SOME CULTIVARS OF **MANIHOT ESCULENTA** CRANTZ IN COSTA RICA[1]

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There were approximately eighty-five cultivars of *Manihot esculenta* present at the Instituto Interamericano de Ciencias Agricolas (I. I. C. A.) in Costa Rica in 1965. These cultivars were being used in the Nuclear Energy Program at the I. I. C. A. and had been gathered from every corner of Costa Rica and from many other parts of Latin America as well (3). It was due to this program's hospitality that a great part of this study was possible.

SOME HISTORICAL CONSIDERATIONS

Manihot esculenta was first named and described by Crantz (2) in 1766. It is a morphologically variable plant, and presents great taxonomic difficulties as is indicated by some of the names that have been applied to it: *Manihot utilissima* Pohl, *Manihot edule* A. Rich, *Manihot manihot* (L) Cocerell,*Manihot aipi* Rusby, *Mandicoa utilissima* (Pohl) Pohl, *Manioca dulcis* Perodi, *Jatropha manihot* L., *Jatropha stituplata* Vell.

The Gray Herbarium Card Index lists two subspecies of *Manihot esculenta* (*flabelifolia* (Pohl) Ciferri and *grandifolia* Ciferri), for each of which varieties have been named -nine for *flabellifolia* and thirteen for *grandifolia*. Besides this, Lanjouw lists a variety for the species (*Sprucei*). Each of these names, especially the varietal names, were probably given for the various local morphological expressions of the highly variable gene pool of the species; local expressions which are no doubt due to the effect of the vegetative method of propagation.

In addition to the complexity of this one species, there exists, as Rogers (11) points out, a complex of species that is closely related to *Manihot esculenta*

In the eastern and central regions of Brazil, where a high proportion of the cultivars are of the bitter kind (11), and where most use is made of the plant, the Indians developed an instrument called the *tipiti* which is used to free the grated roots of the poisonous juice (11). This poison-free pulp is then made into a flour which is used to bake the bread known as cassava.

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The wide occurrence of typically Indian names such as *yucca, rumu, manioc, mandioca,* (4, 14), which were probably first applied to the food product and thence to the plants themselves, is one factor that indicates that *M. esculenta* had been in cultivation a considerable length of time before the white man came to the New World. This is also indicated by archeological evidence (14).

DESCRIPTION OF THE CULTIVARS AT THE INSTITUTO INTERAMERICANO DE CIENCIAS AGRICOLAS

The plants are 2-3 meters high, shrubby, branching at ground level or close to it. The stems are sprawling to upright, and branched to unbranched. The petioles on the immature plants (those plants not yet bearing flowers) and the vegetative branches of mature plants (branches not bearing any flowers) are usually from 10 to 30 centimeters in length. The leaves are palmately lobed, and there are from five to nine lobes on the leaves of the vegetative branches and immature plants. The number of lobes on the vegetative leaves were usually constant for a particular cultivar. The lobes themselves, are usually oblanciolate but often are linear or anything between the two.

As the plants begin to produce inflorescences, the leaf pattern changes on the branches possessing the inflorescences. The leaves on these reproductive branches do not possess more than five lobes, usually three, and often there are entire leaves present.

There is a great deal of a carmine colored pigment present, the concentration and location of which varies from cultivar to cultivar. The species is monoicious with the flowers arranged in panicles. Pistillate flowers are located in the lower parts of the panicles and the staminate flowers above. The staminate flower has a uniseriate, fused, five-parted perianth of tepals; the ten stamens originating on the receptacle are arranged in two concentric rings and surround a disc. The pistillate flower possesses an unfused, five-parted, uniseriate perianth of tepals; the superior, trilocular, tricarpellate ovary possesses one ovule per locule. The base of the ovary is located in the center of the disc. There is one short style and a tri-parted stigma. The fruit is a capsule.

Variable taxonomic characters. The characters that were found to vary among the cultivars are listed below.

1. Petiole color and length.
2. Immature leaf color.
3. Immature leaf midrib color.
4. Mature leaf midrib color.
5. Number and shape of lobes of leaves.
6. Immature stem color, at apex of stem.
7. Mature stem color, at basal portions of stem.

8. flower color:
   (a) perianth color (usually of the pistillate flowers).
   (b) Ovary color.
   (c) Nectary color.
9. Capsule color.
10. Height of mature plant and amount of branching.

