Examine displays on 1st floor—

Spices + perfumes

~~1. Spices~~

I. Introduction—

Last lect- on alleviating man's ills- drugs, painkillers- perhaps not fundamental to survival but-

This lect on a group of similar nature- perhaps not basic to survival, but still one of man's greatest motivations in civilization.

II. Included groups:

Spices, perfumes,

1 Spices- pepper, cinnamon + cassia, capsicum spices, cloves, allspice, parsley, mustard, nutmeg, celery, ginger, aniseed, laurel leaves, mace, garlic, sage, mint, thyme, curry, marjoram, cardamom, caraway, savory, turmeric, coriander, dill, fennel, cumin, basil, rosemary, + fenugreek.

Open sesame! Sinbad the Sailor- Sesame spice, oil, ~~xxx~~ food, perfume base.

2 Uses of spices- today- largely used in rather small quantities, as far as an individual is concerned- not for bulk, but a dash, or sprinkling-

Actually, large extracts could be quite harmful if too much is taken ex- oil of cinnamon is a powerful, irritating germicide- rarely used in medicine

Contain little nutritive value- but add greatly to the pleasure of eating- the odors + flavors stimulate appetites + increase the flow of gastric juices-

Seeds -
Cardamom - India + Ceylon -
Curries, cakes, pies

Combination of many different spices in curry - varying in composition depending on use.

Perfumes -
Grouped together here for 3 reasons -
1. Aromatic substances from plants, the material an essential oil
2. Uses are small, as compared to other plant materials
3. Played a role throughout history -

Cleopatra - snares for Anthony with perfume.
Catherine de Medici knew as much of perfumes as of poisons
French of Louis XIV court - camouflage and antiseptic -
An industry today concentrated in the S. of France
Fls cult there total 10's of millions of lbs. includ 5 million # of orange fls; 4,000,000 # roses, 440,000 # jasmine and 330,000 # violets -

Important perfume oils
1. Otto of roses - mostly from the damask rose - fls picked in early morning, May-June, + distilled as early as possible
2. Geranium oil - several species -
3. Ylang-Ylang - Asia - Cananga odorata.

Grass oils -
Citronella
Lemon-grass

Many others - from all plant parts -

Processes -

1. Distillation - old way - boiling water today, by steam distillation - whole or ground parts put in still, + live steam - condensed essential oils
2. Expression - some oils destroyed by heat - use pressure for lemon + orange peels -
3. Solvent extraction -
Non volatile oils - lards or suet - absorb ess. oils - pomades -
Enfleurage - glass plates covered w/ cold fat - materials to be extracted placed in contact.
Maceration - hot oils or fats
3. Direct extraction - alcohol or petroleum ether

Examples-

Roots-

Horseradish - s. Europe-

Rhizomes-

Ginger - S. E. Asia - today Jamaica a favorite source - odor - from an essential oil, the pungent taste from a nonvolatile oleoresin - gingerin-

Bark-

Wintergreen - probably only N. Am. spice either from checkerberry or from bark of the sweet Birch - c

Cassia + cinnamon - 2 sp., same genus S. E. Asia -

Fls + fl. buds -

Cloves - unopened fl. buds of <u>Eugenia caryophyllata</u>, with associated fl. stalk. Word <u>cloves</u> from French word for nail <u>clou</u>.

Fruits -

1. Allspice - dried, unripe fruit of <u>Pimenta dioica</u> - sm. tree native of W. Ind.
2. Capsicum - cayenne peppers, <u>paprika</u>
3. Pepper - most imp. of spices in this country, black + white - S. E. Asia.

~~Seeds-~~

~~4 Coriander - Mediterranean~~

~~Celery seeds~~

Medicinal value - slight - except as either carriers or disguisers of taste -

Origin of spices -
Largely from tropical countries, few from temperate zones, chiefly Asiatic in origin - some from Africa, and a few from trop. Am.: ex: vanilla, red pepper, and allspice -
Vanilla - from an orchid - almost only use for orchids other than in the florist trade.
Allspice - from Jamaica.
Classification:
No sharp distinctions as to use:
Usually - all aromatic vegetable products used in flavoring foods + drinks.
Spices - may be restricted to hard or hardened parts, used in a pulverized state.
Condiments - spices or flavoring having a sharp taste, usually added after food is cooked.
Savory seeds are small fruits or seeds used whole.
Sweet or savory herbs - fresh + dried leaves as flavoring or garnishing.
Essences - aqueous or alcoholic extracts of essential oils.
For convenience in classification, frequently refer to the plant parts used, as:
Roots, barks, buds + flowers, fruits, seeds, leaves and stems.

References:
Good Reading:
1. The Story of Spices - J.W. Parry -
Chem. Publ. Co. 1953
History
2. Garden spices wild pot herbs - W.C. Muenscher
Cornell Univ. Press. 1955
Beautiful illustr. - native and introduced
plants, with methods of growing -
3. E B - Hill -
Library - a wonderful selection
Spice Shop -
219 + White Plains Ave.

A

Title: Studies on variation in Manihot utilissima and related species

Grant was made to assist in collection of materials and to establish further experimental work in two areas, Jamaica and Costa Rica. With some changes, this plan was followed.

Upon arrival in Jamaica, I was notified the Department of Agriculture had ruled against importation of any varieties from any other area. Since the original plan was set up for the study of the varieties from all areas of the tropical world under uniform conditions, there had to be a complete revision of the experimental work to be done in Jamaica. A sufficient number of varieties occur in Jamaica, however, to make possible another aspect of the same study.

Two general types of "cassava" are known, the so-called "bitter" varieties with a lethal amount of HCN in the roots, and the "sweet" either without HCN, or a low enough concentration of the poisonous principle to make the sweet varieties edible without any previous treatment. One of the problems in my study is to determine whether there is some genetic difference between the bitter and sweet varieties, or whether the concentration of HCN is governed by environment. That this does not seem to be the case is shown by the fact that both bitter and sweet varieties are usually found inter-mingled. However, to fully determine the extent of control of this factor, two experimental plots were established in widely different habitats: one in a low coastal zone in the parish of St. Catherine, on the Bodles Experimental Farm of the Department of Agriculture, the other at an elevation of about 2000 feet in the parish of Manchester on the Grove Place Experiment Station of the Department of Agriculture. The first plot is in an area of heavy marine clay, pH about 7.8, low rainfall, high average temperatures, farmed by irrigation methods; the second has lighter lateritic soils, pH about 6, moderat to heavy rainfall, and moderate, average temperatures.

Upon establishment of these plans, efforts were made to collect as many of the local variants of Manihot utilissima as possible. The wide variety of habitats on the island proved to produce a surprisingly large number of variations, both of the bitter and of the sweet types. Trips were made with agricultural extension agents or by hired car to all of the southern parishes exclusive of Westmoreland, and to St. Ann and St. Mary parishes on the nothern side. On these trips, the agents were instructed to sample cassava plantings at frequent intervals in order to secure as much of the variation as possible. At the same time, samples (dried herbarium specimens) were made of each variant found. Each agent was asked to have six cuttings of each variant sent to the two experimental plots, in order to provide duplicat studies of environmental variations.

Although it is certain that some of the variants which occur in Jamaica have escaped my attention, a large enough proportion of those existing have been brought together to make the studies of environmental variation significant. At the same time, the systematic studies of the varieties will be more significant.

Altogether, 48 named varieties were collected throughout Jamaica. Without doubt, many of these names are synonyms, but until comparisons of characteristics have been made on the herbarium material and on the specimens in the "museum" plots, no accurate figures of the numbers existing can be presented. In addition, the plants at maturity are about eight to twelve feet tall, making it impossible to make entirely adequate herbarium specimens. One of the most stable characteristics of the varieties is the branching pattern. This characteristic is not reflected in the dried specimen, although a large number of photographs were taken to accompany the dried material.

