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NATURE PROGRAM FOR TEACHERS

1. What is cassava?

    A. Tropical root crop--describe plants--use slides 1-6

    B. Describe products and uses

        1. Grated--with fiber remaining
        2. Grated--with fiber removed
        3. Grated and fermented
        4. Grated and pressed and baked
        5. Tapioca and how produced
        6. Leaf protein
        7. Use of expressed juice as Cassaripe
        8. Industrial uses
        9. Stamp mucilage

2. Why is cassava important?

    A. Basic food for tropical peoples

    B. Grows in places unsuited for other crops
        Dry, arid lands
        Low altitude in tropics

    C. Ease of planting and growth

3. Interesting aspects

    A. Content of prussic acid

    B. Methods of removal

4. Geography

    A. World wide--in lands with no frost

    B. Lower elevations--little above 5000'

    C. Origin--South America, Brazil--dry zones--spread--by plant hunters--Portuguese and Spanish

5. Problems

    A. How many varieties are there?

    B. Is there one species or more?

6. Classification--one of the major problems

Mr. Leech (Dan)

1. Speech prompted by announcement of grant from NSF

2. Grants received from several sources - Am. Philos. Soc, Allegheny College, + NSF for last year.

3. What is this research? + Why
   Study of variability of one species of plant under man's hand.
   Illuminate or further knowledge of processes of evolution.
   Not to discover some commercial value, or improve, or increase production
   Purely for sake of knowledge - - a curiosity factor
   Hope data will be valuable - need for food in the world.
   Agriculture people support in Jamaica + Costa Rica.

4. "Tapioca" is really not subject of talk.
   1. Only one product - and one requiring
   2. Plants produce other, more basic foods,

5. This talk tells general info concerning plants,
   Does not include too much technical data of my own research.

6. Reference will be to cassava, not tapioca

Of all the world's important food crops, one of the least well known is cassava. Even in the tropical lands where cassava is of greatest importance to the people this statement is true. Wherever one travels, it is possible to find experts on cotton, on tobacco, rice, potatoes, corn, coffee, sugar cane or cacao, but to find someone who knows even one aspect of the study of cassava, one must travel great distances. Yet cassava is one of the world's great food crops. FAO of United Nations list as 7th largest in terms of food Why has this crop been over-looked by researchers and agriculturists? It is difficult to find any good answer to this question, nor will answers to such questions be attempted here. Rather, let us confine ourselves to some of the biological problems concerning cassava, or Manihot utilissima.

In any aspect of the study of cassava there are mostly unsolved problems. There is no agreement concerning methods of fertilizing for best results. The question of method and time of planting is one which is unsettled. Genetically, the plants are almost completely unknown, aside from a few chromosome counts (2n = 36) but there is no documentation of the plants from which these counts were made. How many stable variants are there? Look at several slides showing variants. Over two hundred names have been compiled from South America alone, but it is doubtful that these local names are indicative of the same number of varieties. There is no good histori-cal data concerning the plants, and prior to the first explorations of the Americas, no written reports are known. A few scattered ceremonial vases from Inca graves in Peru depicting cassava roots have been found, but no prehistoric picture has been built up from analyses by archeological techniques.

Even the proper scientific name of the plants is in doubt. Most botanists and agronomists use Manihot utilissima Pohl, but some say that this is not the valid name and substitute M. esculenta Crantz. As for common names, one must have half a dozen names available in order to converse with people in as many different lands. "Cassava" has been chosen because it is the name used most frequently by English speaking peoples, and is commonly applied to the plant and its products in the British West Indies. The name cassava seems to be a corruption of an earlier, pre-Columbian Antillean term, " casavi" or "cuzavi". The word "casabe" is found amongst primitive tribes of Northern South America. In Spanish speaking areas of the New World tropics, "yuca" is appropriate; in Brazil, the most frequently applied name is "mandioca", and in tropical Africa, the French use "manioc". These last two names are apparently derived from one of the South American Indian (Tupi-Guarini?) languages. " Tapioca ", a name familiar to most temperate zone peoples and applied in English, French, Portuguese and other languages to one of the products of these plants is likewise derived from aboriginal South American Indian languages. These names, incidentally, give some indirect clues as to the original home of these plants.

We are not through with the names of these plants by use of any of the above terms, however, because these common names, without modification, are too inclusive. There are two races or types of cassava which must be dealt with: one is "bitter" cassava, the other "sweet" cassava. Frequently these two races are considered as two separate species, but more often the two are considered as subdivisions of one large species.

slide #9

The edible portion of cassava is the root. (Mention will be made later of the use of the foliage as a green vegetable.) Large fleshy roots resembling those of an over-grown sweet potato are produced just below the soil surface and at time of harvest, a steady, gentle pull on the woody stems brings out anywhere from three to fifteen enlarged structures with a total starch content of from 20 to 40 % of total weight. The sweet cassava can be eaten with very little preparation: peeling and boiling the root produces a vegetable dish tasting something like a boiled Irish potato. The bitter cassava must go through a much more extensive treatment before it becomes safe for eating. All parts of the raw plant contain a deadly poison, hydrocyanic acid. First the root is ground or grated into a pulp and washed, then the pulp is placed under fairly high pressures to expell the water (see cut); after this treatment, the pressed cake can be either baked, boiled, or fermented to remove the remaining "bitter" principle. Various names are applied to the products of the different treatments: "casabe" is applied to the bread made by baking. The expressed juice is not wasted either, but by long boiling and concentration, and by addition of seasoning materials, becomes the famed "pepper-pot" of many South American tribes. With all the preparation necessary to make a food product out of the bitter cassava, one wonders why the bitter plants were continued in cultivation, especially so when there is the sweet type which requires much less effort. Almost invariably, the bitter types are more productive of starch than are the sweet ones* (3). The variety of products from the bitter cassava is greater, which may have some bearing on the

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continued use of the poisonous varieties. Both bitter and sweet have their special places in the lives of the people, however.

