Cassava, *Manihot esculenta* Crantz

Genetic Resources: II. Anatomy of a Diversity Center

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Summary:

Central Brasil is one of the four centers of diversity of Manihot species. Out of 26 wild Manihot species reported to occur in it, 20 species were collected from two limited areas each of less than 100Km diameter. These two areas are: Goiás Velho and Corumbá de Goiás. Considering Harlan concept of geographic patterns of variation of cultivated crops, it is assumed that the two areas are microcenters of cassava diversity. Topographic, soil and ethnological evidence are discussed.

Since the exposition of Vavilov theory on centers of diversity in 1926, many inquiries arose which still receive attention from plant breeders. Vavilov (12) explained the distribution patterns of variation in cultivated crops assuming that the area of maximum diversity of a given crop is its place of origin. In the beginning, he assumed the existence of 6 main geographic centers for cultivated plants all over the world; later in 1936, in increased them to ten. One of the several puzzling problems in Vavilov theory is that some cultivated crops have their centers of diversity far from these ten defined centers. For example, sorghum, yam and many others.

Harlan, in a series of papers, explained a number of topics as that centers of diversity for a given crop may occur far from its center of origin. He also showed that domestication of some crops had taken place far away from these limited determined centers; moreover, it happened along a vast area, something that cannot be called “center”. These were called by Harlan (4) nonecenters. In the case of these nonecenters there is neither an evidence for a center in which agriculture originated nor an evidence for the kind of center described by Vavilov. In centers of diversity as well as the so-called nonecenters, its common for a crop to show enormous diversity in very small regions. These are the microcenters as defined by Harlan (3), and applied by him afterwards to Sorghum (4). Microcenters were observed by Harlan for wild plants as well as for land races. They appear to be fairly common in the variation of plant species. Geographic pattern of variation os so-called microcenter seems to be applicable for wild cassava distribution in Central Brazil.

Table 1 -
Variation of altitude of Natural habitats of some *Manihot* species in the two microcenters (see photo gallery to know growth habit of each species).

Species	Locality of collection	Altitude
M. gracilis	28 Km South Corumbá	1050m
M. peltata	9Km South Corumbá	940m
M. falcata	10Km North Corumbá	890m
M. paviaefolia	21Km North Corumbá	1150m
M. procumbens	24Km North Corumbá	1030m
M. zeentneri	44Km South East Goiás Velho	715m
M. pruinosa	31Km South Goiás Velho	890m
M. reptans	12Km South East Goiás Velho	800m
M. alutacea	6Km South East Goiás Velho	1200m
M. anomala	2Km South East Goiás Velho	720m

Through the project of evaluation of genetic resources of wild cassava, *Manihot spp.* , localities of wild Manihot species were determined according to Rogers and Appan monograph (10), and Mueller (5). Seeds, cutting or the whole plant of the *Manihot* species were collected from their natural habitats. Altitudes was recorded, and soil was analized according to Black et al. (2). History indigenous and etnological groups of these regions was also studied.

Two regions in Goiás state, each of about 100 Km diameter, were found to have majority of wild *Manihot* species known to occur in Central Brazil.

These regions are:

1. Goiás Velho, which was found to have: *M. tripartita* Muell. Arg,.

M.anomala Pohl, *M. zehntneri* Ule, *M. pruinosa* Pohl, *M.pruinosa* Pohl, *M. reptans* Pax, *M. divergens* Pohl, *M. mossamedensis* Taubert, *M. sparcifolia* Pohl, *M.alutacea* Rogers & Appan.

2. Corumbá de Goiás which was found to have: *M. peltata* Pohl, *M. gracilis* Pohl, *M. oligantha* Pax, *M. fruticulosa* Rogers & Appan, *M. paviaefolia* Pohl, *M. procumbens* Muell. Arg., *M. falcata* Rogers & Appan, *M. reptans* Pax, *M. violacea* Pohl, *M. anomala* Pohl, *M. tripartita* Muell. Arg.

Out of 98 species recognized by Rogers and Appan (10) for the genus *Manihot*, 26 species were found to occur in Central Brazil (8). This leads to the belief that this region is one of four principal centers of diversity of cassava. Over extensive areas in Goiás state few *Manihot* species occur, while in the two mentioned areas, aggregates of 20 wild *Manihot* species were encountered by the author.

