factors limiting the use of these plants may be as much as social and cultural as ecological. Some products are obtained from semiwild plants but others, such as tacaco (*Frantzia tacaco*), from the highlands of Costa Rica, are known only in cultivation and have never spread far from their places of origin. Flowers of loroco (*Fernaldia pandurata*) and pito (*Erythrina* spp.) are offered for sale as food in the markets of Guatemala and El Salvador, but are not eaten elsewhere. Similarly in Guatemala young shoots of chipilin (*Crotalaria* spp.) and of ixtlan (*Solanum* sp.) and flowering shoots of pacayas (*Chamaedorea* spp.) are in daily use as food. Wild species of Malvaceae and Compositae are offered in the markets of Oaxaca and in Yucatan; chaya *(Cnidoscolus chayamansa)* is encouraged to grow near to dwellings on account of its tender foliage. The many methods of cooking chaya testify to ancient usage, but it is little known outside Yucatan.

Finally we should consider the completely wild plants of economic importance or which have supplied basic material for genetic improvement work outside the region. Among the more important are chicle (*Manilkara zapota*) from the forests of Mexico and Guatemala; yams (*Dioscorea* spp.) which are collected to produce cortisone; ipecac from the woods of Nicaragua and Costa Rica; allspice (*Pimenta dioica*) in Peten, and others.

Central America has provided a number of fodder plants for selection and improvement in other parts of the world. For instance, *Leucaena leucocephala* is being improved and systems for its management are being developed in Hawaii and the Philippines. 'Siratro' is a new pasture legume selected and developed in Australia from Mexican material of *Macroptilium atropurpureum*. Improved varieties of *Desmodium*, *Vigna* and *Stylosanthes* are also being developed from Central American material.

Gardeners owe to Mexico and Central America the basic genetic material for many ornamental plants, such as *Dahlia*, *Tagetes*, *Ageratum*, *Zinnia*, *Euphorbia*, *Solanum* and *Antigonum*. Indeed the horticultural trade in orchids with showy flowers has led to the near disappearance of some species.



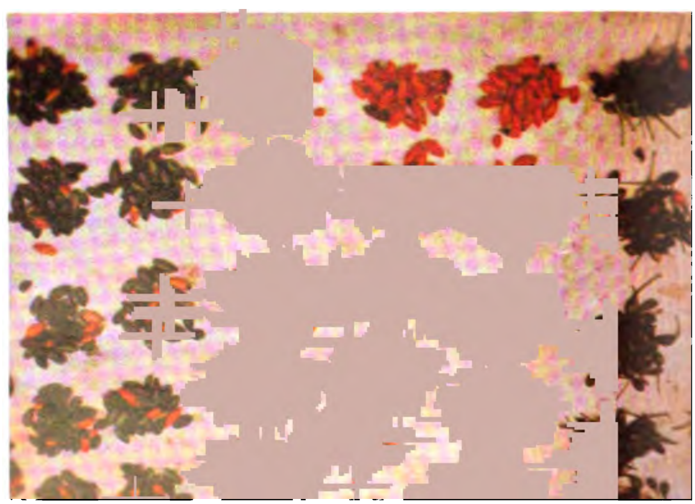
Market at Sololá, Guatemala:
an important native trading centre in Mesoamerica.

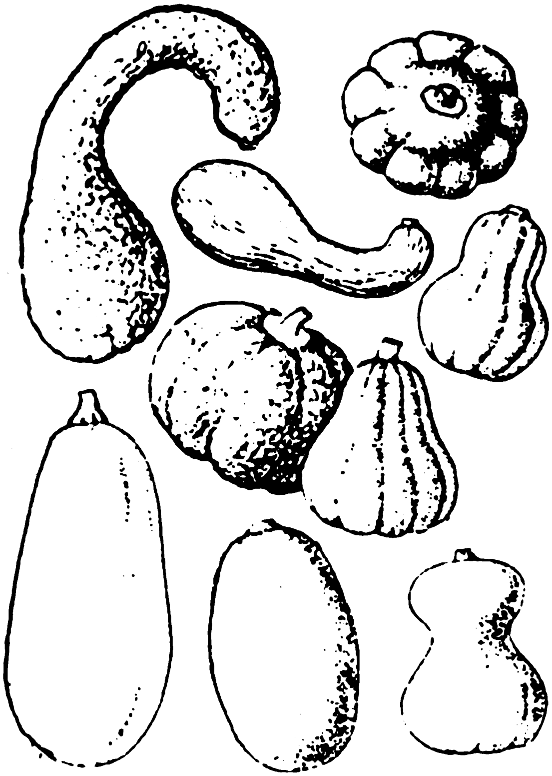
Achiote (*Bixa orellana*): different colours and shapes of fruit.

Zunza (*Licania platypus*): a native fruit tree, from the Pacific slope of Central America, which is fast disappearing.

Chayote (*Sechium edule*): many cultivated varieties occur specially in Guatemala and Mexico.

Chiltepe (*Capsicum frutescens* var. *baccatum*): different kinds arranged for sale at Mazatenango, Guatemala.





Ayote (*Cucurbita moschata*): variety of fruits in the market at Antigua, as drawn by Vavilov.

Ayote (*Cucurbita moschata*): cultivated at Antigua, Guatemala, c.f. figure 8.