The second phase of the summer's activities proved more successful in terms of the original plans. With the cooperation of the staff of the

Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica. museum plots for varieties of _Manihot utilissima_ and allied species from all over the tropical world were established. That is, the plots where these varieties are to be raised were established. At the moment, requests have been sent to most of the important centers for propagating materials, and some of the requests have been filled. Fortunately, Costa Rica had no ban upon importation of varieties which might be carriers of diseases. In addition, through the cooperation of Dr. Frederick Wellman, Regional Plant Pathologist of the Foreign Agriculture Department of the United States Department of Agriculture stationed at Turrialba, I have been assured of a close check against introduction of diseases which might cause serious damage to an important crop in Costa Rica.

At the Institute at Turrialba, Dr. Jorge Leon, collaborator in this study, had previously established plots of most of the varieties grown in Costa Rica. Through his cooperation, it was possible to make a large number of population studies to determine differences amongst local varieties. This provided a basis for future studies when the large introduction plantings become sufficiently mature for further study.

Several trips were made in Costa Rica to areas of largest concentration of production of tapioca or yuca. The amount of variation found in Costa Rica was considerably less than that of Jamaica. The method of planting was usually different from Jamaican methods in that the Costa Rican plantings were uniformly of one type per field whereas the Jamaican plantings were frequently mixtures of several varieties. The advantage or disadvantage of either has not been examined. Another significant difference between the Jamaican and Costa Rican plants was the fact that about 3/4 of the plantings in Jamaica consisted of bitter varieties, and only 1/4 of the sweet type whereas in Costa Rica the sweet varieties have been selected almost to the exclusion of the bitter ones. There was not opportunity to check a report that bitter varieties were raised by the native Indian population in the remote areas of southern Costa Rica.

In Costa Rica, the largest plantings of *Manihot utilissima* occur on the Atlantic side, mostly at elevations lower than 2000 feet, but many areas of higher elevation had a few plantings. The Pacific slope of Costa Rica and Nicaragua were uniformly less variable as to numbers of varieties, and only six to eight different ones were added to the plots at Turrialba after a week's expedition to areas of production in Nicaragua and western Costa Rica.

This summer's activities were obviously of an introductory nature. It is impossible to make any systematic studies with so small a population sample as that which was made. In all, not more than 200 specimens were taken, but these include many duplicated in order to study variability within a so-called variety. It is hoped that through cooperation with Brazilian and other South American botanists and agriculturists, a broader spectrum of the variation will be obtained. It was indeed encouraging to achieve such fine cooperation from agriculturists for a problem whose basic aspects are somewhat removed from an immediate practical return. Both Jamaican and Costa Rican officials were most helpful in establishing this work.

B.

RESEARCH PROPOSAL SUBMITTED TO

THE NATIONAL SCIENCE FOUNDATION

1. Institution: The New York Botanical Garden, New York 58, New York.
2. Principal Investigator: David J. Rogers
3. Title of Proposed Research: Systematic investigations of *Manihot esculenta* and related species.
4. Desired Starting Date: July, 1960
5. Time Period for which Support is Requested: 3 years.
6.. Budget Requested: $30,110.00.

TABLE OF CONTENTS

ABSTRACT

The problems of the origin, classification, ethnology, and geography of *Manihot esculenta* (cassava, yuca, mandioca, manioc, tapioca) and allied species are discussed. Reviews of the principal investigator's work, of the economic importance, and of the pertinent literature are appended. Details of procedures, facilities, personnel and budget are given.

OBJECTIVES

1. To determine the systematic relationship of *Manihot esculenta* to other species of *Manihot* (Euphorbiaceae).

2. To provide a classification of the sub-specific taxa of *Manihot esculenta*.

3. To study the problems of the origin of the cultivated species.

4. To study the geography and ethnobotanical aspects of the lowland tropical root crop.

DESCRIPTION AND BACKGROUND OF PROPOSED RESEARCH

Introduction

Several outstanding students have proposed hypotheses for the first areas ofcultivation of *Manihot esculenta* Crantz, one of the world's most important lowland tropical root crops. DeCandolle (1886), who accepted the American origin of this species, has been supported by a number of subsequent authors. Further, from travelers' accounts of *Manihot* cultivation in Brazil and from the large number of cultivars of *M. esculenta* found there, DeCandolle considers eastern Brazil to be the area of origin. He is supported by Vavilov (1951) whose hypotheses are widely known. Sauer (1952), considering varied ethnological and botanical evidence, prefers the Venezuelan savannas.

The Relationship of *Manihot esculenta* to Other Species of the Genus *Manihot*

Before the origin of this lowland tropical root crop can be reasonably determined, it is necessary to know the basic relationships of this to other species of the genus. Further hypotheses on the origin of one highly specialized species will not be profitable until we understand the taxonomy of the species group to which it belongs and the position of this group within the genus. Although considerable numbers of herbarium specimens of species related to *M. esculenta* have been collected and deposited in the herbaria of the world, no recent attempt has been made to interpret the relationship of the various specimens.

Standard morphologic, ecologic, and geographic data demonstrate the close relation of about a dozen species to Manihot esculenta:

1. Manihot carthaginensis in all countries bordering on the Caribbean Sea (also found in Trinidad and Tobago and in the Dutch West Indies).

2. M. gualanensis and M. aesculifolia in Mexico and Central America.

3. M. palmata (= M. digitiformis and/or M. dulcis ??) in western South America (Peru, Bolivia, and western Brazil).

4. M. tweediana and/or (may be synonymous) M. flabellifolia in Paraguay, Uruguay, northern Argentina, and the southernmost states of Brazil.

5. Several little known species in eastern Brazil.

6. M. saxicola in northeastern South America in the more humid areas of British Guiana, Surinam, and Venezuela.

7. Only a few species in the Amazon basin, though the cultivated species is abundant.

M. esculenta and its immediate relations are all lowland tropical shrubs. Their habitats range from semi-arid provinces to rainforest associations. They are confined (as natives) to the Western Hemisphere, from Mexico to Argentina and the West Indies. Several species have been introduced into the old world tropics and subtropics. They are altitudinally limited by temperature, and none isfound in areas with frost. The greatest differentiation between M. esculenta and its related species is in the production of fertile seeds and fruit. The cultivars, selected particularly for root production, seem to have been selected against seed production. The cultivars are normally propagated by stem cuttings, and only in breeding or hybridization work have agriculturists propagated plants from seed. The related species, by contrast, produce greater numbers of seeds per plant. All species have a terminal inflorescence, but the degree of development of the inflorescence varies. M. palmata, M. aesculifolia, and M. gualanensis have very stout, many-branched inflorescences, whereas M. esculenta produces a much weaker, fewer-branched one. The leaves of M. palmata are more deeply lobed than those of M. esculenta, forming almost palmately compound leaves. The lobes of the leaves of M. aesculifolia and M. gualanensis are more pronouncedly pandurate or hastate. Manihot saxicola has smaller foliage (average length of median lobe about 5 - 8 cm.), and the leaves are more evenly three-lobed, both vegetative and inflorescence leaves. M. saxicola has been experimentally crossed with M. esculenta in Surinam and in Indonesia, and the F_1 and later generations produced a small number of seeds (Bolhuis, 1949). Apparently, few barriers exist to interspecific hybridization, although considerable selection of M. esculenta clones as parents is necessary. Similar crosses have been made with M. Glaziovii, a distantly related species, with some success.

