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CONSERVATION OF THE GENETIC RESOURCES OF CASSAVA (*MANIHOT ESCULENTA*) DETERMINATION OF WILD SPECIES LOCALITIES WITH EMPHASIS ON PROBABLE ORIGIN

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Wild species of Manihot *are progenitors of cassava. They constitute valuable genetic reservoirs with genes of new characters. Study of geographic distribution of wild* Manihot *species showed concentration of wild species in a number of centers in South and Central America. Considering Vavilov's concept of centers of diversity based on the Age and Area hypothesis of Willis, ad Harlan's theory of Introgression, and by studying Indian immigrations in Pre-Columbian times, it is assumed that northern Amazonia is the place of domestication of cassava and that Goias is the primary center of diversity of* Manihot *species as a "biological group".*

Many reports have referred to wild species of *Manihot* as carriers of useful characters that do not exist in cassava (*M. esculenta* Crantz). Resistances to mosaic and high protein content have been discovered in M. *glaziovii* and M. *tristis* var. *saxicola*, respectively (Nichols 1947; Bolhuis, 1953). It seems that there is a richness of useful genes in wild *Manihot* species still not discovered. At the same time, these wild species are threatened by extinction, due to changes of environment and destruction of their natural habitats. Frankel and Bennett (1970) reported extinction of many wild species in different places, some wild *Triticum* from Palestine and African rice from West Africa. Thus, it is obviously essential to collect wild species of *Manihot* and maintain them in cultivation.

MATERIALS AND METHODS

From May to July 1975 I made a trip to northeastern Brazil to collect seeds of wild species of *Manihot*. The trip covered three states: Pernambuco, Ceará and Bahía. Geographical distribution of Manihot species was studied in Roger and Appan (1973) and in Martius' Flora Brasiliensis (1874). *Manihot* specimens collected by the expedition of Reading University and deposited at IPA herbarium Recife were also examined.

RESULTS AND DISCUSSION

Table 1 lists the wild species of *Manihot* that were collected from different localities of northeastern Brazil. Localities of the species are indicated in Maps 1, 1 a, 1b and 1c. It is apparent that western Pernambuco and central Bahia have the greatest variability in *Manihot*. It may be worthy of mention here that certain species reported by Reading University Expedition to occur in some localities could not be collected from these places. An example: specimens of M. *glaziovii* collected from about 12 km west of Ibimirim, PE. Unfortunately, it was found that vegetation in that place had been cleared and the land cultivated by mamona. Unlike most *Manihot* species, M. *glaziovii* grows in large numbers and not as sporadic plants. Extinction of some wild *Manihot* species from their rural habitats may be due to another factor. The majority of these species are poisonous to grazing animals because of the presence of HCN. They are known among people of "Nordest" as "maniçoba", i.e., the poisonous cassava. Because of this fact, farmers exterminate many plants.

Table 1: Wild species of Manihot Collected from Different Localities in Northeastern Brazil

Species	Locality
M. cearulenscens	Ariripina, PE
M. heptaphylla Ule	Seabra, BA
M. dichotoma Ule	Jequié, BA
M. catingae Ule	Itaberaba, BA
M. brachyandra Pax et Hoffmann	Petrolina, PE
M. maracasensis Ule	Itambé, BA
M. epruinosa Pax et Hoffmann	Belmonte, BA
M. pseudoglaziovii Pax et Hoffmann	Pentecoste, Fortaleza, CE
M. glaziovii Mueller	Arcoverde, Ouricuri, Serratalhada, PE
M. jacobinensis Mueller	Vitória da Conquista, BA
M. quinquefolia Pohl	Senhor do Bonfim, Juazeiro, BA

By studying geographic distribution of *Manihot* species in both Rogers & Appan (1973) and Martius (1974) combined with localities determined on this trip. It became possible to present a map to concentration of wild species (see Fig.50 Photos Gallery) It shows that central Brazil (southern Goias and western Minas Gerais) has about 38 wild species of the total 98 species recognized. Thus, this region includes the largest number of wild *Manihot* species and represents the highest diversity. In this region the following species occur:

M. acuminatissima Mueller
M. sparsifolia Pohl
M. pruinosa Pohl
M. alutacea Rogers et Appan
M. divergens Pohl
M. cecropiaefolia Pohl
M. triphylla Pohl
M. pentaphilla Pohl
M. anomala Pohl
M. procumbens Mueller
M. crotalariaeformis Pohl
M. pusilla Pohl
M. longepetiolada Pohl
M. tomentosa Pohl
M. purpureo-costata Pohl
M. attenuata Mueller
M. orbicularis Pohl
M. tripartita (Sprengel) Mueller
M. weddelliana Baillon
M. pilosa Pohl
M. sagittato-partita Pohl
M. falcata Rogers et Appan
M. quinqueloba Pohl
M. violcea Pohl
M. irwinii Rogers et Appan
M. mossamedensis Taubert
M. fruticulosa (Pax) Rogers et Appan
M. gracilis Pohl
M. warmingii Mueller
M. reptans Pax
M. stipularis Pax
M. oligantha Pax
M. nana Mueller
M. stricta Baillon
M.salicifolia Pohl
M. janiphoides Mueller
M. handroana N. D. Cruz
M. peltata Pohl

The second center of diversity is southwestern Mexico. It includes:

M. zentneri Ule
M. surinamensis Rogers et Appan
M. quinquefolia Pohl
M. pseudoglaziovii Pax et Hoffmann
M. maracasensis Ule
M. catingae Ule
M. brachyloba Mueller
M. quinquepartita Huber
M. reniforms Pohl
M. caerulescens Pohl
M. marajoara Chermont de Miranda
M. tristis Mueller
M. glaziovii Mueller
M. epruinosa Pax et Hoffmann
M. brachyandra Pax et Hoffmann
M. dichotoma Ule
M. leptophylla Pax
M. heptaphylla Ule