## TABLE No. 1 INDIGENOUS CROPS OF CENTRAL AMERICA

| | PC | WP | WC | Distribution |
|---|---|---|---|---|
| **CEREALS** | | | | |
| maize, *Zea mays* | x | | x | R |
| **DYE–STUFFS** | | | | |
| annatto, *Bixa orellana* | x | | | R* |
| **SPICES** | | | | |
| peppers, *Capsicum annuum* | x | x | x | R |
| peppers, *Capsicum chinense* | x | x | x | R |
| peppers, *Capsicum frutescens* | x | x | x | R |
| allspice, *Pimenta dioica* | x | x | | M, CR, A |
| vanilla, *Vanilla planifolia* | x | x | x | R |
| **BEVERAGES** | | | | |
| cacao, *Theobroma cacao* | x | x | x | R |
| **FIBERS** | | | | |
| henequen, *Agave fourcroydes* | x | x | x | M |
| henequen of El Salvador, *Agave letonae* | x | x | x | ES |
| sisal, *Agave sisalana* | x | x | x | M |
| cotton, *Gossypium hirsutum* | x | x | x | M–G |
| cabuya, *Furcraea cabuya* | x | x | x | CR–P |
| **FODDER CROPS** | | | | |
| ramon, *Brosimum alicastrum* | | x | | M |
| pega-pega, *Desmodium* spp. | x | x | x | R |
| guaje, *Leucaena leucocephala* | x | x | x | R |
| siratro, *Macroptilium* spp. | x | x | x | R |
| prodigioso, *Tripsacum latifolium* | x | x | x | M–G |
| guatemala, *Tripsacum laxum* | x | x | x | M–G |
| teocinte, *Zea mexicana* | x | x | x | M–H |
| **FRUITS** | | | | |
| chirimoya, *Annona cherimolia* | x | x | x | R* |
| ilama, *Annona diversifolia* | x | x | x | M–ES |
| soursop, *Annona muricata* | x | x | x | R* |
| soncoya, *Annona purpurea* | x | x | x | M–P |
| bullock's heart, *Annona reticulata* | x | x | x | R |
| sugar apple, *Annona squamosa* | x | x | x | R* |
| pejibaye, *Bactris gasipaes* | x | x | x | H–P* |
| nance, *Byrsonima crassifolia* | x | x | x | R |
| papaya, *Carica papaya* | x | x | x | R |
| white zapote, *Casimiroa edulis* | x | x | x | M–CR |
| icaco, *Chrysobalanus icaco* | x | x | | R |
| star apple, *Chrysophyllum cainito* | x | x | x | R |
| olosapo, *Couepia polyandra* | x | x | x | M–CR |
| tejocote, *Crataegus pubescens* | x | x | x | M–G |
| black zapote, *Diospyros digyna* | x | x | | M–CR |
| genipa, *Genipa americana* | x | x | x | R–A |
| membrillo, *Gustavia superba* | x | x | | P |
| pitahaya, *Hylocereus undatus* | x | x | x | R |
| guabo, *Inga fagifolia* | x | x | x | R |
| jinicuil, *Inga jinicuil* | x | x | x | M |
| paterno, *Inga paterno* | x | x | x | S–CR |
| pitahaya, *Lemairecereus eichlami* | x | x | | M–G |
| zunzapote, *Licania platypus* | x | x | | M–P |
| acerola, *Malpighia glabra* | x | x | x | A |
| mamey, *Mammea americana* | x | | | R |
| sapodilla, *Manilkara zapota* | x | x | | M–CR |
| mamon, *Melicoccus bijugatus* | x | | | R* |
| cuajilote, *Parmentiera edulis* | x | x | x | M–G |
| avocado, *Persea americana* | x | x | x | R |
| coyo, *Persea schiedeana* | x | x | x | M–CR |
| canistel, *Pouteria campechiana* | x | x | x | M–CR |
| pan de vida, *Pouteria hypoglauca* | x | | x | ES |
| zapote, *Pouteria sapota* | x | x | x | R |
| injerto, *Pouteria viridis* | x | x | x | M–CR |
| capuli, *Prunus capuli* | x | x | x | M |
| cas, *Psidium friedrichsthalianum* | x | x | x | G–CR |

| | | | | |
|---|---|---|---|---|
| guava, *Psidium guajava* | x | x | x | R |
| jobo, *Spondias mombin* | x | x | x | R |
| spanish plum, *Spondias purpurea* | x | x | x | R |
| **GRAINS** | | | | |
| alegria, *Amaranthus hypochondriacus* | x | x | x | M–G |
| ixcomite, *Phaseolus acutifolius* | x | | x | M–ES |
| piloy, *Phaseolus coccineus* | x | x | x | M–CR |
| botil, *Phaseolus dumosus* | x | | x | R |
| lima bean *Phaseolus lunatus* | x | x | x | R |
| common bean, *Phaseolus vulgaris* | x | x | x | R |
| **VEGETABLES** | | | | |
| pacaya, *Chamaedorea tepejilote* | x | x | x | M–G |
| huazontle, *Chenopodium nuttalliae* | x | x | x | M |
| chipilín, *Crotalaria longirostrata* | x | x | x | M–ES |
| chaya, *Cnidoscolus chayamansa* | x | x | x | M |
| chilacayote, *Cucurbita ficifolia* | x | | x | M–CR |
| cushaw, *Cucurbita mixta* | x | | x | M–G |
| pumpkin, *Cucurbita moschata* | x | | x | R |
| squash, *Cucurbita pepo* | x | | x | M–G |
| tacaco, *Frantzia tacaco* | x | | x | CR |
| tomato, *Lycopersicum esculentum* | x | x | | R |
| husk tomato, *Physalis ixocarpa* | x | | x | M–G |
| chayote, *Sechium edule* | x | | | M–CR |
| yerba–mora, *Solanum americanum* | x | x | x | M–ES |
| ixtlan, *Solanum wendlandi* | x | x | x | G |
| loroco, *Fernaldia pandurata* | x | x | x | G–ES |
| **DRUGS** | | | | |
| ipecac, *Cephaelis ipecacuanha* | | x | | N–CR |
| yam, *Dioscorea* spp. | x | x | x | M–G |
| jalapa, *Ipomoea purga* | | x | x | M |
| **OIL SEEDS** | | | | |
| corozo, *Elaeis oleifera* | | x | | CR–P |
| cohune, *Orbignya cohune* | | x | x | M |
| **ORNAMENTALS** | | | | |
| floss-flower, *Ageratum houstonianum* | x | x | x | M |
| coral vine, *Antigonum leptopus* | x | x | | M–G |
| cattleya, *Cattleya* spp. | x | x | x | R |
| cosmos, *Cosmos bipinnatus* | x | x | x | M |
| dahlia, *Dahlia pinnata* | x | x | x | M–CR |
| poinsettia, *Euphorbia pulcherrima* | x | | x | M |
| tuberose, *Polianthes tuberosa* | x | | | M |
| volcan, *Solanum wendlandi* | x | x | x | G–CR |
| marigold, *Tagetes erecta* | x | | x | M |
| cacomite, *Tigridia pavonia* | x | x | | M–G |
| zephir-lily, *Zephyranthes carinata* | x | x | | M |
| zinnia, *Zinnia elegans* | x | | | M |
| **ROOTS AND TUBERS** | | | | |
| llerén, *Calathea allouia* | x | | | P, A* |
| mapuey, *Dioscorea trifida* | x | | | R, A* |
| sweet potato, *Ipomoea batatas* | x | | x | R, A |
| arrowroot, *Maranta arundinacea* | x | | | A |
| cassava, *Manihot esculenta* | x | | x | R* |
| jicama, *Pachyrhizus erosus* | x | | | M |
| tania, *Xanthosoma sagittifolium* | x | | x | R |

**DISTRIBUTION**

PC = Primitive cultivars
WP = Wild Populations
WC = Wild congeners

A = Antilles
CR = Costa Rica
ES = El Salvador
G = Guatemala
H = Honduras

M = Mexico
P = Panama
R = Regional

* Precolumbian introductions

# The Story of Cocoa

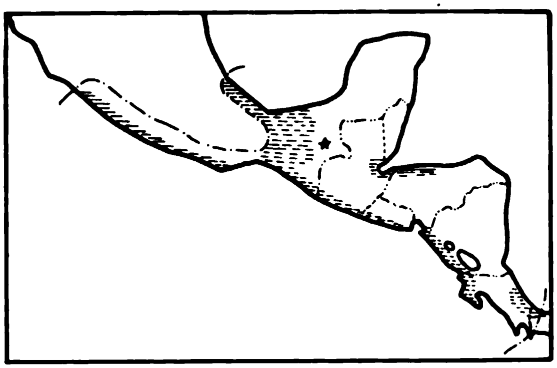
Cacao (*Theobroma cacao*) is one of the many crops domesticated in Mesoamerica. Although before the arrival of Europeans the tree grew wild throughout the New World tropics, the art of cultivating it was known only in Mexico and Central America.