The origin of the related species is as difficult a problem as determination of the origin of cultivated Manihot esculenta. Frequently, information on habitats on the herbarium labels of the species is indicative of a weedy nature. Descriptive phrases as "abandoned field," "wild manioc," "roadside," and "ruderal" may be indicated. In those cases where local names have been recorded on the specimens, another indication of the putative relationship of these species closely related to cultivated Manihot esculenta may be found. "Mandioca brava," "yuca cimarrona," "maniva silvestre," and others indicate the opinion of people who live closely with the cultivated manioc. The names are applied to several of the species mentioned above; and, although the common names may be the same from country to country, they may be applied to different Manihot species.

Whether the closely related species are progenitors of the cultivated species, or derivatives from it, is a debatable although important question. Harlan (1959) recently hypothesized that, in general, the wild relatives of various cultivated plants are more likely derivatives from the cultivated species than progenitors thereof. He referred particularly to those wild relatives with a known "weedy" aspect. In the genus Manihot, the related species seem to fit this hypothesis nicely. It is possible that the complexity of the cultivated species is due to the hybridizing of the cultivated and wild species in various parts of the range of the cultivars. Also, the related species, having the general aspects of weeds, growing in disturbed areas, and never entirely isolated from the cultivated species, may have been derived from the cultivated species by natural selection out of hybrid swarms.

If these hypotheses have any validity, the research project I propose may not bring me closer to the solution of the origin of the cultivated species, but at least will establish a better basis for further study which will be more precise and acceptable. The genus Manihot offers an excellent opportunity for study of origins of cultivated species in lowland tropical areas. All other intensive studies of the origins of cultivated crops have been made on those plants acceptable to European tastes and those adaptable to growth in temperate climates. These studies should have some usefulness to the anthropologist whose studies of culture change and transmission, and movement of people must inevitably be interwoven with the studies of plants which support the various cultures. It should also provide some useful data to the agricultural student interested in upgrading and improvement of the cultivars of M. esculenta.

The Taxonomic Problems of the Cultivated Species

Manihot esculenta has many minor variants. Because of the numerous cultivars the distinction into subspecific taxa is very difficult. An assemblage of the specimens of the various races demonstrates an almost solid continuum. Geographic and ecologic data play a fundamental role in subspecific taxa differentiation of wild species. There is still no evidence that geography or ecology play a major role in defining the categories below the species level in M. esculenta. Perhaps some geographic and ecologic differentiation may be found upon further investigation in South America, but one must be cautious in employing such data for the following reasons:

1. Cultivars are maintained by man, who establishes "artificial" ecological conditions for the growth of a selected plant.

2. Cultivars of value may have been transported far from their point of origin.

3. New cultivars developed by hybridization may be successful as cultivated plants, but would be completely unsuccessful if natural selection only were operative.

There are characteristics which may permit an adequate classification, however. Within the species M. esculenta herbarium specimens that I have collected from Costa Rica, Nicaragua, and Jamaica demonstrate constant combinations of vegetative characters that may serve as adequate major subdivisions of the species. These characters are:

1. Epidermis of mature roots roughened, flaking, dark brown; stems brown, reddish, or yellowish

2. Epidermis of mature roots smooth, not flaking, light tan or pinkish tan; stems gray or silver-gray.

These combinations of vegetative characters are sufficiently constant to make a provisional subdivision of the species into two "convariants" (see Regnum Vegetabile 10: 13 art. 14. 1958). Below the convariant (a taxon roughly equivalent to subspecies) level the differentiation becomes more complex. Other vegetative characters, of branching pattern, foliage variations, and pigmentation, may be satisfactory to establish subsidiary categories. Whether these sets of characters remain constant over the whole range of the species has yet to be determined. Unfortunately, the average herbarium specimen has no such information available. Until these characters can be tested in the field, it will be impossible to produce a sound classification.

A biochemical trait within the cultivated complex has often confused the classification of the cultivated manioc. High concentrations of cyanogenetic glucosides are found in many of the cultivars. In some plants, the quantity is low, but none so far tested is completely free. In many cultivars the [CN⁻] * is confined to the phelloderm of the root, and none is found in the cortex, the portion producing the edible food material. These are generally called "sweet" manihot. In others, the phelloderm and the cortex have about equal quantities of [CN-], in some cases as much as 2,000 ppm. These are designated "bitter."

Because of the variability in [CN⁻] content, several authors (Pohl, 1827; Muell. Arg., 1866; Pax, 1910) have attempted to find differences and erect species to separate those races of cassava which have the [CN⁻] confined to the phelloderm, and those where the content of cyanogenetic glucosides is great enough to make a bitter taste. At any one locality, differentiation of the cultivars may be accomplished. That is, if "sweet" (low or no concentration of [CN⁻] in the cortex) and "bitter" cultivars are growing together in one field, there are sufficient numbers of morphological differences between the cultivars to permit the grower to be able to distinguish accurately between those which are dangerous if eaten raw or boiled, and those which he may serve safely as a table vegetable in the same manner as Irish potatoes. However,

* This symbol is used to represent the cyanide, indicating its combination with a glucoside.

I have been able to observe sufficient numbers of cultivars to know that the morphological distinctions which serve to separate the sweet and bitter variants in one locality are not satisfactory to distinguish them over the total range of the cultivars. The idea that there is no basis for differentiation of the cultivars into two separate species is not new (Grisebach, 1864; Sagot, 1871; Standley, 1923). Pax (1910) maintained the artificial differentiation and so obscured further studies in this connection.

There is a persistent problem which is not solved by the decision to maintain all the cultivars in one species, however. Several sources (in Steward, 1948, Vol 3) indicate that a geographic distinction, at least in the extent of distribution, exists between bitter and sweet manihot. If these reports are correct, the sweet manioc is more widely distributed than the bitter, even where there has been a considerable interchange of people before and after contact with Europeans. In continental South America a vague dividing line seems to run north and south east of the Andes. To the west most manioc is reported as sweet, and this holds true for Central America. The geographic distinctions between sweet and bitter cultivars in Colombia almost coincides with the Magdalena River: to the east, both bitter and sweet manihot are raised; to the west, only sweet. It is true that food preparation from the roots in Central America is seldom as complicated as it is in areas where bitter manioc provides the greater amount of food. I have no reports of the instrument or basket, the tipití, * occurring in Central America. In those areas where only sweet manioc is found, this root crop does not seem to be the major carbohydrate food and is frequently relegated to secondary importance. In Brazil people of high and low estate alike use mandioca for their major source of carbohydrate and prefer it to any other starchy food. There are certain Brazilian tribes, of course, who depend more on maize and cultivate it more than mandioca.

An hypothesis of some merit is that the first varieties used by South American Indians were the "sweet" varieties found along the eastern slopes of the Andes. In the same areas, however, a few cultivars with low [CN^-] content may have been grown. By trial and error, crude techniques for extracting the prussic acid could have been developed. As the tribes progressed eastward into eastern and southern Brazil, Venezuela, and the Guianas, where variations with higher cyanogenetic glucoside concentrations were found, better, more efficient tools for extracting the bitter juice evolved. The most sophisticated instrument, the tipití, was very likely developed in northeastern South America, where there is a preponderance of bitter cultivars over the sweet.

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* The tipití is found primarily among peoples of Venezuela, the Guianas, and recent Tupian emigrants to the peripheries of the Amazon area. The tipiti is a sleeve-like basket made from certain Aroid lianas (at least in parts of Venezuela). The fibers are twilled on the bias, a detail which allows great compressibility and stretch.