POSSIBLE ORIGIN AND EVOLUTIONARY DEVELOPMENT

Sauer (13) states that *Manihot esculenta* probably originated in a semiarid region, such as parts of Venezuela, rather than in rain forest where it is commonly cultivated today, for the starch that is stored in the enlarged tuberous roots enables the plant to make a rapid start after rains begin in an area of alternating dry and rainy seasons. However, this hypothesis does not take into consideration those immature plants or seedlings that would require some months before there are sizable tuberous roots, or the fact that the sizable tuberous roots themselves are probably the product of man's selection. In general, the origin of the species is very much in doubt, and if the riddle is to be solved, two factors must be considered: man, and the relationship of *M. esculenta* to the wild species that strongly resemble it.

The existence of *Manihot esculenta*, as it is known today, depends upon men as much as men have depended on it in certain lowland tropical areas of the Americas. The men upon which this plant depends for propagation came from the north, through Central America and onto the Western slopes of the Andes. From there they filtered from the north and west to the south and east of the continent of South America. If this theory is true and the archeological interpretations are correct (14), man must have aquired the ancestor or ancestors of *M. esculenta* before he got to South America proper, or found them when first setting foot on that continent. Roger (11) states that there appears to be two major geographical centers of speciation for the genus: one in Southern Mexico and Central America, and the other in northeastern Brazil. Since man progressed from north to south and from west to east, it is very probable that the origin of the cultivated species was in the former area. Rogers also gives reference to the fact that archeological evidence indicates that *M. esculenta* was cultivated in Mexico over two thousand years ago.

The two major differences between *Manihot esculenta* and its closely related, uncultivated relatives is that *M. esculenta* is considerably less fertile and possesses a much larger tuberous root (12). Since many of these closely related species are found in disturbed areas, it is possible that their origins are due to the escape of the cultivated species which, through the process of natural selection and hybridization with other *Manihot* species, have become considerably more fertile. Or is it the other way around... have the wild species given rise to *Manihot esculenta?*

From the evidence available, it is believed that there was a species complex--a group of closely related *Manihot* species in Central and South America when the Indian first came. This complex was probably in the process of rapid speciation, judging from the present day variability of these plants and the extent of interspecific crosses possible (1, 6, 7, 10). The Indians, discovering that many of the members of this group produced sizable, edible roots, undoubtedly began to cultivate some of the varieties or strains of this complex which happend to fall into their hands. Man thus became a part of the evironment of this plant, and the major selective factor. This man-made evironment encouraged vegetative growth over sexual reproduction. Through the years there has probably been an accumulation of natural mutations. These mutations might have eliminated many of the plants had they been in the natural state, but in the man-made environment they survived because of the attribute of possessing an edible root. As long as that attribute remains, no matter how many mutations arise and affect the fertility of the plants, they will survive, because they will be vegetatively propagated by man. This accumulation of spontaneous mutations would not have been the same in each cultivar, and this, in part, may explain the fact that different cultivars possess different degrees of fertility and pollen sterility (9). This, of course, would also explain why certain cultivars have irregular meiotic divisions (5)

There is also, most likely, some introgression of genes from the cultivated species into the germ plasm of the wild species present in the particular area of cultivation. This area of cultivation has been greatly extended during the past two hundred years, particularly in the Old World where *M. esculenta* has been introduced along with other *Manihot* species. This has greatly increased the possibilities of hybridization and may explain the abundance of the "weedy" species.

Figure 1. Growth patterns and some morphological characteristics of *Manihot esculenta* Crantz.

(A) Cultivated field of Manihot esculenta maintained at the I. I. C. A. in Costa Rica. Note that most of the plants shown possess a sprawling growth habit.