Domestication was achieved by indigenous tribes who lived in the region between the present border of Guatemala with Mexico and the Atlantic coast. Archaeological remains, of possible Mayan origin, have been found in Guatemala which show pods of "cacao lagarto". This variety may have been the first kind to be domesticated because of its soft husk and well-flavoured seeds. In Mexico the same kind of cocoa is illustrated in ancient inscriptions, and its importance in religous ceremonies may be deduced from stone carvings of the Totonaca culture in Veracruz, which date from the 5th to the 9th century A.D.

The preparation of chocolate from cocoa beans is a complex process which the first Spanish invaders learnt from the Aztecs. In Aztec culture the use of chocolate was restricted to the upper classes of society. The Spaniards adopted the use of chocolate to which they added sugar and spices and they extended the cultivation of cocoa trees to South America. Cultivation was subsequently spread to Africa and south-east Asia.

In Central America cocoa production gradually declined to such an extent that during the latter part of the Spanish colonial era cocoa beans were rare enough to be used as money. There have been changes in varieties, and high quality cultivars, such as the "Criollos", but which were susceptible to disease have almost disappeared. They have been replaced by South American cultivars which are more disease resistant and give higher yields.

A cocoa tree represented in a stone carving of the Totonac culture (6th-11th cent.) from El Tajín, Veracruz, Mexico (Archaeological Museum, Jalapa, Veracruz, Mexico).



Cocoa: The crop was originally domesticated in Central America; shaded area represents the limits of cultivation pre 1500.

Controlled pollinization of Cocoa to obtain hybrids with preferred characteristics.

Cocoa (*Theobroma cacao*): various fruits showing shapes and colours characteristic of several clones.

Cocoa flowers ready for pollinization.

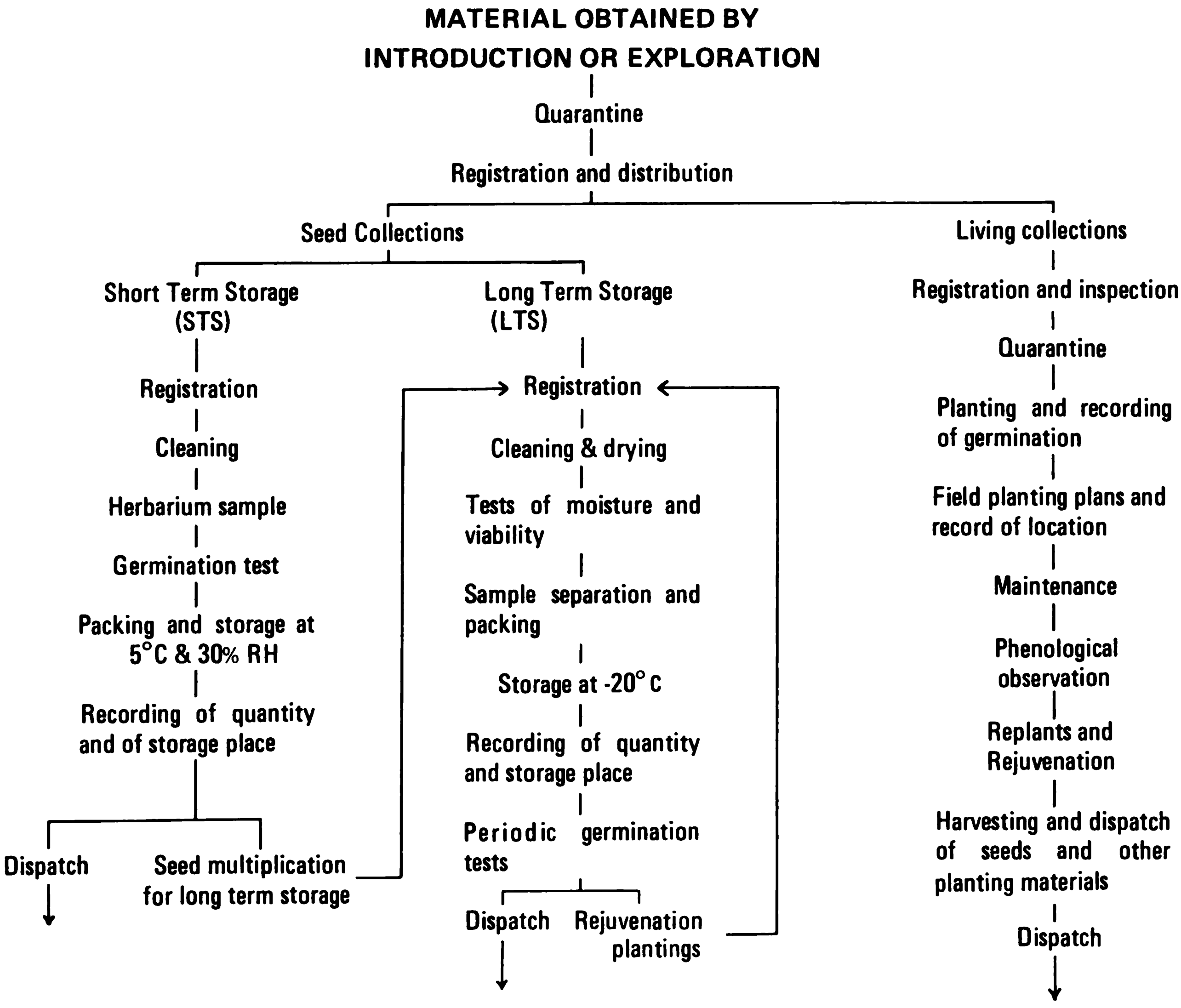
# 3. Activities of the CATIE/GTZ Program in Crop Genetic Resources

## 3.1. Conservation of Genetic Resources

Losses of plant genetic resources in Central America, as in other regions of agricultural development, result from several causes. The most important of these is clearing of natural forest to make more land available for agriculture and pastures, thereby destroying wild species which grow in woods and forests. Thus the vast area of forest clearing in the tropical part of Mexico and in the Peten region of Guatemala is eliminating the wild types of sapota, cocoa, sapodillas, yams, allspice, vanilla and other species. A second cause of loss of germplasm is rapid change in the range of crops grown by farmers, which is induced by changing tastes of the consumers, by commercial propaganda and by agricultural extension programmes. Such extension programmes, while usually sponsored by government bodies, international organizations or religious societies, are often executed by foreign advisers. These people, in good faith, but often in ignorance of the true value of indigenous crops and local food production systems, believe that it is necessary to alter the kinds of crops grown in order to increase food supplies. A case in point is the replacement of native cucurbitaceous vegetables (squashes, etc.) in Guatemala and Costa Rica by introduced cultivars. A third factor contributing to loss of germplasm is the abandonment of crops for economic reasons when cheaper sources of the product (or a substitute for it) are discovered. As previously mentioned, indigo and castilla rubber are examples of uneconomic crops no longer grown in Central America. Finally, changes of land use may be a cause of loss of crops of minor importance or their wild relatives. In the Guatemalan highlands teocinte (*Zea mexicana*), a near-wild relative of maize, disappears when intensive cultivation of maize replaces the old traditional mixed crops.