Geographic and Ethnological Problems of *Manihot esculenta*

From documented historical evidence and from archeological finds it is quite clear that this root crop was first cultivated in the tropical Americas. Also, the most frequently encountered common names, "manioc," "mandioca," "yuca," "cassava," are all derived from native Indian terms, giving more basis to the theory of American origin. However, there are still too few data to permit designation of any one geographic area of origin within the western hemisphere. There are certain parts of the western hemisphere which do not seem likely as points of origin. For example, it is doubtful that *Manihot esculenta* could have originated in any area where frosts occur. Therefore, the highest regions of the western cordilleras in South or Central America are excluded. Also, the West Indies seem to be poor possibilities for the origin of *M. esculenta* for the following reasons

1. Except for one other cultivated species of the genus, *M. Glazovii*, no other species of *Manihot* occurs in the West Indies (with the exception of Trinidad and Tobago, both of which have continental affinities with South America).

2. Use of the root is (or was) identical, including the pressure basket (tipití), with South American mainland use.

3. From the widespread distribution of manioc in South America, one may infer a greater antiquity there than that of the first introduction of cultivars into the West Indies.

If the cultivar(s) originated in eastern Brazil, one must account for the fact that the people who would have been required to bring manioc into cultivation were mostly in western South

America and that cultures progressed eastward. The oldest archeological evidence of Manihot culture is found in Peru (Sauer, J., 1951) and in northern South America, in Venezuela and Colombia (Willey, 1960). The pottery from the Peruvian coastal areas is beautifully formed and unquestionably reflects a cluster of roots of manioc. These pots were made by an agricultural people believed to be some 4,000 years old. In Colombia Reichel-Dolmatoff (1956) has found pottery fragments of griddles used in yuca cooking which he tentatively dates at 1000 B.C.

It is dangerous, of course, to assume from present-day distribution of either Indian tribes or of their plants that certain plants are more primitive or advanced than others. However, because of the intimate relationship between manioc and many of the tribes of South and Central American Indians, one must examine the plants in relation to the people.

One may assume that if certain tribes employed advanced processing techniques they might also employ better cultivars and discard any older variations which were not as productive of food material. On the other hand, those tribes which have continued to use less elaborate devices might be considered more primitive. There are several grades of less complex procedures of extraction than the tipití, ranging from simple hand-squeezing of the grated roots to open baskets, to sack-like devices. The tribes employing the simpler devices are scattered about the periphery of the Amazon and in eastern Brazil.

Whether these tribes were pushed out of central Amazonia by more advanced, aggressive tribes from northwestern South America or represent remnants of earlier tribes of the same locality is a moot question. Also, whether these peripheral (or marginal) tribes have maintained primitive cultivars of manioc or have selected more productive, derived cultivars is another unresolved problem.

At any rate, it seems more profitable to examine the cultivars maintained by the marginal tribes than to study those of the central Amazon basin. Whether investigations of these tribes and their cultivars are more significant to answer problems of origins of the cultivars or not can best be determined by investigation.

Economic Importance of *Manihot esculenta*

This root crop is one of the most important food sources for millions of tropical peoples all over the world. In Brazil, mandioca is the fundamental carbohydrate crop. All others are very secondary. In Africa manioc, which has been known only since its introduction by the Portuguese about 300 years ago, has become one of the most important food producers in many areas south of the Sahara.* In the Indo-Malaysian areas thousands of tons of tapioca are produced for shipment to Europe and the United States. The extracted starch is a very significant product for industrial nations, used for paper sizing, glue, and other industrial products. Most of this starch is produced in Indonesia and the Malay Peninsula. In India, the crop has become an in-

* William O. Jones has documented in great detail the significance of manioc to Africans in "Manioc in Africa." Stanford University Food Research Institute. 1959.

creasingly important carbohydrate source in the tropical and sub-tropical areas (Abraham, 1956). The roots are commonly sold in the Puerto Rican markets in this country.

In most areas where Manihot esculenta is the chief carbohydrate food it has been thoroughly condemned by nutrition experts. The protein content of the root is almost nil, and because of this, it is thought to be one of the more serious causes of the nutritional deficiency disease "kwashiorkor." Yet it has one of the highest caloric contents of any starchy food and provides sizeable quantities of vitamins.

In the Belgian Congo, and to a lesser extent in other areas of West Africa, the young foliage is used as a fresh vegetable. Tests have shown that the crude protein of young leaves is considerably higher than those of most plants (Rogers, 1959) and in protein content is certainly comparable to alfalfa and to certain forage grasses. Leaf protein utilization may pose problems because the leaves also contain considerable quantities of [CN^-], and even when dried and ground, may not be palatable to cattle, although they will eat it (Echandi, 1952). Good tests of amino acid composition have not been made. If the protein does not have good percentages of nutritionally significant amino acids, its value is considerably reduced. However, if tests do show appropriate concentrations of the amino acids, a new contribution to better diets for tropical people may become available.

REVIEW OF PRINCIPAL INVESTIGATOR'S STUDIES OF *Manihot esculenta*

A. General

Prior to field studies and collecting trips, I examined the collected specimens of *Manihot esculenta* in Washington, Cambridge New York, and St. Louis. It was obvious that insufficient dried material was available to reflect the great variability of the cultivars mentioned in the agricultural literature. Typical herbarium specimens contained only inflorescences and leaves associated with the inflorescence. As is common in many plant groups, there is considerable dimorphism between the vegetative leaves and the leaves associated with the inflorescence. The characters of the reproductive parts, although quite variable, are less significant for subspecific differentiation than are certain vegetative characters. Vegetative characteristics of the plants are seldom noted on herbarium materials. No roots were found as parts of herbarium specimens.

Before an adequate classification could be accomplished, therefore, it was necessary to become familiar with the plants in the field, to learn methods of collecting specimens which would beuseful for the classification, to determine which parts of the plants would provide diagnostic characters, and which types of information would be necessary to accompany the specimens.

There were two choices of areas to start field work: (1) Brazil, where the largest number of cultivars are located, or (2) the periphery ofthe areas of cultivation, in regions nearer to the United States. I chose the second alternative for the following reasons: having little knowledge of the plants themselves, it seemed undesirable to spend time in the area of greatest diversity until techniques for studying the plants had been firmly established; another reason was, of course, financial Brazil is more than twice as distant from the United States than the West Indies and Central America. In addition, it was necessary to have the cooperation of institutions interested in these studies to help maintain growing collections of the cultivars. After much inquiry, two institutions gave their wholehearted support to my studies: the Department of Agriculture, Hope Gardens, Kingston, Jamaica, and the Interamerican Institute of Agricultural Sciences, Turrialba, Costa Rica. With the assistance and guidance of these two institutions, an excellent beginning of the study was initiated in 1954.

Eight weeks were spent in Jamaica, Costa Rica, and two weeks in Nicaragua. A survey of the numbers of the cultivars in these areas was undertaken, and methods of collecting, growing, and recording information were studied. Procedures for the cooperative work with the Department of Agriculture in Jamaica and The Institute in Costa Rica were established. Upon completion of this field work, only seventy different cultivars were collected in all areas visited. The first specimens collected were, of course, incomplete, and did not contain all necessary information. However, they were sufficiently complete to provide material for examination and to point to the needed type of collection.

Both experiment stations were visited in succeeding years, at intervals of about 11-13 months, and specimens and field notes prepared.

Jamaican Studies

A surprising number of cultivars was found in Jamaica, and many different common ("fancy") names were applied to the cultivars in various parts of the island. To study the cultivars of all localities was impossible. The varying soils and climatic conditions made it difficult to judge the stability or variabilit of the cultivars. The Jamaican agricultural officials were requested to collect as many different cultivars as possible in each parish, to record the local names, and to send cuttings to two experiment stations, one at Bodles, near Old Harbor, and the other at Grove Place, near Mandeville. The two stations have quite different soils and offered an opportunity to observe, unde controlled conditions, the reactions of plants to different environmental conditions.

