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MANIHOT, MAN AND COMPUTING MACHINES
Fairchild Garden Lecture
February 21, 1969

1. Purpose
   Talk about one tropical food plant--cassava, yuca, manioc or tapioca
   1. What it is
   2. " " " used for
   3. " " " related to
   4. Where it grows
   5. How did man start to use it--origins
   6. How do we advance these studies--use of computing machines.

2. What it is.
   a. Over 1,000 varieties (or cultivars) of shrubs, unbranched or many-branched.
   b. Propagated almost entirely from stem cuttings.
   c. Roots enlarged, the edible portion.
   d. Stems 1-2" in diameter, up to 12-15 feet tall.
   e. Leaves palmately lobed simple, 3-9 (11)-lobed.
   f. Flowers small, inconspicuous, staminate and pistillate sep., on same plant.
   g. Fruits & seeds.
   h. Chemical properties--CN^- content.

3. What it is used for.
   a. Staple carbohydrate (calory-producing) for millions of lowland tropical people.
   b. Seminoles cultivate it. Now many Cubans grow it here.
   c. 5th or 6th largest productivity of all food crops.
   d. Boiled (as a potato) or peeled, grated, squeezed, dried, etc.
   e. A growing cattle and hog food (dried chips), expecially in western Europe.
   f. Importance as we go further into crisis of populations.

4. What it is related to
   a. Spurge family (Euphorbiaceae), which also contains poinsetties, crotons, Brazilian rubber, tung oil, many other less well known genera.
   b. Generic name <u>Manihot</u>--what some European thought the Indians were calling it.
   c. Species name, esculenta--obvious meaning.
   d. species in genus--100-200, depends on which authority you read.
   e. Sub-shrubs-trees.
   f. Interesting in that one of few cult. sp. in a large genus.
   g. Much hybridizing with wild species.
   h. very complex variations as a result.

5. Where it grows
   a. Western Hemisphere. All wild species. None native to any other region
   b. World-wide cultivation in the lowland tropics.
   c. Below 6,000 feet alt.
   d. From mudbanks of Amazon to dry NE Brazil.
   e. Almost any soil type.

6. Origins--hypotheses
   a. All agree, at least, on Western Hemisphere tropics.
   b. Many think Brazil, others Venezuela, I believe MesoAmerica.
   c. Studies involve both man and plants.
      1. Where were people who might have started it.
      2. Where is the coincidence of some possible wild ancestor.
      3. Evidence very scattered: archeological, anthropological, geological, historical, botanical.
   d. History tells us <u>not</u> in Old World Tropics before Columbus.

6. Origins, (continued)
   e. Archeological (very incomplete evidence) places some where in MesoAmerica.
   f. Geological: most wild species grow on limestone type soils.
   g. Geo-archeo-anthropology--man lived in caves in limestone areas.
   h. Botanical tells us what wild species exist in areas juxtaposing above.
   i. With these various bits, I think eastern side of Mexico, anywhere from Tamaulipas state down through Yucatan Peninsula to Guatemala.
   j. Later spread to other parts of South America, by man as he migrated.

7. How do we advance these studies?
   a. Maze of data, many seemingly conflicting.
   b. Disparate types of information--much qualitative, little quantitative.
   c. Use of large computing machines an inevitable need.
   d. 1. To aid first in classifying the cultivars and wild species.
      2. to discover the relationship between disparate (and seemingly unrelated) evidence.
      3. keeping up with the flood of data.

   d. Great advantage--test various hypotheses of relationships and origins very rapidly.
   e. Calculating various statistics and other mathematical equations.

8. All these efforts to bring an olde, little-known, crop up to modern day standards of agriculture in time to help feed the world's increasing populations.

MANIHOT, MAN, AND COMPUTING MACHINES

Summary of Talk at Fairchild Tropical Garden

Under the rather confusing, but I hope intriguing, title above, I will talk about one tropical food crop, Manihot esculenta, or as it is commonly known, cassava, yuca, manioc, or tapioca. I will tell something about what the crop is (for many of us in the temperate zone have not become familiar with the plants), where the crop is grown, what its relatives are, where it came from, how it is used, and how we study the plants.