Special steps are needed to save the genetic wealth of a particular crop, country or region. One such step applicable to crop plants is the formation of collections representative of as many varieties as can be found. These collections may be of seeds, which can be stored in cold-rooms for long periods without losing viability, or collections of growing plants. Two types of genetic collections may be recognised; **basic collections,** intended to preserve the full range of genetic variation permanently and, **working collections** which are accumulated during the course of a breeding programme for the crop but which, once the objects of the programme have been achieved, may be dispersed with significant loss of valuable germplasm or variants which might be difficult to recover.

Another way of conserving living plants is to maintain them *in situ*, that is in their natural habitats such as forests, grasslands or swamps. This method which implies that the site must be maintained in its natural state without any interference by men or domestic animals, is suitable for many forest species and wild relatives of crop plants. Indeed, with present knowledge of the vast majority of wild plants no other method is practicable. It is not suitable (and would be far too costly) for cultivated varieties of plants, which cannot persist under natural conditions, nor for near-wild, weedy species which need disturbed sites for survival.




**GERM PLASM FLOW-CHART AT CATIE/GTZ PROGRAM**
**Turrialba, Costa Rica**

### 3.1.1. Storage of Seeds

Storage of seeds is an effective method of preserving germplasm at institutions dedicated to the conservation of plant genetic resources, but it is complicated by the many kinds of seed produced by the various plants it is hoped to conserve. Some plants rarely, if ever, produce seed; others regularly produce seeds that keep well, and yet others produce seeds that are difficult to store. It is convenient to recognize two classes of seed for storage purposes: Orthodox Seeds which can be thoroughly dried and stored in cold-rooms for many years, and Recalcitrant Seeds which rapidly lose viability if allowed to dry out and which can only be stored for short periods. Cocoa, coffee and many fruits have recalcitrant seeds.

The techniques used for storing seeds for short periods –Short Term Storage– differ from those used for Long Term Storage (say, a period of ten years or more). Seeds intended for short term storage are cleaned, carefully inspected to ensure freedom from pests and diseases, labelled and kept in cold rooms at about 5°C. Seeds intended for long term storage must be very fresh and in sufficient quantity, so small batches of previously stored seed are planted and a crop grown to provide larger quantities of fresh seed. The new seeds are cleaned, inspected and dried to either 4-6 per cent, moisture content, depending upon species. Next they are divided mechanically into equal samples, each of which is hermetically sealed in a special envelope made of laminated plastic and aluminum foil, labelled and stored at -20°C.

The moisture content and viability of each seed batch is checked before storage. In long term storage seeds may remain viable for 10-100 years depending on species, but the germination percentage should be re-checked every 3-5 years, depending on circumstances. When the germination percentage falls some 10% for uniform genetic material, or 5% for seed collected from field populations of plants, or the quantity in store becomes too small, the batch must be rejuvenated. This is done by planting a sample, growing a crop and collecting the new seed produced. Seed in long term storage is only released in very limited quantities to other institutions for genetic conservation or to approved breeding programmes.

Facilities available at Turrialba for seed storage include: 1) a preparation room where seed brought in from the field is cleaned, inspected and packed; 2) a cold-room of 55 $m^3$ capacity maintained at 5°C and 30-40% Relative Humidity (RH) for short term storage; 3) a drying room kept at 20-25°C and 10-20% RH where the moisture content of seed batches can be adjusted to any desired level in specially designed cupboards and where seed is divided and packed ready for long term storage; 4) a cold-room of 110 $m^3$ maintained at -20°C for long term storage; and 5) a laboratory where tests of seed quality and storage methods are carried out. The main cold-room is constructed to specifications issued by the International Board for Plant Genetic Resources.

All receipts and releases of germplasm are recorded on punched cards and, in addition, reference collections of photographs and seed samples are maintained.

Seed preparation for storage. Equiment at the CATIE/GTZ project, Turrialba.

The cold room at CATIE for long term storage of seeds at -20°C.

**Experimental Work.** Much scientific information is available on the best methods of collecting, treating and storing seed of temperate crop plants, but very little is known about the handling of seed of tropical crops. Research is necessary to find the best seasons and stage of ripeness at which to collect seed, the best conditions for germination, methods for breaking dormancy and the effects upon subsequent germination of various degrees of drying the seeds. Similarly, research is needed to find out how varying conditions of storage (temperature, relative humidity, methods of packing, etc.) affect the life of seed of tropical species. Such experiments, when concerned with seed that can be kept dry for very long periods, must be continued for many years before sufficient data are accumulated to estimate the potential storage life of the seed.

The distinction made earlier, between orthodox and recalcitrant seeds is somewhat arbitrary, because both groups show variation in their ability to withstand drying. Experiments must be made to find alternative storage methods for seeds whose viability falls off if they are dried to less than 10% moisture content, or if they are dried too quickly. One possibility is to store such seeds moist but under conditions which prevent germination. Lettuce seed, for example, keeps better when stored in darkness completely saturated with water, and at a relatively high temperature (30°C) than it does when stored dry at low temperature. In the case of seeds which are less sensitive to light, germination may be prevented during saturated storage by the use of germination inhibitors, solutions of high osmotic pressure and other means. Preliminary experiments carried out in 1977 with seed of *Eugenia brasiliensis, Melicoccus bijugatus* and *Coffea arabica* have given promising results, but much remains to be learnt before saturated storage can be generally used for keeping recalcitrant seeds for periods of several years.

### 3.1.2. Conservation in Living Collections

The alternative to storing germplasm as seeds in cold-rooms is the accumulation and maintenance of living collections. For many species, especially in the tropics, it is the only feasible way of conserving them. There are two reasons for this: firstly, there are species which do not seed, or produce recalcitrant seeds which cannot be stored for long and, secondly, many tropical species are normally multiplied vegetatively, either because they seed sparsely or because they are out-crossing and therefore do not breed true from seed.

Growing collections may include long-lived species, such as fruit trees, or species which live only a few years. Many important crops belong to the latter group, for example: bananas, sugar cane, cassava, sweet potatoes, taros and yams, all of which are propagated vegetatively. Collections of these species must be renewed fairly frequently, while collections of long-lived trees can be established on a long term basis.