One hundred and seven accessions were planted in the plots at the two stations, with six plants of each accession. Planting was done in August, 1954, and the specimens examined one year later. Although the activities of the Jamaicans were outstanding, several unfortunate occurrences made it impossible to have an absolute comparison of the cultivars at the two stations. There were several mistakes in labelling at the two stations; at one station, the plants received excellent attention; at the other, because of insufficient personnel or funds, the plants were neglected; an invasion of apical budworms caused excessive lateral branching to develop at one station.

In 1955 the plants were examined, photographed, and specimens taken according to the following schedule:

1. Each cultivar was examined in the row. After examination, one plant was selected as "typical" of the six examples, dug, and photographed against a scaled board.

2. As the photographs were made, data were recorded on pigmentation, habit of the plant, and any other significant feature.

3. Herbarium specimens were prepared after further comparisons of leaves, stems, and roots of the specimen plant and the remaining five plants. The specimen was chosen to be the most "typical" of all the plants of the cultivar of the plot. Thus, in effect, a rough "population sample" of that particular cultivar was prepared. Many cultivars were completely vegetative but specimens were prepared for all, flowering or not.

4. After I had left Jamaica, root and leaf samples were collected and sent to the agricultural chemist of the Jamaican Department of Agriculture for analysis of sucrose, starch, and [CN^-] content of the root and crude protein content of young foliage. Unfortunatdy, two or three days passed before the samples reached the laboratory; thus, the concentration of the volatile cyanide was reduced. The analytical procedures were good and carried out by competent technicians. The analyses

provided an insight into the problems of [CN-] variation and to the possible nutritional significance of the foliage, but because of mislabelling and mixing of the specimens, the data could not be used to bolster the morphological information of the herbarium specimens. Much closer supervision must be made by the principal investigator of each step in the procedure.

5. As the specimens were prepared, close comparisons were made with other cultivars in the plot to prevent duplication at replanting time. When no duplicates were found, stem cuttings were made, labelled, and stored in preparation for replanting.

Upon completion of the sampling of the plots at the two stations, fifteen cuttings of each cultivar were replanted. The purpose of the replanting was to give an accurate check of the plants and the stability of the various characters over more than one growing season, to provide the agronomists of the Department of Agriculture an opportunity to study various cultural characteristics of the cultivars and to select promising cultivars for field testing.

In 1956, after one year's growth, the plants were again observed, specimens taken, and additional notes on various characteristics of the plants made. At the end of work in the summer of 1956, the plots were turned over to agronomists of the Department of Agriculture who have continued studies of the plants for various agricultural problems. I had the plants roughly classified on branching patterns, foliage, and root characters. At the end of the work there remained some 48 cultivars out of the original 107 accessions. These represent, Ithink, most of the cultivars in Jamaica.

Costa Rican Studies

At the Interamerican Institute of Agricultural Sciences at Turrialba, Costa Rica, Dr. Jorge Leon had already collected a number of cultivars in 1954 and earlier and had these growing in garden plots. I found several more cultivars in Costa Rica and Nicaragua, and these were added to the collections.

The same collecting procedures were used in Costa Rica as in Jamaica. The number of cultivars (35) was much smaller in Costa Rica, perhaps because the crop is of lesser importance to the people. Among the Jamaicans who had been brought to Costa Rica by the United Fruit Company and who have settled in the lowland Atlantic regions of Costa Rica, yuca, or cassava, is nearly as important for food as it had been in their earlier homes.

In 1955 cuttings of 25 cultivars were sent to Costa Rica from Jamaica, and these were examined in 1956. Only about 50% survived, and the remainder are still among the collections growing in the plots of the Institute. I intend to observe the effect of different environmental conditions on these cultivars.

B. Techniques Developed

With the background of these studies in the field, the procedures necessary to provide an accurate classification came sharply into focus. Having studied the prepared herbarium specimens over a three-year period, making several tentative classifications, reviewing field notes, and improving the collecting and recording techniques, I now have sufficient background for the future endeavor.

The process of correlating data of the numerous cultivars is, of course, quite complex. Several attempts were made to find precise techniques. Key-sort cards were employed with some success, but the method was cumbersome. Various statistical devices were tried, with the same results. Finally, a method employing electronic computers, essentially following standard taxonomic techniques, proved to be feasible, has been tested, and is now employed by several organizations abroad and in this country.

Procedures for studies of chromosomes have been established. The schedule and reagents are essentially those of Sharma and Sharma (Stain Tech. 32: 167. 1957) for young leaves or buds.

The importance of the variability of the cyanogenetic glucoside content in the roots to taxonomic studies has been discussed (p. 7). It is imperative to prevent the escape of the volatile cyanide so that a true reflection of the content in each sample can be achieved. The procedure adopted is as follows: 100-150 g. of fresh root will be homogenized using a meat chopper and mixed with $CaCO_3$. The $CaCO_3$ will "fix" the cyanide at pH 11 or 12. After such "fixing" the samples can be stored or shipped in polyethylene containers without losing any of their original $[CN^-]$ content. Little danger of decomposition by fermentation exists at the high pH. Final analysis will be made in the laboratories of The New York Botanical Garden.

REVIEW OF PERTINENT LITERATURE

More and more scientists--anthropologists, nutrition experts, agriculturists, and sociologists--have become aware of the importance of Manihot esculenta in underdeveloped countries where it is most raised. Yet few large-scale studies have been carried out in any important aspect, either agricultural or botanical. Local classifications have been made of the cultivars in three areas (Chandraratna, 1944, Ceylon; Ciferri, 1938, Dominican Republic; Zehntner, 1919, Brazil). Unfortunately, local classifications have taken only those cultivars of a particular region and do not consider the total variability of the species. In Africa, breeding for resistance to a mosaic virus has been done (Nichols, 1947; Storey and Nichols, 1938). In Indonesia, Dutch agriculturists brought the plants to their highest productivity (Koens, 1948) producing as much as 30 tons of fresh roots per acre. The French (Francois, 1938) and Belgians (Pynaert, 1951) have devoted considerable attention to the agricultural studies of the plants in the Belgian Congo, in Madagascar, and in other colonial areas. Brazilian scientists have probably touched more areas of research with the plants than have the scientists of any other one nation. Preliminary investigations of the genetics (Graner, 1935, 1940, 1942, 1944), anatomy (Viégas, 1940), cultural procedures (Mendes, 1940, 1941; Normanha, 1942, 1950), variety trials (Normanha and many others), productivity (Correia and Fraga, 1945), cyanogenetic glucoside content (Correia, 1947), etc. have been made on a small scale.

Several Brazilian agricultural stations have made collections of cultivars in the vicinity of the stations. The two largest living collections are at Belém and at Campinas, in governmental experiment stations. These collections will be of extreme importance to the taxonomic studies, providing sources of specimens, ranges of variation, and other vital data.

REFERENCES CITED

Abraham, A. 1956. Tapioca cultivation in India. Ind. Council Agric. Res. Farm Bull. 17. 20 pp.

Bolhuis, G. G. 1949. Kruisingen bij cassave. Meded. Alg. Proefstat. Landb. 94: 1-16.

Chandraratna, F. F. and K. D. S. S. Nanayakkara. 1944. Studies in cassava. I. A classification of races occurring in Ceylon. Trop. Agr. (Ceylon) 100 (4): 219-230.

Ciferri, R. 1938. Saggio di class. delle razze di manioca. Relazioni e Mon. Agr. Col. Ist. Agr. Col. Italiano 44: 1-58.

Correia, F. A. 1947. Ácido cianídrico em algumas variedades de mandioca. Bragantia 7: 15-22.

