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About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

Mr. David Rogers

NATIONAL ACADEMY OF SCIENCES
2101 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

October 24, 1957

Dear Dr. Robbins:

Thank you for submitting the card and abstract (three copies) indicating that you will sponsor a paper by David J. Rogers before the Autumn Meeting of the Academy next month. In accordance with subsequent telephone conversations, entry on the printed program will be as follows:

David J. Rogers, The New York Botanical Garden, New York, New York (Introduced by William J. Robbins): Intraspecific Categories of Manihot esculenta. (Illustrated) 15 minutes.

It is noted that lantern slides, size 2" x 2", will be used by Dr. Rogers in his presentation.

Sincerely yours,

Edna Gilbertson

Edna Gilbertson
Office of the Home Secretary

Dr. William J. Robbins
New York Botanical Garden
Bronx Park (Fordham Station)
New York 58, New York

File copy

ABSTRACT OF PAPER ENTITLED

"Infraspecific Variation of Manihot esculenta"

David J. Rogers

Manihot esculenta (Euphorbiaceae), a complex of tropical food plants, has a large number of unclassified subspecific units. In this study the variability of the species has been intensively examined in two areas where the crop is important--Jamaica and Costa Rica. The 75 cultivars found here probably are representative types of amuch larger area, inasmuch as man has introduced many variants in his efforts to improve the crop. A After examination of plants in the field and specially prepared herbarium specimens, it is possible to make a few rather definitive groups, and from these, to judge something of the total range of variation which can be expected in other regions of the growth of cassava.

The framework of taxonomic categories proposed for a classification of the subspecific entities of Manihot esculenta is:

1. Convariants, the equivalent of subspecies in wild plant taxonomy;
2. Sub-convariants, comparable with "series";

5. Cultivars, the cultivated counterpart of the taxonomist's "variety."

In Manihot esculenta two convarients exist, and below this category many sub-convarients are found. In each of the convarients the characteristics which differentiate the subordinate groups are almost identical and parallel categories are established. In this classification the importance of individual cultivars is subordinate to those units designated as sub-convarients. Some inferences as to the origin of the cultivated forms may be drawn after this classification is proposed.

NATIONAL ACADEMY OF SCIENCES

Autumn Meeting

NOVEMBER 18, 19 AND 20, 1957

MEMBERS' PROGRAM

FINAL EDITION

ROCKEFELLER INSTITUTE
AND NEW YORK BOTANICAL GARDEN
NEW YORK, NEW YORK

NATIONAL ACADEMY OF SCIENCES

Autumn Meeting

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ABSTRACTS OF PAPERS

ROCKEFELLER INSTITUTE
AND NEW YORK BOTANICAL GARDEN
NEW YORK, NEW YORK

Intraspecific Categories of Manihot esculenta

The systematics of cultivated plants had illustrious beginnings with the outstanding work of such men as Liberty Hyde Bailey, Alfred Rehder, and others. These taxonomists, however, generally have concentrated on the classification of the higher units (the family, genus, and species), and little attention has been given to ~~the classification of~~ categories within species. There are several reasons for this lack of work with the inter- and intraspecific units of cultivated plants. Among these, we might cite the fact that the morphological characters for separating subspecific units are frequently tenuous; that many categories below the species level depend upon geographic and/or ecological isolation as a factor in distinguishing them, one which may not exist for cultivated varieties; that the variety of the horticulturist or agronomist depends upon man for its continued existence, and, if left alone, would not survive; and that most herbaria do not have enough specimens for adequate study of subspecific categories of cultivated plants, nor indeed enough room for such collections. These may be valid arguments, but the fact remains that many of our cultivated plants are poorly known, and there are very wide gaps in our knowledge of the numbers and kinds, past and present, most important to mankind's continued livelihood.

The following discussion considers one such problem. It probably is an intraspecific problem, but it may prove to be interspecific also. It will demonstrate that typical methods of the taxonomist, with a few additions, are valid for the elucidation of systematic problems of cultivated plants. One of the most important items is the collection of data and specimens. Much more time is spent in the preparation of the individual herbarium specimen of

a cultivated plant than of a wild one. Actually, each specimen is a population sample, not a random gathering. Manihot esculenta is the epithet usually applied to a tropical root crop, the only edible species of the genus, in the Euphorbiaceae. There are no presently defined boundaries of this species, and possibly two species are mixed.

The plants are commonly known as cassava in English-speaking areas, as yuca in Spanish, and either mandioca or manioc in Portuguese. We may not call the group "tapioca", for "tapioca" refers only to one of many different products of the complex.

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lights

The cultivated cassava is a shrub, from about five to twelve feet tall. Nearly all variants have a tuft of leaves near the apex of the stem at maturity, but some are known which maintain their foliage throughout the length of the stem. The enlarged tuberous roots, varying in shape, size and number, produce the main source of carbohydrate food for many millions of tropical people. The plants are propagated almost exclusively by vegetative means: eight to ten inch stem cuttings, planted vertically, at an angle or horizontally give nearly 100% reproduction. In common practice, two groups of cassava are recognized: bitter (with high concentration of HCN) and sweet (without HCN, or the prussic acid confined to

the cortical zones of the root). So far, I have not been able to differentiate these two morphologically, and from analyses made on 45 varieties from Jamaica, there is no clear-cut differences between these two biochemically.