Living collections present a number of difficulties. In the first place they require a large area of accessible land and are expensive to establish and maintain. In the case of tree species, the area that each tree occupies means that only a few individuals can be grown. Secondly, environmental conditions at the new site may favour some varieties and individual plants more than others, to the extent that some varieties may never fruit at the collection site. However, this is not important for vegetatively multiplied species. Thirdly, the presence of a substancial population of plants of the same variety growing together, may intensify insect or disease attacks. Fourthly, growing different varieties or provenances of a species in close proximity may facilitate hybridization and loss of genetic identity in seed harvested from the collection. Finally, introductions of actively growing plant material to a country or region should be made through quarantine. Quarantine regulations are often framed in such a way that they prohibit the entry of any part of the genetic material of a particular species.

There are several living collections in the Caribbean and Central American region. They include the Wilson Popenoe Botanic Garden at Lancetilla, Honduras; the Hope Gardens in Jamaica; the collections at Soledad in Cuba; the Summit Gardens in the Canal Zone of Panama, and miscellaneous collections at CATIE, Turrialba, Costa Rica. These collections comprise many exotic species, but they are often represented by only one, or very few introductions from the native sources. From the genetic standpoint, there is also repetition, that is to say material once successfully introduced to Hope Garden may have been propagated and sent to Summit Garden, from there to Turrialba, and so on. Nevertheless, these garden collections have made most important contributions to the regional distribution of plant germplasm as we shall see in Chapter 6 on Plant Introduction.

At CATIE, Turrialba, the Genetic Resources Programme took over several existing collections which needed to be restored and increased. The coffee collection with more than 1400 entries representing eight species, but especially varieties of *Coffea arabica,* is perhaps the biggest in the world. The cocoa collection contains more than 300 entries, some of them the results of genetic improvement work carried out at CATIE. There are also collections of tropical fruits and other crops totalling some 360 species and, in all, the live collections at CATIE occupy some 30 hectares. These existing collections are presently being expanded to accommodate new material gathered in Central America, especially local fruits, fibre plants and native spices.

View of part of the variety collection of coffee (*Coffea arabica*) at Turrialba. The collection preserves about 1400 entries.

The general principles of genetic conservation apply to living collections in the same way as they do to collections of seeds. In the first place a genetic collection should, so far as possible, represent the whole range of natural variation found in the species. Hence in a living collection, a species should be represented by as many different entries as possible and each entry by a sufficient number of individuals (in this sense they differ from botanical gardens, where the object is to accumulate representatives from as many families and species as possible, and the number of individuals per species can be quite small). Secondly, collections should be replicated on different sites to reduce the risk of accidental loss and to minimize the selective effects of one particular site on the populations. Thirdly, meticulous recording and documentation is essential and must show for each lot full details of origin, location in the field, management of the crop, season and methods of collection of propagating material, etcetera.

The miscellaneous collection at CATIE.
This collection specializes in tropical fruits.

View of part of the cocoa variety collection at CATIE, Turrialba.

## 3.2 Exploration

To conserve the genetic resources of a particular crop it is necessary to accumulate as many of its varieties as possible. This involves careful exploration of its natural range and, often, other parts of the world where it has been introduced and successfully cultivated.

Exploration work must be planned according to the needs and local circumstances of each particular case. During an expedition one species or more may be collected, different sampling procedures may be necessary, and different information recorded about the various plant populations encountered.

The main sources from which plant genetic materials are collected are: firstly, plants that are growing wild and (for crops) cultivated fields or wild populations; secondly, stocks of seed held by farmers for sowing the next season's crop and, thirdly, rural markets which attract the many agricultural products of a region.

Collections from cultivated areas depend very heavily on the transport and time available. For the majority of the Central American crops no precise information is available on the locality, season or extent of planting, and systematic sampling (planned in advance) is very difficult. Expeditions visit preselected places, and both itinerary and sampling procedures must be modified in accordance with experience and local reports obtained in the field. Because areas bordering main roads are more frequently examined, a collector has a better chance of finding new material when he searches further away from roads and townships but, often, the extra time and energy spent searching remote areas are not rewarded by the value of the samples collected. In Mesoamerica, it is important to consider the distribution of ethnic groups, because often a particular group grows its own special varieties of crops, which differ from those of its neighbours. A knowledge of the ethnology of the region and, where possible, of the native languages, is invaluable and facilitates both the collection of a wider range of materials and of much valuable information on the management and utilization of the crops sampled.

Peasant cultivators still hold over some seed of the crops they grow in case their plantings fail, or for use in the following season. Samples obtained from such stock seed can never be very large, nor fully representative of local crop varieties, but often they are the only material available except during the harvest season.

Rural markets in Mexico and Central America offer excellent opportunities for collection of genetic material because they concentrate much of the variation to be found in crops of the district which they serve. It must be remembered, however, that varieties grown in small quantities, or at places remote from market centres, may not be brought in for sale. Further, as means of transport improve, inter-district trade increases so that popular markets develope to display, not only local district produce, but also that from a wider region. This fact and the practice in many native markets of grading products for display into several sizes, shapes and colours, may give an impression of greater genetic diversity than really exists.

Success in collection of genetic material from any of the three sources discussed above is governed by harvest seasons. Some species, for example avocado, have varieties which ripen successively throughout the year; other species have a very short harvest season which varies from place to place. Thus an expedition of limited range or short duration must necessarily fail to collect all the varieties available. The ideal is to station permanent collectors in the region being examined.

The majority of plant exploration in Mexico and Central America has been carried out by foreign collectors and scientists who sought germplasm either for direct introduction to their own countries, or for plant breeding purposes. The story starts in the mid-nineteenth century with expeditions made by collectors of ornamental garden plants, especially orchids. From the beginning of the present century the United States Department of Agriculture has directed a series of expeditions with specific genetic objectives. Among them may be mentioned: cotton (O.F. Cook & G.N. Collins ca. 1910); avocado and other fruits (W. Popenoe, 1914–1921); Mexican potatoes (D.S. Correll 1947); medicinal plants (H.S. Gentry, 1952–1959; E.P. Imle, 1957; B.C. Schubert, 1954–1957); beans (H.S. Gentry, 1961 & 1965); vanilla (L. Williams, 1962).

The Rockefeller Foundation has also promoted systematic exploration of the races of maize, in Mexico by E.J. Wellhausen, E. Hernández-X. and others; in Central America by F. LeBeau, Alfredo Carballo and others.

Exploration on a smaller scale was carried out in Guatemala by F.W. McBryde collecting beans and maize; by V.M. Patiño collecting cassava; by H.G. Wilkes collecting teosinte and by R. Echandi collecting beans. Expeditions sponsored by the Australian Commonwealth Scientific and Industrial Research Organization to collect leguminous fodder crops should be mentioned and, since 1910, there has been a long series of small expeditions by foreign foresters to collect seed of forest trees, especially pine species.