_____, and C. G. Fraga, Jr. 1945. Tecnologia da mandioca. Bragantia 5: 213-237.

De Candolle, Alphonse. 1886. Origin of cultivated plants. 2nd ed

Echandi M., O. 1952. Valor de la harina de hojas y tallos deshidratos de yuca en la produccion de leche. Turrialba 12: 166-169

Francois, E. 1938. Le manioc, sa production et son utilisation. Rev. Bot. Appl. 18 (204-205): 533-573. Concluded 18 (206): 682-707.

Graner, E. A. 1935. Contribuicão para o estudo cytologico da mandioca. Univ. de São Paulo.

_____. 1940. Tratamente de mandioca pela colchicina. I. Jour. Agron. (São Paulo) 3: 83-98.

_____. 1942. Genetica de Manihot. Bragantia 2: 13-22.

_____. 1944. Uma tetraploide de mandioca "vassourinha." Rev. Agric. 19: 380.

Grisebach, A. H. R. 1864. Flora of the British West Indian Islan(

Harlan, J. 1959. Geographic origin of plants useful to agriculture (not published). In AAAS Symposium on Germ Plasm in Agriculture. Chicago.

Koens, A. J. 1948. De Landb. in de Indische Archipel. Part IIA. 165-200.

Mendes, C. T. 1940. Contribuicão para o estudo da mandioca. São Paulo. 99 pp.

_____. 1941. Clima e terra para mandioca. O Agronomico (Campinas) 1: 77.

Joh. Mueller, Argoviensis. 1866. Manihot in A. DC. Prod. 15(2): 1063-64.

Nichols, R. F. W. 1947. Breeding cassava for virus resistance. E. Afr. Agric. Jour. 12 (3): 184-194.

Normanha, E. S. and O. J. Boock. 1942. Ensaios de variedades de mandioca na Estacão Exptl. de Ubatuba. Bragantia 2: 521-560.

_____, and A. S. Pereira. 1950. Aspectos agronomicos da cultura de mandioca. Bragantia 10: 179-202.

Pax, F. 1910. Manihot in Engler, Pflanzenr. IV 147, Heft 2. 21-111.

Pohl, J. E. 1827. Plantarum Brasiliensis icones et descriptiones 1: 32.

Pynaert, L. 1951. Le manioc. Publ. de la Direccion de l'agriculture. Brussels.

Reichel-Dolmatoff, G. and A. 1956. Excavaciones en el Sinú. Rev. Colombiana antropol. 5: 109.

Rogers, D. J. 1959. Cassava leaf protein. Econ. Bot. 13: 261-263

Sagot, P. A. 1871. Du manioc. Bull. de la Soc. Bot. de France 18: 341-354. (8 Dec., 1871)

Sauer, C. O. 1952. Agricultural origins and dispersals. Am. Geogr. Soc., New York.

Sauer, J. 1951. Crop plants of ancient Peru modelled in pottery. Bull. Mo. Bot. Gard. 37: 187-194.

Standley, P. C. 1923. Trees and shrubs of Mexico. Contr. U. S. Nat. Herb. 23 (3): 643.

Steward, J. H. (ed.) 1948. Handbook of South American Indians. Vol. 1-6. Bull. 143. Bur. Am. Ethnol. Washington.

Storey, H. H. and R. F. W. Nichols. 1938. Studies of the mosaic diseases of cassava. Ann. Appl. Biol. 25 (4): 790-860.

Vavilov, N. I. 1951. The origin, variation, immunity and breeding of cultivated plants. Transl. by K. Starr Chester. Chron. Bot. 13: 1-366.

Viégas, A. P. 1940. Anatomia da parte vegetativa da mandioca. Inst. Agron. do Est. S. Paulo. Bull. Tec. 74. 1-32.

Willey, G. R. 1960. New world prehistory. Science 131 (3393): 73-86.

Zehntner, L. 1919. Estudo sobra algumas variedades de mandiocas Brasileiras. Soc. Nat. Agri. Imprensa Ingleza. Carina 61.

PROCEDURES *

I. Explorations

Two expeditions to collect cultivars of *Manihot esculenta* and related species are planned. One expedition will be to Brazil and the other to Colombia, Ecuador, Peru, and Bolivia (localities listed below). Attempts will be made to visit some of the collecting sites of Pohl (1827) whose Brazilian collections and studies are more important for systematic work than those of any other student of *Manihot*. The actual itinerary in each area will include intermediate stops in localities of most importance to the studies. However, the exact collecting sites will depend on circumstances of travel facilities and advice in the countries listed.

The localities in this list are those of agricultural experiment stations. Most of these stations have facilities for assistance to visiting investigators. They, or the main experiment station of which they are subsidiaries, have cooperative programs with the U. S. Government and/or international (U.N. and FAO) agencies. I plan to request the assistance of the officers in charge of these stations. In the past many local government and international agencies have provided assistance for travel, housing, accommodations, guides, etc.

Eastern South America

Brazil: Belém, Pará; Campinas, São Paulo; Bello Horizonte, Minas Geraes; intermediate stops in the states of Maranhão, Piaui, Pernambuco, Bahía, Goias.

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* Details of procedures have been given on p. 19.

Western South America

Colombia: Barranquilla, Palmira, Villavicencio, Miraflores, Puerto Leguizamo.

Peru: Lima, Tingo Maria, Iquitos, Pucallpa, Huancayo.

Bolivia: La Paz, Riberalta, Reyes, Santa Cruz.

II. Collections To Be Made

1. Herbarium specimens--standardized procedure.
2. Materials for cytological and anatomical study.
3. Root samples for analysis of [CN^-] content.
4. Cuttings of selected species and cultivars sent to Rockefeller Foundation Experimental Farms in Vera Cruz. (The director in Mexico City, Dr. R. W. Richardson, has agreed to a co-operative program.)

III. Analysis of Field Data

In the herbarium. Typical herbarium procedures will be followed for the analysis of herbarium specimens. In addition to morphologic, ecologic, and geographic information, anatomical, cytological, and bio-chemical data will be correlated. (See discussion of methods on p. 19.)

FACILITIES

The New York Botanical Garden will provide the major facilitie of herbarium, library, laboratory space, and general laboratory equipment. Special requirements for equipment are as follows:

For herbarium and laboratory analyses:

a. Stereoscopic dissecting microscope (American Optical or Bausch & Lomb).

b. Compound microscope (AO or B & L), adequate for anatomical and cytological studies.

PERSONNEL

1. Principal Investigator: David J. Rogers (see p. 28 for biographical sketch.) The principal investigator requests no salary.

2. Research Assistant. A graduate student in taxonomy of vascular plants will be chosen. The special nature of the field work in connection with this problem requires an intelligent and partially trained assistant to the principal investigator to assure that each step of the collection of data and the preparation of samples are properly carried out. His duties will be as follows:

a. assist in field studies
b. analyze specimens for [CN^-] and carbohydrate content
c. prepare specimens for anatomical study
d. assist in correlating data
e. prepare distribution maps
f. organization of comprehensive annotated bibliography of *Manihot*.

Because of recent tuition increases, other school expenses, and the high cost of living in the New York area, a stipend of $3,600 per year is requested.

BIOGRAPHICAL SKETCH OF PRINCIPAL INVESTIGATOR

Born: De Funiak Springs, Florida, October 18, 1918.

Marital Status: Married, 3 children.

Education: Secondary and undergraduate, public schools of Florida and the University of Florida. Major: botany; minor, soils and horticulture. Graduate: Washington University, St. Louis, Ph.D., 1951. Major: Taxonomy of phanerogams.