Vavilov (12) observed in the 20's that centers of variation he encountered occured mainly in mountaineous regions. Such a topography is encountered in Goiás state particulary in these two regions (table1) providing heterogeneous environments that would lead to evolution of new subespecies and species. As Sewal Wright pointed out in the 30's the most rapid divergence of a biological group can be obtained by its fragmentation to small populations partially isolated from one another and each occupies its specific niche. The large amount of variation in soil constituents in the two limited areas of Goiás Velho and Corumbá de Goiás (Table2) would provide such specific niches for these populations.

Evolving such a number of *Manihot* species is believed to be a matter of hundreds of years. It need not be a period of Pre-historic ages. A similar case was explained by Harlan (3) on Sorghum. Historical and archeological evidences encountered in Goiás state support this assumption. Archeological study shows that Goiás had been inhabited by indigenous Indian groups who cultivated cassava. This is seen from the technique of pottrey style (1).

Table 2 -
Analysis of soil from natural habitat of some *Manihot* species in the two microcenters.

Species	Depth (cm)	PH	Ca**+Mg**	P (ppm)	K* (ppm)	Al*** (mg/100g)
M. peltata	0-15	4.9	1.0	1	83	0.8
M. procumbens	0-15	4.9	0.2	-	18	0.5
M. stipularis	0-15	5.0	0.3	1	28	0.6
M. zehntneri	0-15	6.1	3.0	-	887	-
M. pruinosa	0-15	5.5	19.0	1	136	-
M. alutacea	0-15	5.2	1.5	2	36	0.8

Study of history of Indian groups in Pre-Columbian age shows that cassava cultivating tribes of Aruak and Guarani had immigrated from the Amazon Basin to Central Brazil. North Amazon is reported early by Schmidt (11) and assumed by Nassar (8) to ried by these immigrant Indians could have come to close contact with indigenous wild *Manihot* species resulting in an extrordinary large gene pool, isolated small populations in specific niches coulkd have developed giving rise to new species.

These two microcenters in which enormous diveersity is found in a restricted geographic area represent a valuable source of genetic variability. Wild *Manihot* species collected by the author from these microcenters were found to have many valuable attributes that may be useful in breeding programs such as resistance to drought and soil toxicity (6,7) and very low HCN content (9). A summary of this evaluation is represented by table 3.

Table 3 -
Wild *Manihot* species native to Central Brazil against economic characteristics for wich they were evaluated (see gallery photos to know growth habit of each species).

Species	Tuber Formation	Protein Content	HCN content	Growth habit	Particular characteristics for breeding programs
M. anomala Pohl	+	Low	High	Tall shrub	Adapted to shadow
M. tomentosa Pohl	----	----	High	Shrub	Densy hair stem
M. nana Muell	----	----	High	Sub-shrub	A useful source for breeding cassava for dwarf or short cultivars
M. gracilis Pohl	+	Very high (8%)	Low	Sub-shrub	Source of: low hight, low HCN content and high protein content
M. oligantha Pax subesp. nesteli	+	Very high (7-8%)	Low	Sub-shrub	Source of: low hight, low HCN, high protein content (cross readily with cassava
M. falcata					

Rogers & Appan	----	----	Medium	Sub-shrub	Source of low hight
M. alutacea Rogers & Appan	----	----	High	Sub-shrub	Source of resistance to soil toxicity, adaptation to cool temperature
M. paviaefolia Pohl	+	Low	Medium	Sub-shrub	Resistance to soil toxicity
M. pentaphylla Pohl	----	----	Medium	Sub-shrub	Source of low hight, adaptation to rich calcium soil
M. zenhtneri Ule	+	Low	Medium	Tall shrub	Adaptation to wide range of soil
M. tripartita Muell	+	Low	Medium	Shrub	Source of resistance to mosaic by having its vegetativeparts die back to the ground in the dry season
M. fruticulosa Rogers & Appan	----	----	Medium	Short shrub	Source of low hight
M. peltata Pohl	----	----	High	Shrub	Source of resistance to severe soil toxicity
M. caerulescens Pohl	+	Low	Medium	Tall shrub	Source of adaptation to sandy and calcium-rich
M. reptans Pax	----	----	High	Shrub	Source of adaptation to wide range of soil types
M. procumbens Muell	----	----	High	Sub-shrub	Resistance to severe toxicity of soil-production of very short cultivars
M. stipularis Pax	----	----	Medium	Sub-shrub acaulescent	Resistance to severe toxicity of soil; production of dwarf cultivars
M. longepetiolata Pohl	----	----	Medium	Sub-shrub acaulescent	Production of dwarf cultivars
M. pussila Pohl	----	----	Medium	Sub-shrub acaulescent	Production of dwarf cultivars
M. pruinosa Pohl	+	Low	Very low	Sub-shrub	Breeding for a very low HCN cultivars

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