Cassava plants are shrubs which range in size from approximately three to fifteen feet high, and in shape from many-branched to tall and unbranched. There are numerous varieties, perhaps over a thousand. All of the plants have rather attractive foliage, and each leaf is deeply palmately lobed, with from five to nine lobes. The flowers and fruits are rather small and inconspicuous, and many varieties seem to be sterile. The roots of the plant, for which the crop is raised, resemble very large sweet potatoes. There are a variety of colors exhibited by the plants in stem, leaf, and root. The stems may be brown, red, yellow, or silver. The stalks of the leaves may be green or brilliant red (reminiscent of the colors in poinsettias), and the leaf blade is most often a very attractive dark, glossy green. Roots may be either light tan or dark brown. All of these colors help to differentiate the varieties, in combination with other attributes of shape and height.

A fascinating chemical characteristic is found in some varieties; namely the content of a substance known commonly as prussic acid. Actually, free prussic acid in the plant would be as deadly to it as it is to us, and the plant maintains the poisonous principal bound up in a complex chemical structure, and only when the plant parts are severed does the complex release prussic acid. Not all varieties contain the same quantities of the "bitter" principal, and there are some varieties known as "sweet" cassava, indicating that they do not contain the poisonous substance. Unfortunately, we cannot determine from examination of the exterior of the plant whether or not any plant contains the poisonous material. Apparently the way the people who grow the crop for food know the difference between poisonous and nonpoisonous varieties is by growing known varieties which have been determined to be bitter or sweet. With only five or six varieties, it is easy to distinguish among them, but when hundreds of varieties are grown together (as in agricultural experiment stations) it is almost impossible, except by chemical analysis, to determine which are sweet and which are bitter.

Relatives of Cassava

Cassava, or _Manihot esculenta_, is one species in the genus _Manihot_ which in turn is a member of the large tropical family Euphorbiaceae (the spurge family). This family contains a number of useful and ornamental plants such as Brazilian rubber (_Hevea brasiliensis_), castor oil (_Ricinus communis_), tung oil (_Aleurites Fordii_), croton (_Codiaeum variegatum_), poinsettia (_Euphorbia pulcherrima_), and several others. The genus _Manihot_ is a relatively large genus of perhaps 150 species. It is a morphologically diverse group, with species as clambering vines, weak-stemmed shrubs, large shrubs or small trees. One section of the genus contains latex-producing species from which a low-grade rubber is derived; perhaps the best known of these is _M. Glaziovi_. These species are all native to the New World tropics, and only a few have been transported around the world as tropical cultigens. Cassava, now grown in all the lowland tropics of the world, apparently originated, as did all the other species of the genus, in some portion of the New World.

Habitats of *M. esculenta*

I have not been able to detect any specific soil or water requirements when we take into account all of the varieties. So far, the only seeming restriction on the places where the crop will grow is altitude and frost. Perhaps some cultivar may be found in localities above 6,000 feet, but commonly the crop is grown at lower altitudes. Generally, any area where frosts occur, *M. esculenta* will not survive. But this generality does not hold completely. For example, farmers in southern Brazil do raise the crop where a few light frosts occur, and their technique to save the crop is to cut the plants back to the ground, and allow the sprouts to come up again, hopefully after the frost season has passed. Aside from the above restrictions, one may find some variety (or cultivars, as I prefer to call them) adaptable to a wide range of soil and water conditions. Indians raise the plants on mud flats along the Amazon River, and other farmers raise cultivars in some of the driest areas of Brazil where rainfall may be only 10-15 inches per year. Most of the crop is raised as a door-yard source of food; seldom do large acreages occur. Frequently cassava is interplanted with other food and medicinal plants in local gardens. Only rarely may one find the crop raised on the scale which we find normal in the temperate zone. I suspect that there are good reasons for such practices, such as keeping down the incidence of diseases, but there may be cultural reasons which I have not detected.

Origin of the Cultivated Species

Everyone agrees that *M. esculenta* was brought into cultivation somewhere in the New World tropics, but the actual site or country of origin is not precisely known. Many scientists have said that Brazil is the primary point of origin, and others have said that the most likely country is Venezuela. After examining the crop in many different localities, gathering the meager information from archeology and anthropology, and correlating these observations with the occurrence of wild species in the genus, I have postulated that the lowland areas of southern Mexico and Guatemala probably were the areas where man first took this crop under cultivation. We have much more research to do, however, before we can be certain. Something can be said for all of the countries mentioned above. Where man has introduced the crop to a new locality, it has a chance to modify from what it might have been earlier by several biological processes - among them mutation, hybridization, and natural selection.