Membership in Scientific Societies: International Association of Plant Taxonomists, The American Society of Plant Taxonomists, The Society for Economic Botany (Treasurer), American Institute of Biological Sciences, Botanical Society of America, American Association for the Advancement of Science, Conference of Biological Editors, American Association of University Professors, Torrey Botanical Club (Council).

Professional Career: Allegheny College, Meadville, Pa., 1951-57, Associate Professor, teaching general botany, bacteriology, pathogenic bacteriology, field botany, lab methods, and general education course in biology.

Present Position: Curator of Economic Botany and Editor of ECONOMIC BOTANY at The New York Botanical Garden, 1957-present.

Research: (see p. 14) Studies of Manihot. Publications of this research have not been completed because the data at hand are too fragmentary to permit an overall classification of this species. Publication of classifications of those cultivars already studied would be of little significance.

Publications

Research

1. Stegnosperma: A new species and generic commentary. Ann. Mo. Bot. Gard. 36: 475-477. 1949.
2. Monograph of Stillingia in the New World. Ann. Mo. Bot. Gard 38: 207-259. 1951.
3. Variation in Manihot utilissima and related species. Am. Phil. Soc. Yearbook, 166-168. 1953.
4. Infraspecific categories of Manihot esculenta. Science 126 (3285): 1234-1235. 1957.
5. New IBM computer technique is desiged to compare and classify masses of information. IBM Tech. Info. Publ. 8 pp. 195
6. Cassava leaf protein. Econ. Bot. 13(3): 261-263. 1959.
7. What is a cultivar, and why bother? Jour. N. Y. Bot. Gard. 9: 6-7, 23. 1959.
8. The IBM 704 taxonomy application--an experimental procedure for classification and prediction purposes. IBM 704 program IB CLF. Data Systems Division. Mathematics and Applications Dept. 1959.
9. Modern methods for taxonomy. The use of the electronic computer. In press. 1960.

Reports

10. Proceedings of the Economic Botany Conference. Econ. Bot. 12(4): 405-422. 1958.
11. On the formation of The Society for Economic Botany. Econ. Bot. 13(3): 165-166. 1959.

Book Reviews

12. Rauwolfia: Botany, pharmacognosy, chemistry and pharmacology. Econ. Bot. 11(2): 183. 1957.

13. An introduction to the botany of tropical crops. Econ. Bot. 11(3): 277. 1957.

14. El ajonjoli en Venezuela. Econ. Bot. 11(3): 277. 1957.

15. The wealth of India. Econ. Bot. 12(2): 207. 1958.

16. Abstract bibliography of fruit breeding and genetics to 1955. *Rubus* and *Ribes*--a survey. R. S. Knight and Elizabeth Keep. Tech. Comm. No. 25, Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, England. January, 1959. Econ. Bot. 13(3): 204. 1959.

17. Nomenclature of plants. Harold St. John. The Ronald Press Co., New York. Econ. Bot. 13(3): 204. 1959.

18. Edible wild plants of eastern North America. M. L. Fernald and A. C. Kinsey. Revised by R. C. Rollins. Harper and Bros., New York. 1958. Econ. Bot. 13(3): 265. 1959.

19. Some plants used by the bushmen in obtaining food and water. R. Story. Union of South Africa, Dept. of Agr., Div. of Bot., Bot. Surv. Mem. No. 30, 1958. Econ. Bot. 13(4) 371. 1959.

20. The staple food economies of western tropical Africa. Bruce F. Johnston. Stanford University Press. 1958. Econ. Bot. 13(4): 372. 1959.

21. Systematics of today. Editor: Olov Hedberg. Symposium held at Univ. of Uppsala. Bull. of The Torrey Bot. Club. 86(5): 349. 1959.

Utilization Abstracts

22. Guar. Econ. Bot. 11(2): 159. 1957.

23. Pine gum research. Econ. Bot. 11(2): 173. 1957.

24. Sassafras. Econ. Bot. 11(2): 182. 1957.

25. Seed protection. Econ. Bot. 11(3): 234. 1957.

26. Essential oil of coriander. Econ. Bot. 11(3): 234. 1957.

27. Antioxidants. Econ. Bot. 11(3): 234. 1957.

28. Antioxidants from tomatoes. Econ. Bot. 11(3): 234. 1957.

29. Native grass seed. Econ. Bot. 11(3): 243. 1957.

30. Wax from henequin bagasse. Econ. Bot. 11(3): 262. 1957.

31. Castor oil in perfumery. Econ. Bot. 13(4): 280. 1959.

32. Ylang ylang for perfume. Econ. Bot. 13(4): 370. 1959.

BUDGET ESTIMATES

	1st Year	2nd Year	3rd Year	3-year Total
Salaries:				
a. Principal Investigator (David J. Rogers) Salary paid by N. Y. Botanical Garden	--------	--------	--------	--------
b. Research Assistant * (Graduate student part-time)	$ 3,600	$ 3,600	$ 3,600	$10,800
c. Social Security for Research Assistant	108	108	108	324
d. Typist (part-time)	200	200	200	600
e. Social Security for typist	6	6	6	18
f. Custodial activities (dish-washing, mounting of specimens, etc.)	50	50	--------	100
Permanent Equipment:				
All furnished by The N.Y. Botanical Garden except for:				
a. One (1) binocular compound microscope	700	--------	--------	700
b. One (1) binocular dissecting microscope	400	--------	--------	400
Expendable Equipment and Supplies:				
Field press, drying frame, metal corrugates, drying stove	150	--------	--------	150
Glassware, slides, chemicals, labels, etc.	170	--------	50	220
IBM cards	100	100	--------	200
Photographic materials	200	200	--------	400
Polyethylene bottles	120	--------	--------	120
Portable photo board, scaled	50	--------	--------	50
Paper, stamps, pencils, etc.	50	50	50	150
Homogenizer (old-fashioned meat chopper)	10	--------	--------	10

* See note under Research Assistant in "Personnel."

	1st Year	2nd Year	3rd Year	3-year Total
Travel:				
a. Primary cost of trips via commercial airlines (tourist where available):				
1960: Travel to Brazil (Figure given is cost for principal investigator and assistant	2,600	(travel for 2 people)		2,600
1961: Travel to western South America (Colombia, Ecuador, Peru, Bolivia)	--------	(travel for 2 people) $ 2,800	--------	2,800
1962: Travel to herbaria and libraries	--------	--------	300	300
b. Other travel expenses				
Train, bus, tips, passport, photographs, immunization, excess baggage charges	250	250	--------	500
c. Per diem during travel for principal investigator and assistant at $15 per day each:				
1960--65 days	1,950	--------	--------	1,950
1961--65 days	-------	1,950	--------	1,950
Principal investigator only: 1962--10 days	-------	--------	150	150
Publication Costs:				
Purchase of reprints and publications of illustrations	200	200	200	600
---	$10,914	$ 9,514	$ 4,664	$25,092
Indirect Costs (20%)				5,018
Total Budget Requested				30,110

OTHER SPONSORS

No other sponsor has been sought for support of the endeavors in this grant request. There are, however, three other organizations with whom I hope to collaborate on projects related to the primary research. These are:

1. UNICEF. Cooperative studies to make quantitative and qualitative analyses of the amino acids in the leaves of selected cultivars. I will collect the leaf material, prepare voucher specimens, and send the material for analysis to a laboratory sponsored by UNICEF. I do not intand to make the analyse personally.

2. International Cooperative Administration (Point Four), Food and Agriculture Division, Rio de Janeiro. I hope to be able to have assistance locally from several experiment stations in Brazil and hope to arrange for advice and assistance with travel, laboratory space, and perhaps a few items of equipment for drying specimens, etc., through I.C.A.