Two expeditions organised by the Russian Institute of Plant Genetics and Crop Improvement deserve special mention. One to Mexico and Guatemala in 1930, in which Vavilov participated personally, and that made by S.M. Bukasov and his colleagues to Mexico, Guatemala, Panama, Colombia and Cuba in 1925–1926. Thousands of specimens were collected during these expeditions, and subsequent studies elucidated taxonomic problems in the cucurbitaceae and in beans. They also gave rise to the only comprehensive publication on Central American crops. S.M. Bukasov: The cultivated plants of Mexico, Guatemala, and Colombia. Leningrad, 1930. Russian with a large resume in English; Spanish translation 1963 IICA Miscellaneous Publication No. 20, Lima, Peru,

The CATIE/GTZ project makes explorations throughout Central America in accordance with the recommendations of the Consultative Committee who, in 1973, nominated areas and crops to be explored. Investigations and collections are made directly through expeditions by CATIE/GTZ staff, through local collectors and in collaboration with national agricultural research stations.

## 3.3. PLANT INTRODUCTION

A plant genetic resources centre works, not only with indigenous plants of the region which it serves, but also with introduced crops. In Central America coffee, bananas and sugar cane, as well as other foreign fruits and vegetables, are all essential to the economy of the region. Part of the work of a regional genetic resources centre is concerned with introducing, storing and distributing new genetic material of foreign crops.

Plant introduction, by simply moving plants to a new home to see if they would thrive, has been practised since the beginnings of agriculture. The adaptability of a species to a new locality depends on the interaction between the new environmental conditions such as climate, soil, day-length, etc., and the genetic characteristics inherent in the material introduced. The capacity to adapt to a new environment varies greatly among varieties of a species, so it is usually desirable to introduce as many varieties as possible. The methods of growing and processing the crop should also be modified to suit the new varieties introduced. As a rule, crop plants give their highest yields when grown as exotics, outside their native range, and this is true of maize, wheat, coffee, rubber, cocoa and many others. The higher yields of exotic crops can be attributed partly to natural factors, especially the absence in their new home of pests and diseases which have evolved with the crop and reduce yields in the area of origin. But, equally important are improved cultural practices. When a crop is introduced to a country more technologically advanced, the methods of cultivation developed and applied are usually more efficient than the traditional methods used in the country of origin.

Plant introduction should be a systematic process, which first identifies the needs of a country or region for new crops, next selects sources of high quality, healthy material and finally carefully introduces the selected material through a plant quarantine station. Much waste of effort can be avoided if these steps are followed, thus eliminating the introduction of unsuitable material and preventing the accidental entry of pests, diseases and weeds. A Central American example of systematic introduction was the transfer of thousands of coffee seedlings, seed for which came from African and Asian countries infested by coffee rust (*Hemileia vastatrix*). The seeds were sent to the quarantine station of the United States Department of Agriculture, where they were germinated and small plants raised. The seedlings were inspected and later distributed in to several countries in Latin America without a single infected plant being discovered. On the other hand it is probable that the appearance of coffee rust in Nicaragua is the result of an uncontrolled introduction of coffee from an infected source. Such is the case with the infestation of coffee berry borer (*Stephanoderes hampei*) in Guatemala.

The first plant introductions to the Central American region date from the Spanish conquest and included many food crops, such as wheat, pulses, fruits and vegetables brought from Europe. Other early introductions later developed to become important export crops, such as sugar cane and bananas. Potatoes and other crops of less importance were introduced from South America. Towards the end of the 18th century coffee spread to Mexico and Central America from Cuba where it had earlier been introduced indirectly via the Paris Botanic Garden. Since the first introductions, there have been many changes in the varieties of sugar cane and bananas grown in America and also, to a lesser extent in coffee varieties. These changes of variety were necessary mainly to replace varieties susceptible to disease by disease-resistant ones. This resulted in the loss of much valuable germplasm because, at the time, there were no permanent collections in which to preserve the old types.

Fruits and spices from south-east Asia, among others citrus, mangoes and nutmeg, have been introduced several times. African oil palm is the exotic crop which has spread most rapidly in Central America in recent decades, and the primitive germplasm which existed in botanic gardens and served to establish the first plantations is now being replaced by new cultivars developed in Africa and Malaysia. It often happens that germplasm of a plant introduced to a foreign country, there undergoes intensive selection and returns to its native home in the form of improved cultivars. Thus clones of rubber and quinine varieties which are planted in Central America derive from south-east Asia, where they had been developed from material of South American origin.

Botanic gardens have played an outstanding role in distributing exotic crop plants in the Caribbean and Central American regions. The first to be established was that on St. Vincent in 1765, and Hope Garden in Jamaica which was established in 1775 is still active. Soledad Garden in Cuba was started in 1900; Summit Garden in the Canal Zone of Panama in 1923; Lancetilla in Honduras, now called the Wilson Popenoe Botanic Garden, in 1926; and the miscellaneous collections at CATIE, Turrialba were started in 1944.

These gardens have been the bases for several crop breeding programmes: sugar cane at Soledad and Summit, bananas at Lancetilla and coffee and cocoa at Turrialba. These collections have features in common: firstly they are mixed collections with food crops, export crops, forest trees and ornamental species; secondly the introductions, have been reduced to one or a few varieties and, thirdly, there has been much redistribution of the same germplasm among the different collections. Despite these limitations there are some excellent genetic collections in Central America. The Turrialba collection of coffee species and varieties is perhaps the largest in the world, and La Lima, in Honduras, has the most important collection of bananas.

## 3.4. DOCUMENTATION

A genetic resources centre must maintain complete records on all aspects of the germplasm with which it works and on storage methods. It should also be able to supply information promptly to those who need it in order to use germplasm stored at the centre, or for other purposes.

Documentation is the process of compiling, selecting, classifying, storing and recovering information. Because of the wide diversity and large number of samples to be handled at a gene bank, a great many facts must be recorded in easily accessible form. Thus documentation at plant genetic centres is necessarily complex. It must provide information for five main purposes, namely: a) sample identification (scientific name and common name of the material; name of the collector, date, place and reference number of the collection; reference number allocated by the gene bank, place of storage, etc.); b) description of the environment (altitude, climate, soil type, vegetation, etc. of the collection site); c) description of the plant (morphological, physiological and genetic characteristics, such as fruit colour, resistance to disease, pollination mechanism, etc.); d) description of the crop (kinds of product obtained, agronomic data, methods of processing, uses as animal feed, oil content, etc.); e) bibliography (references to sources of information other than that accumulated by the centre itself).

In genetic documentation systems, each descriptive term is named a **descriptor.** Such item may be the "introduction number", "fruit color", "fruit length", etc. The value or grade of a descriptor is called **"descriptor state".** The descriptor state may be a unique number, e.g. the accession number assigned to an entry in a genetic resources centre. If the descriptor refers to a quantitative characteristic, such as fruit length or yield, the descriptor state can be expressed in the unit of measurement used, e.g. cm or tons/ha. Alternatively, measured values may be coded to facilitate storage of the data. For example, fruit length could be classifed in a scale from 1 = very short to 9 = very long; a length scale in cm is established for each grade from 1 to 9. When the descriptor refers to a qualitative characteristic, such as color or shape, the corresponding descriptor states can be recorded by reference to a standard color chart, or in geometric terms, respectively. These terms may also be coded, if convenient. The descriptor state of a particular characteristic may be recorded as "0" when the character is absent or non detectable; where it occurs, but is not graded, '+' is used. Finally, some descriptors, such as proper names of countries, people or plants, must be recorded in verbal form.