Uses of *Manihot esculenta*

The major use of the crop is as a starchy food producer. The roots contain large quantities of starches and sugars and little else. For this reason, the crop has been thought to be very poor in the nutrition of the people who use it. However, by careful observation of the means by which some of the people prepare the crop for food, we may find that there is an increase in the balance of nutritive elements required by man. In some areas (though by no means all), the roots are allowed to ferment before they are prepared as a food. The process of fermentation builds up very large quantities of yeasts, and these themselves are very high in protein. Thus, possibly, the natives who employ the fermentation process have found a way to improve the quality of the food derived from the roots.

Normally, there are two ways the crop is used. The sweet varieties, mentioned above, can be prepared as a boiled vegetable, similar to the way Irish potatoes are used. The bitter varieties, however must be given special treatment before they are freed from the poisonous substances. The process may involve fermentation as the first step, but not always. Usually the roots are peeled, grated into a pulp, the pulp then squeezed to remove the poisonous juices, and then formed into a dried cake on a griddle. The dried cake is called "casabe" in some areas and from this probably comes one of the common names "cassava."

Many different recipes for preparation are employed and there are literally hundreds of techniques for making some edible product from the grated roots. The leaves of the plant are sometimes eaten as a vegetable, particularly in West Africa, where the native population boils the leaves and uses them as we would spinach. This use is not common, however, in the areas where the plants are native. Even the poisonous, extracted juice is turned into a useful product. Since prussic acid is volatile, it can be dispelled from the liquid by long continuous simmering. Frequently, where the bitter varieties are commonly raised, one may find a pot of juice simmering over the fire, and after some time, the juice turns a rich brown and becomes thickened. To this juice may be added a variety of spices, particularly capsicum peppers, and anything else that comes to hand. The prepared sauce is used in the same manner that sauces are used all over the world - to add some extra flavor to various dishes.

There are several industrial uses of the starch derived from the plants. For example, the starch is converted to dextrins, and this is useful in the manufacture of paper-board (cardboard) boxes. The starch itself is frequently used for laundry purposes, and has been used with some frequency as sizing for paper. In recent years, many tons of chipped and dried roots have been imported to Europe (particularly Holland and West Germany) to serve as a supplemental cattle food.

Manihot Research Needed

Strangely enough, scientific studies of *Manihot esculenta* have lagged far behind that of other important food crops. One may compare what we know about the crop to the state of knowledge about corn one hundred years ago. There are many reasons for this, perhaps the most important of which is that the crop is of main importance outside of the temperate zone, and its products are (or have been) of little significance in those centers of the world that have encouraged research with other crops. But now that people around the world are beginning to recognize the terrible population pressures in the underdeveloped parts of the world, and that we need desperately to increase food production to feed the growing populations, we must turn to all possible methods by which we can meet these needs. Since cassava has a tremendous potential for producing calories at a rate greater than most other crops in the lowland tropics, it behooves us to increase our knowledge to the point that we may take advantage of that potential.

At this point, I introduce the third term of the title, computing machines. Since we have much work to do to correlate all the knowledge we need to bring cassava into a modern state of agriculture, we will have to use the tremendous powers available to us in the computing machine. We have devoted considerable time to putting these machines to work in the study of cassava, and hopefully, will be able to catch up much more rapidly than we would be able to do before we had the computer to correlate the many facets of information about the kinds of varieties there are, what the qualities of each variety are, what kind of agricultural system is best for large-scale productivity, etc. In any large-scale agricultural research endeavor, many scientists, in many different disciplines, are discovering facts about the crop, and to use these many facts in agricultural production, the computer has the potential to be a powerful ally. By employing scientists with the best training, and using the computer as the tool to correlate the data, we can hope to quickly overcome the lag time that now exists for cassava.

In summary, _Manihot esculenta_, a tropical root crop, is a very important source of carbohydrate food for millions of tropical people. It is fascinating as a problem to many types of workers - botanists, plant breeders, agricultural specialists of many types, economists and humanists. We need to work very hard to bring it up to a state of knowledge whereby we can aid people whose lives depend on it.