Today, cassava is distributed generally throughtout the world's tropics. Prior to European discovery of the New World, the plants were probably confined to the Americas, and the closely associated islandschains of the West Indies. It is likely that they were first used in cultivation in northern South America. Today, there are more recorded varieties from Brazil than from any other country of the world. The oldest archaeological records that I have examined in which there is a specific reference to Manihot is from a ceremonial vase made in the shape of a cluster of roots which is easily identified as depicting cassava. It was taken from an Inca grave in Peru. The tentative date given for this piece of pottery is about 2000 B.C. Peru is not considered as an area of origin for cassava. Therefore, the plants must have been much longer in cultivation to have been transported to Peru and there become so well established as to be incorporated into decorative pottery.

A cursory glance at the assembly collectively termed cassava gives the impression of rather continuous variation from one extreme of dimensions to the other, caused by many crossings of different genetic stocks. This is, of course, an oversimplified observation which has no basis in fact. My discussion of the varieties is confined to those found in Jamaica and in the two Central American countries, Costa Rica and Nicaragua. In these areas, I recognize 70 variants, 45 from Jamaica, the

remainder from Central America. In wild-plant taxonomy, to make inferences about the classification of the total group from the rather limited geographical samples which I have made would be sheer folly. Cassava, however, has had the agency of man to assist in its distribution, both prior to and after Columbus' discovery, and introductions to Jamaica have been carried on for hundreds of years, bringing many plants from South America into cultivation in areas far beyond their possibility of spread had they to depend on "natural" methods. The same may be said for the Central American countries. Certainly, the material represents particular selections of plants to be introduced, but over the years, with shifting interests and new motives for introduction, one may assume that an almost random sampling of varieties occurring in South America have been brought to Jamaica and Central America for culture.

After examination of plants in the field and from specially prepared herbarium specimens, it is possible to make a few rather definitive groups, and from these, to judge something of the total range of variation which can be expected in other regions of the growth of cassava.

A point should be emphasized: the classification of the varieties of Manihot esculenta requires no new framework of taxonomic categories. The variants may be divided into subspecific categories using common taxonomic methods, if satisfactory specimens have been prepared. Another point should be mentioned here. Many of the characters utilized for differentiation are vegetative, not floral or reproductive. Although not considered good practise, it is necessary to make use of these because many of the variants do not produce any flowers in their normal growth cycle. Many vegetative characters were measured in preliminary studies and those which

showed constancy were retained, while those of low stability were discarded.

Two broad groups of the entities may be recognized. For present purposes, these are designated "convariants" in accord with proposals for an international code for cultivated plants. "Convariant" is used at the same level of classification of cultivated plants as "subspecies" is used for wild ones. It does not carry any suggestion of geographic separation, for obvious reasons, as does subspecies for native populations.

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The characteristics which differentiate the two convariants are: Group A: silver-colored stem, and light tan, smooth-surfaced roots. Group B: brown to yellow stems, and dark brown, rough-surfaced roots. These are well-defined groups, with very little over-lapping. The genetic systems governing this stability is unknown, but whether one or many genes are involved is not significant taxonomically, because these characteristics provide a convenient method for distinguishing groups of closely related plants.

The establishment of the two categories (convariants) solves one problem, but introduces several others. Upon examination of plants from categories A and B, one finds that characters, other than those used for the major division, cross back and forth between the convariants. For example, the branching pattern of the variants is a significant taxonomic character. In both convariant A and convariant B may be found plants with unbranched, tall stems, or stems branched once, twice, three, four, or five times. The same may be said for the numbers and shapes of the lobes of the leaf, for the coloration of the young foliage, the petioles, etc.

Within each of the two convariants, small clusters of the individual entities, or subconvariants, demonstrate similar characteristics. These subconvariants have from one to six entities. The individual entities or variants are correctly designated taxonomically as "cultivars."

The characteristics which distinguish closely related cultivars are obviously tenuous, frequently quantitative, not qualitative. It is very difficult, therefore, to make key differentiations of the individual cultivars in any one subconvariant. Perhaps this would not be true if a purely arbitrary arrangement of the cultivars was desirable, but my intention has been to reflect relationships first, before differentiation. The subconvariants themselves are not too difficult to key out. For practical purposes, I doubt that it is too important to distinguish characteristics of the individual variants separately from those of the constellation. If one knows the constellation to which the cultivar belongs, and to which of the two major categories (convariants), the very minute differences are not too significant. This is not to say that within the constellations the cultivars all demonstrate the same cultural characteristics. There is some variance in the starch content and in other such characters, but these do not assist in ready field identification.

Although much more data must be accumulated from a wider range of sampling, some inferences concerning the type of plants which were the original progenitors of the cultivated forms may be drawn. At least two species must be involved. One is low, many-branched, occurring in regions of moderate to high rainfall. The other, tall and seldom branched, is distributed in more arid lands than the former. This second type occurs more frequently

in cultivation in arid regions today whereas the first occur, as anticipated, where rainfall is plentiful, and evenly distributed. These hypothesized progenitors have not been found, exactly as a pure form. As with many cultivated plants, they may no longer exist as such.

I believe the classification of this cultivated complex is not an unsolvable problem. It is entirely possible to make satisfactory taxonomic categories. The recommended modification is that the emphasis not be placed on the individual cultivar, but on the subconvariant.

Although the classification and determination of relationships of Manihot esculenta are still far from complete, the proposed system provides a framework for further enumeration of the cultivars, and, I hope, will give students interested in other botanical disciplines a better organized body of knowledge for continued investigations of a valuable food plant.