Fourth center of diversity is western South Mato Grosso and Bolivia. It includes the following species:

M. guaranitica Choda et Hassler
M. pruinosa Pohl
M. jacobinsis Mueller
M. condensata Rogers et Appan
M. xavantinensis Rogers et Appan
M. flemingiana Rogers et Appan

Vavilov (1920) showed that variation in cultivated plants is confined to relatively few restricted areas or centers. He set up (1920) six main geographic centers for cultivated plants and later (1935) increased their number to about ten. He assumed that cassava has its center of diversity in the Brazilian-Bolivian center. Vavilov proposed that centers of diversity are places of origin of cultivated plants. Since this exposition of centers of diversity in the 1920's, much more information has been gathered, and it has become clear that not all centers of diversity represent centers of origin.

Thanks to Harlan (1961), it was shown that more than one center of diversity may be formed for a given crop through introgression. This phenomenon explained why in many cases we find centers of diversity for a given crop very far from areas of much diversity of wild relatives. Since Harlan proposed this theory (giving a convincing example of the evolved species of *Helianthus*) much evidence has supported it. Dobzhansky (1973) stated many conspicuous cases, such as formation of species of *Iris*, *Eucalyptus*, *Liatris*, *Penstemon*, and *Tragopogon*.

Thus, this phenomenon serves as a model for what apparently happened in formation of these four centers of diversity of *Manihot*, assuming that cassava was domesticated for the first time in one place, then carried by Indians through their immigrations, there could then result an extensive hybridization between the cultivated species and local wild ones, giving rise to numerous new species through introgression.

Cassava does not grow wild. The large variation of cassava cultivars due to maintaining them by vegetative reproduction over hundreds of years makes it difficult to designate definite characters for *M. esculenta*. Thus, it is believed that this species did not arise by natural selection. Hybrids between some wild species may have been domesticated and maintained after words through vegetative reproduction. Surely if these cultivars were left to sexual reproduction and left subjected to natural selection, it would have led to different populations with specific gene pools depending mainly on local environments.

Our assumption is that domestication included some natural hybrids and that the selected plants were maintained by vegetative reproduction for hundreds of years. This assumption is supported by the fact that many experimental crosses and observations led to frequent hybridity of cultivars of *M. esculenta* and local wild species (Abraham, 1975; Bolhuis, 1953; Cruz 1968; Jennings 1957; Lanjouw, 1939; Magoon et al.,1966;

Nichols, 1947). It seems that in this genus systems of genetic and cytologic barriers are not yet well stablished. Another support may come from Schmidt's (1951) statement about the very response of selection in different wild species to increase tuber formation and starch content in tubers and tuber formation through low number of generations. It seems that many wild species have the potentiality to increase tuber formation and starch content. I observed two tree species of Manihot (*M. epuinosa* and *M. brachyandra*) frequently grown in dooryards at Goiânia with considerable tuber production. These two species are native of Bahia. It seems that people of this estate immigrating to central Brazil carried them. This immigration was common during the last thirty years due to the rapid development of Goias. The assumption that domestication included hybrids and did not include a certain wild species has been referred to by Rogers (1963), using the expression "species complexity".

The place of domestication still needs much discussion. I prefer to use "place of domestication" and not "center of origin", as it is obvious that this crop has not been brought to existence as a wild species by means of natural selection. Studying the history of ethnological groups in Brazil and their immigrations throws light on the subject. It is reported that the Aruak who lived in North Amazonia more than a thousand years ago (Schmidt, 1951) knew cassava and practiced a developed agriculture. Their name in the Indian language means "people who eat tubers". It is seen from numerous reports that they cultivated cassava many centuries before Columbus. The Aruak were obliged to immigrate in the 11th century (see photos gallery fig. 52) to Central America, crossing the Caribbean and establishing themselves for some time in the West Indies. Many reasons were given to explain their immigration - probably escaping from enemies; possibly looking for a place where man does not die. But the most important reason given was that they were searching for a better soil to cultivate cassava. However, this immigration coincides with the formation of a center of diversity of Mexico would be expected to hybridize with local wild species creating a center of diversity. The fact of the Aruak continuing on to the Planalto Boliviano and to central Brazil agrees with the existence of the two centers of diversity in these regions . The northeastern Brazilian center of diversity is believed to be the result of immigration of the Tupi-Guarani group (see Photos gallert, fig.51).

We must still determine which of these four centers constitutes the primary center of diversity of *Manihot*. In other words, *Manihot* as a "biological group" must have passed their differentiation in a certain region from which species spread to other regions. It could seem that central Brazil with its enormous number of species of *Manihot* is primary center. Indeed, this region is an ancient area long available for growth of angiosperms (Map 5). Considering Stebbins' explanation (1950) of Vavilov's interpretation of diversity patterns may be useful here: that Vavilov's concept is an elaboration of Williis" Age-and-Area hypothesis, i.e., that the longer a given biological entity occupies an area, the more viability it will produce. Thus this region, with its enormous variability of *Manihot* species, might constitute its primary center of diversity. This assumption finds support in the fact that species which exhibit the most primitive characters are restricted to this region: *M. stipularis* Pax, *M. pusilla* Pohl, *M. longipetiolata* Pohl with their dioeciously inflorescences and *M. stricta* Baillon, *M. purpureo-costata* Pohl and *M. salicifolia* Pohl with their no lobed and sessile leaves.

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