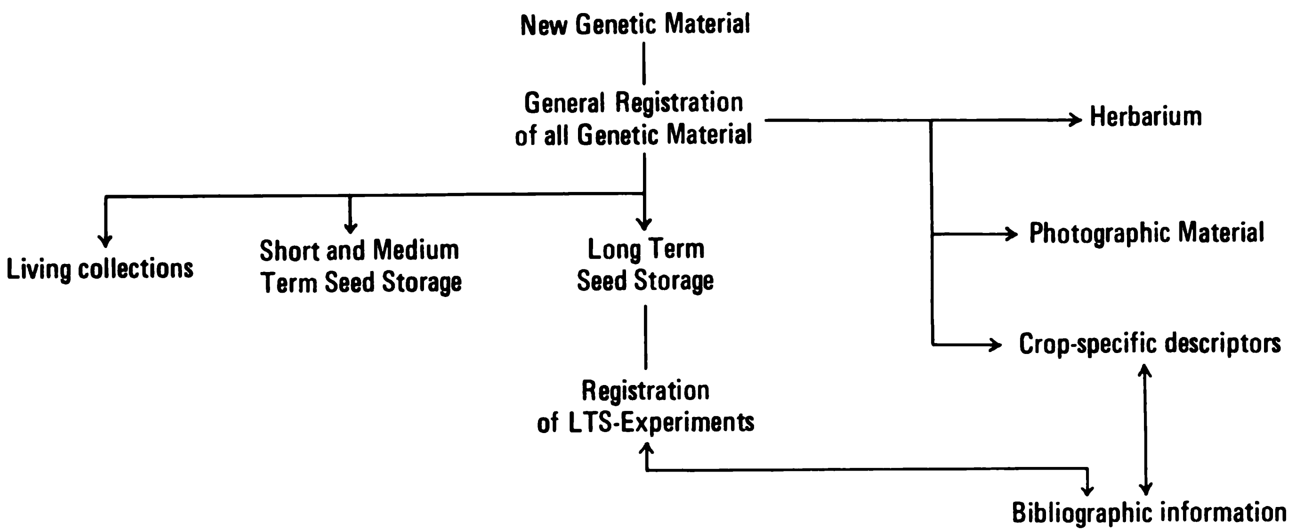
Systematic description of a crop in the manner described facilitates **recognition** of individual varieties or genetic lines, **differentiation** of entries bearing the same or similar numbers, **selection** of entries having particular desirable characters, **classification** of commercial varieties, **study of the relationship** of characteristics within groups of cultivars and **estimations of the variation** of a crop held in the collection.

Specially designed collection books and forms are used to **collect** data on species, identity of samples, morphology, genetic history, etc. The original data are examined statistically in order to **select** characteristics which will discriminate efficiently between individual varieties. The selected data are then **classified** for efficient storage.

At Turrialba data are stored on manually prepared edge-punched cards (McBee, Keysort). Each class of data is stored on a different pattern of card and the flow chart gives an idea of the main classes of data and their interrelationships. The marginal perforations of McBee Keysort cards are divided into fields of four holes each. The four holes in each field are labelled 7-4-2-1 so that by clipping one or two holes (or leaving all intact) any digit from 0 to 9 may be registered. By combining several fields, numbers with more than one digit may be recorded. Verbal descriptor values must be coded as numbers which can then be punched on cards in the same way as other numerical data and thus stored.

The edge-punched card system is being used temporarily at Turrialba until an adequate computer becomes available. The transfer of the stored data from the cards to the computer should be relatively simple since, in effect, all data are already stored in digital form. Statistical calculations, for example to compute the discriminatory value of recorded characteristics, can be carried out on a small computer already available at Turrialba. The edge-punched card system is very suitable for accumulating data for such calculations, for classifying them and for assembling information to be published in catalogues of the genetic material held by the gene bank.

Substantial collections of herbarium material and photographs supplement the punched card records at Turrialba.




**Scheme of the files of the most important data groups**

## 3.5. NEW CROPS

Practically all cultivated plants were originally domesticated by primitive people. Even some of the so-called "New Crops" whose commercial production has been developed in the 20th century, such as oil palm, rubber and Robusta coffee, were previously known and used locally. Among the few exceptions are Macadamia nuts, which are native to Australia and have been developed in Hawaii during the last fifty years, and also certain tropical pasture species which have been developed in Australia from plants of American and African origin.

However, we may speak of "New Crops" where the application of modern techniques of selection, crop management and product treatment has made the commercial production of a primitive crop feasible. One such is the "pejibaye" palm (*Bactris gasipaes*) which was grown by indigenous people from Bolivia to Honduras for its fruits and other useful parts. It thrives under a humid tropical climate from sea level to 1000 m altitude and is thought to have grown wild on the eastern slopes of the Andes, where its local name is "pijuayo" or "pefuayo". It is believed that local indians distributed it throughout the upper Amazon basin as far as the Rio Negro and from there it spread towards the Caribbean and along the coast as far as Honduras. Throughout this area variants of the original name occur; "pixibay" "pisva" "pichivay" and "cachipay". Another line of expansion seems to have been towards the lower Amazon, where it is known as "pupunha", and a third route may have been along the Pacific coast from northern Peru to Colombia. Along this route it is known as "chontaduro" or local variants of the name.

The Indians had many uses for pejibaye and cultivated it around their homesteads. In the eastern part of Costa Rica, the Spanish Conquerors found extensive plantations of the palm, which they made a practice of cutting down so as to reduce the Indians through hunger. Because the fruit crop of pejibaye is seasonal, the Indians had developed methods of storing the fruit, which they ate cooked and from which they prepared alcoholic drinks. They used the stems to build homesteads and fortresses and to make tools and weapons. They also ate "palmito", prepared from the hearts of growing shoots, both boiled and baked.

Nowadays there are commercial plantations on the Atlantic slope in Costa Rica and in the Buenaventura district of Colombia and organized marketing has been developed. Its consumption is increasing throughout tropical America and the palm has also been introduced to tropical Africa, the Philipines, Malaysia and other countries where its popularity is increasing.

Pejibaye (*Bactris gasipaes*): a plantation of different varieties.

Pejibaye (*Bactris gasipaes*): close-up of the trunk.

The most important product is the fruit. The edible part is the dry floury mesocarp which contains good quantities of oil, calcium, carotene and ascorbic acid. It is also rich in phosphorus and niacine and thus provides one of the best balanced foods available in the tropics. The food value appears to vary with the colour, with red fruits containing more nutrient elements than yellow ones. In Costa Rica, under average conditions, pejibaye yields annually 30 tons of fruits or 4 tons of "heart of palm" per hectare.