3. Rockefeller Foundation, Office of Special Studies, Mexico, D.F. I hope to send cuttings of most cultivars of manioc to one of the branch stations of the Rockefeller Foundation in Vera Cruz. These cuttings will be grown under uniform conditions and will be used both by staff members of the Rockefeller Foundation and by me. I hope to have this collection available for further documentation and for supplies of cytological material.

David J. Rogers, Principal Investigator

William C. Steere, Director
The New York Botanical Garden

Robert F. Kolkebeck, Assistant Director and
Business Manager, The New York Botanical
Garden

May 15, 1960

Research Proposal Submitted
to NSF

Inst: NY Bot Garden
D J Rogers
July 1960

NATIONAL SCIENCE FOUNDATION
WASHINGTON 25, D.C.

August 15, 1960

Dr. David J. Rogers
New York Botanical Garden
Bronx Park
New York 58, New York

Dear Doctor Rogers:

The Division of Biological and Medical Sciences is pleased to inform you that your research proposal referenced below has been approved by the National Science Foundation. A copy of the grant document is enclosed in order that you may acquaint yourself with the conditions of the grant.

Our policy with regard to reports on research supported by the Foundation is as undemanding as possible. We would like to have a short informal annual report (in duplicate) at the end of each calendar year, and, at the expiration of the grant, a more comprehensive final report (in duplicate) of the progress of the research. The final report should contain, in addition to a description of the accomplishments achieved during the tenure of the grant, a chronological bibliography of all articles published from the investigation. In addition, we would like the final report to include a listing of personnel who have participated in the work: student, technical assistant, professional associate, etc. If in the course of the research, any unusually significant results are obtained, we would like to know about them as they occur.

We also request that four reprints of each publication resulting from work done under the grant be provided us as soon as such reprints become available. An appropriate acknowledgment should be made in each publication on work aided by the Foundation; usually a simple footnote is adequate.

Should you have any questions about these or other matters, please do not hesitate to call upon us.

May I wish you success in your research efforts.

Sincerely yours,

David D. Keck

David D. Keck
Program Director for
Systematic Biology

Ref: "Systematic Investigations of Manihot esculenta and Related Species"
$14,200 for approximately 3 years

August 10, 1960

Dr. Alan T. Waterman, Director
National Science Foundation
Washington 25, D. C.

Dear Dr. Waterman:

Thank you for your letter of August 9 informing me that the National Science Foundation has granted $14,200 to The New York Botanical Garden for the support of research entitled "Systematic Investigations of Manihot esculenta and Related Species," to be conducted under the direction of Dr. David J. Rogers, for a period of approximately three years beginning on or about August 15, 1960.

We are indeed pleased to accept this grant--NSF-G14129-- and assure you that it will be administered in accordance with the Foundation's policies.

Sincerely yours,

William C. Steere
Director

WCS/gd

Blind cc: Mr. Kolkebeck
Dr. Rogers

FOR: Mr. Countey

FROM: R. F. Kolkebeck

DATE: August 16, 1960

SUBJECT: NSF Grant #G14129
(Dr. Rogers) -
Our No. 335

Attached is copy of NSF's letter of acceptance dated August 9, 1960 for Grant #G14129 which will be accounted for under our #335.

Dr. Rogers will operate on a budget of $11,833 plus a 20% overhead ($2,367) within the total grant of $14,200.

You will note that the first payment will be $5,600; $5,600 on or about August 1, 1961; and $3,000 on or about August 1, 1962.

The grant period begins on or about August 15, 1960 for a period of three years.

CC: Dr. Rogers ✓
Dr. Steere

AUG 9 1960

Dr. William C. Steere, Director
The New York Botanical Garden
New York 58, New York

Research Grant NSF-G14129

Dear Dr. Steere:

I am pleased to inform you that the sum of $14,200 is hereby granted by the National Science Foundation to The New York Botanical Garden, for the support of research entitled "Systematic Investigations of Manihot esculenta and Related Species," under the direction of David J. Rogers, for a period of approximately three years beginning on or about August 15, 1960. Until further notice this grant will be paid as follows: $5,600 on or about two weeks from date of this letter; $5,600 on or about August 1, 1961; and $3,000 on or about August 1, 1962.

It is a condition of this grant that it may be revoked in whole or in part by the Foundation after consultation with the principal investigator and the grantee, except that a revocation shall not affect any commitment which, in the judgment of the Foundation and the grantee, had become firm prior to the effective date of the revocation; and that funds not committed by the grantee prior to the conclusion of the work contemplated under this grant shall be returned to the Foundation.

It is a further condition of this grant that disposition of patent and other rights in any inventions or discoveries made or conceived during the research, construction of facilities, installation or adaptation of equipment, as may be supported by this grant, shall be the responsibility of the grantee; that the grantee shall give the Foundation reasonable notice of application by the grantee or other person or institution for a foreign or domestic patent on any such invention or discovery; and that upon application for any patent on any such invention or discovery, the patentee shall grant the Government an irrevocable, royalty-free, nonexclusive license for use of such invention or discovery for governmental purposes.

The Foundation desires that this grant be administered in general accordance with the Foundation's policies for research grants as stated in "Grants for Scientific Research," January 1960, and in conformity with the other understandings reached between the Foundation and the grantee relating to this grant.

Please acknowledge receipt and acceptance of this grant at your earliest convenience, including reference to the above grant number.

Sincerely yours,

Alan T. Waterman
Director

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

June 28, 1973

Dr. David J. Rogers
Department of Biology
University of Colorado
Boulder, Colorado 80302

Dear Dr. Rogers:

In examining your file on NSF grant GB-25244, we note that we apparently have not received a final report from you. Items to be included in the final report are listed in Appendix V of the attached guide. In addition, we would like three reprints of such publications when they are available.

We look forward to receiving the report at your earliest convenience in order to bring our records on your research grant up to date.

Sincerely yours,

Donovan S. Correll

Donovan S. Correll
Program Director
Systematic Biology

Enclosure

Dr. Duncan Porter
Systematic Biology
NSF

APPENDIX V

Final Technical Letter Report

The following items should be included:

Name of Institution
Name of Principal Investigator
Grant No.
Starting Date
Completion Date
Grant Title
Brief Description of Research and Results
Publications (published and planned) (give title, Journal or other reference, date, authors)
Theses (if any)
Inventions or discoveries (whether or not patented)
Scientific Collaborators connected with grant (including students) (include title or status, e.g., Assoc. Prof., graduate student, etc.)
Comments (include reference to continuation if appropriate, etc.)
Signature of Principal Investigator and Date

File on 55 (closed)

September 28, 1973

Dr. Duncan Porter
Systematic Biology
National Science Foundation
Washington, D.C.

Dear Duncan:

Several months ago, Donovan Correll reminded me that I had not filed a final report on my Manihot grant. Herewith the report is finally submitted. I trust that it is satisfactory. Please let me know if it is not.

As indicated in the report, I trust that the Foundation will be satisfied with a single copy of the Monograph, because they cost me money, which I did not have included in the budget of the grant. (The price of each copy is $23.75.) As also indicated in the report, I will shortly send a copy of the long paper in Economic Botany, A Monograph of <u>Manihot esculenta</u>.

Sincerely,

David J. Rogers
Professor of Biology
114 Hale Hall

Enclosure of 20 copies.

Taximetrics Lab.

October 9, 1973

Dr. Duncan Porter
Systematic Biology
National Science Foundation
Washington, D.C. 20550

Dear Duncan:

Enclosed are three copies of the reprint, "A Monograph of *Manihot esculenta* with an Explanation of the Taximetric Methods Used," which were partially supported by NSF Grant #G-14129. (This Grant was funded early in the 1960's.)

Sincerely,

David J. Rogers

Enc.