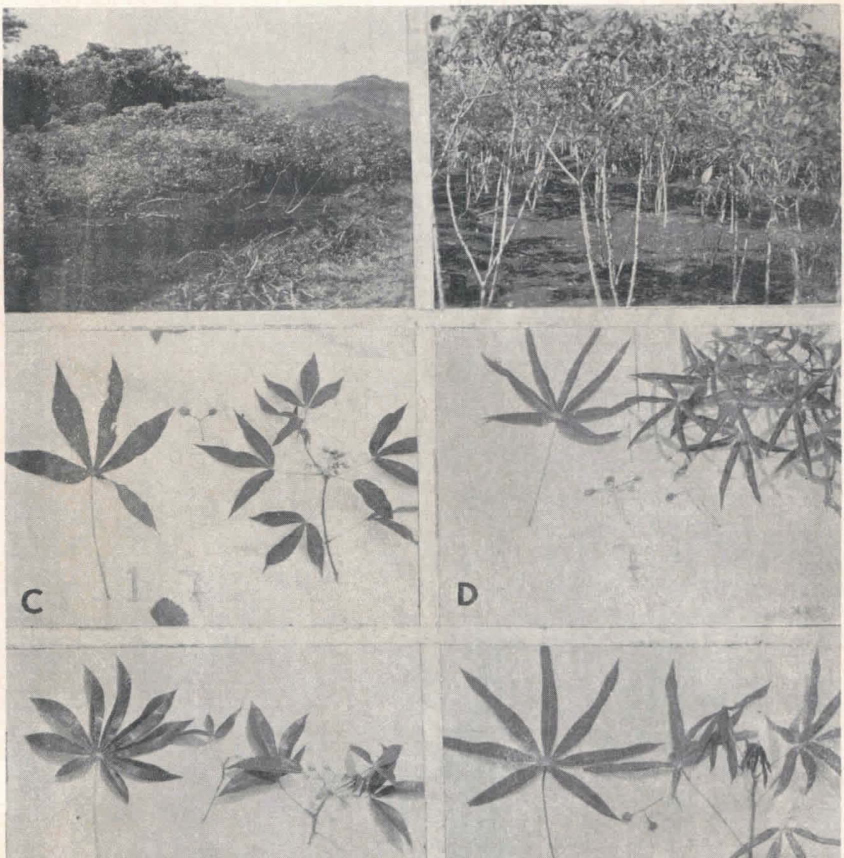
(B) A certain cultivar called "Banilla" which possesses an upright, few-branched stem.

(C) Vegetative and reproductive leaves of cultivar number 17 (from left to right, respectively). The vegetative leaf possesses five lobes, the reproductive leaves three. Both kinds of leaf lobes are more or less oblanceolate. 1/11X.

(D) Vegetative and reproductive leaves of cultivar number 73. This cultivar possesses seven lobes on the leaves of the vegetative branches and five lobes on the leaves of the reproductive branches, the lobes are almost linear in outline. 1/11X.

(E) Leaves of the vegetative and reproductive branches of cultivar number 78. There are nine lobes on the leaf of one of the vegetative branches. There are from one to three lobes per leaf on the leaves of the reproductive branches. 1/11X.

(F) Leaves of the cultivar number 82. 1/11X.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BOOK REVIEWS

DAIRY CATTLE FEEDING AND MANAGEMENT, by Paul M. Reaves and H. O. Henderson, John Wiley and sons, Inc, New York (6th edition, 1963).

The first copy of this book was published in 1917. Due to its abundance of useful information and the combined experiences of its contributors, the public has demanded further publications, with the latest edition printed in 1963.

This book contains most of the information necessary in raising dairy cattle and maintaining them in excellent condition for the production of milk. The authors have emphasized the production of silage and hay, which is highly important in tropical areas where very long dry seasons and abundance of forrages during the wet seasons are the norm.

This book also stresses the importance of the sire in the herd and the use of artificial insemination, a method that is widely spread throughout the world.

The laboratory excercises included in the appendix are unique. They are excellent guides to professors who will use this book as a text.

Aurelio Revilla.

LECHERIA TROPICAL, por *Fernando Vieira de Saá.* Traducción al español por *Carlos Luis De Cuenca,* Unión Tipográfica Editorial Hispano-Americana, Avenida de la Universidad, 767, México 12, D. F., 1965.

Este libro es una recopilación de datos y experiencias del autor adquiridos en muchas de las zonas tropicales en las que permaneció.

El capitulo II, denominado "Productividad Lechera", es quizás el más interesante de todos, debido a que el autor discute en forma excepcional cada uno de los factores climatológicos y su influencia en el ganado de leche. De los pocos libros escritos acerca de la lecheria en los trópicos, éste es el que mejor ha enfocado el problema climatológico en la producción de leche.

En el capitulo V, sección 4., "Plantas Forrajeras Tropicales o Cultivadas en los Trópicos," el autor hace una brillante exposición de las diferentes gramineas forrajeras y leguminosas que pueden ser utilizadas en la alimentación del ganado.

Este libro, además contiene información muy valiosa relacionado con el mejoramiento del ganado lechero en los trópicos de Latino América.

Aurelio Revilla.