Bunches of pejibaye fruits.

Pejibaye fruits ready for market at a farm near Turrialba, Costa Rica.

There is a lot of variation in the form, colour and size of fruits produced and superior varieties are known which produce better yields of good quality fruit. Unfortunately multiplication of these superior varieties is difficult because they do not breed true from seed. Vegetative propagation is possible by severing ratoon shoots from the base of the preferred palm and planting them out. However, each parent produces only a few ratoon shoots and the method is not practicable on a commercial scale. It will be necessary to solve this problem, perhaps by artifically inducing more buds on the roots or stems or perhaps by meristem culture. Moreover as production has built up, with one or two crops per year, methods of preserving the fruit in cans and in cold storage have already been developed.

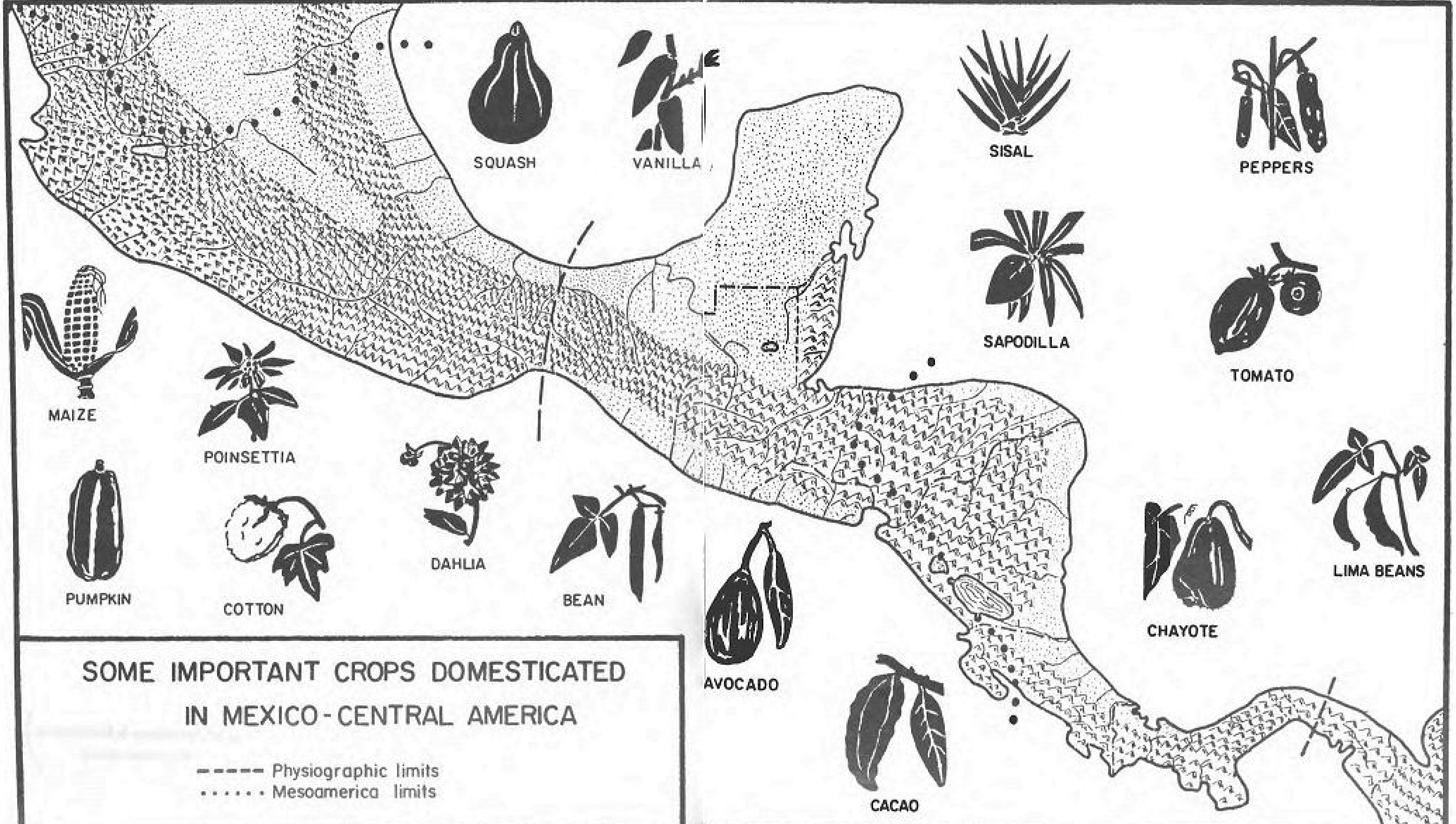
The second important product is "palmito" or "heart of palm". This is a luxury food, cut from the inner part of the terminal bud of the palm, where the tender young leaf bases are rolled round one another in the form of a cylinder. Currently most "palmito" is gathered from wild species of palms and, because most of these produce only a single trunk, removal of the terminal bud for "palmito" kills the tree. However, pejibaye and "assai" (*Euterpe oleracea*) from the Amazon, produce several stems growing in clumps and it is possible to harvest "palmito" by cutting successive trunks as they grow to the correct size without killing the plant. With pejibaye production of "palmito" can be combined with fruit production.

Another production system currently being explored is the use of pejibaye trees as high shade over cocoa or coffee plantations, or in conjunction with annual crops. For this purpose and for "palmito" production, the spiny trunks are a disadvantage, but there are types which bear only a few soft, deciduous spines, and which are being propagated by selection of spineless seedlings. Investigations are also in hand to make use of pejibaye wood, which is very hard and of pleasing appearance.

Besides pejibaye there are other attempts to establish "New Crops" in the region. Cultivation of ipecacuana or "raicilla", (*Cephaelis ipecacuanha*) has been attemped in Nicaragua and Costa Rica but without much success. The conditions of soil and shade under which it grows naturally in the forest are hard to reproduce in cultivation. Some years ago cultivation of "aceituno" (*Simaruba glauca*) was tried in El Salvador for oil production. It did not catch on but a few small plantings remain in production.

More successful has been the cultivation in Mexico of *Dioscorea composita,* a kind of yam used for the production of the drug cortisone. There practical methods of cultivation, propagation and phytosanitary protection have been developed and there is a ready market for the produce.

Finally there is room for the development of organized production of native vegetable crops. Possible species are "pacayas" (*Chamaedorea* spp.), "loroco" (*Fernaldia pandurata*), chaya *(Cnidoscolus chayamansa)* and others. These vegetables are cultivated on a very limited scale, more usually tolerated on the edges of cultivated areas or even collected from wild plants. A similar situation occurs with certain native fruits, fibre plants and oil seeds all of which await the application of modern techniques to achieve stable, commercial yields of a uniform product.




SOME IMPORTANT CROPS DOMESTICATED IN MEXICO-CENTRAL AMERICA

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