How did primitive man learn the relatively complex process of removing the poisonous materials from his cassava plants? Even more fundamental a question - why bother with such plants when it is fairly certain that other starchy, more attractive food plants were available? One factor, no doubt, is that cassava, bitter or sweet, is adaptable to a wide variety of habitats. During the dry season, frequently the only crops with any foliage left are the plantings of Manihot utilissima. Other varieties do equally as well where there is high rainfall the year 'round. The cultivation techniques allow plantings on steep hill-sides and jungle clearings where no " clean crop " cultivation is possible. It is not necessary to remove all the stones and tree stumps to get a good production. Primitive man, without the aid of advanced agricultural methods, could easily derive his carbohydrate food requirements from such plants.

Where did Manihot utilissima originate? Aside from saying in the lowland tropics of the New World, we can find little agreement amongst people who have tried to answer the question. It has been intimated earlier that a piece of secondary evidence for a South American origin is found in the names applied to the plants. Sauer (5), using evidences of agricultural origins in general, prefers the rather dry shores of the Caribbean Sea in South America. Some support is gained for this general region in that one of the most closely allied wild species to M. utilissima, M. carthaginensis, occupies an area along the Colombian Caribbean Coast,

Refer to maps

and along the Pacific coast northward and westward in Central America. Vavilov (6), by contrast, thinks that the place of origin of Manihot utilissima is somewhere in eastern or southeastern Brazil. His theory is based upon two factors: (1) that the greatest number of species in the genus Manihot occur in this region and (2) the greatest number of variations within the species is likewise in Brazil.

Before definite answers to the question of origin can be produced, we must first ask what is Manihot utilissima? Is it a single species complex, or is the tremendous variation which exists under this name the result of hybridization amongst two or more species? The fact that sweet and bitter races exist, with intermediate concentrations of HCN, and that there is some distinction in the range of the two types in South and Central America (although there is much overlapping) suggests that more than one species is involved. Unfortunately few, if any, morphological characteristics for separating the two races can be found. Have the wild progenitors of the two "species" been lost, or has the process of selection of variants in cultivation taken us so far away from the wild state that we could not recognize some non-cultivated plants which are the actual forebears? Before an "origin" may be postulated, however, we must have answers to the foregoing questions.

How can we answer these questions? Techniques of taxonomy are applied in the present study. The older methods of the taxonomist, coupled with more recently developed techniques for critical examination of minor differences will be most useful in approaching a problem of this nature. For example, one of the criteria for distinguishing species might be the number of nodes in a certain length of stem, a small number for one species, ahigher number for another. In older taxonomic studies, if intermediate numbers existed, these were accounted for as " possible hybrids ". Starting with the " possible hybrids " it is now possible to evaluate what parent species must have looked like by making quantitative studies of the intermediate condition between low and high numbers of nodes. Obviously, evaluations of many additional intermediate structures must be made prior to any definite conclusion as to the original parental types*.

If two species be involved, we must find their geographical distributions, find the place or places where these distributions overlap, and look in these regions for evidence of greater variability. This is no simple matter with plants which man has found useful. He carried his plants about with him, and in such movements, it is very likely that there will be some mixing or hybridizing, either by conscious effort or by purely accidental crossing with nearby closely related species. (_Manihot glaziovii_, ceara rubber, has been crossed with _M. utilissima_ to increase disease resistance and to produce more robust plants.) If these hybrids have some peculiar advantage that the parents lacked, it is quite possible that the parents may be discarded in favor of the more desirable traits of the hybrid offspring. The favorable characteristics can be maintained year after year in the case of cassava by vegetative propagation, using cuttings of mature stems.

One piece of information concerning the differentiation between the two races is that the sweet types can apparently be raised over a

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wider range of temperature variation than can the bitter types. The bitter seems more cold sensitive, and is seldom found outside of latitude 27° North or South, whereas some of the sweet varieties can be found to 30° North or South. A factor in this differentiation may be the length of time required for maturity of the two groups. There is no average for either group, but what little data have been recorded show that the bitter varieties require a longer period, twelve to eighteen months, to accumulate their highest starch content while the sweet types require only from seven to twelve months.

The selection of better hybrids, or mutants, has not always been under " scientific " control, but has been done with a great deal of practical know-how by the peoples whose lives depended on the crop. Hybrids have been selected for varying factors such as high yield of starch, flavor, or low fiber content of root. These factors are, no doubt, the ones uppermost in the minds of the farmers, but other factors such as drought-resistance, rate of maturity, and others have entered the picture. A variety of bitter cassava which has high favor in Jamaica is locally known as " Catch Thief ". This particular form resembles closely one of the sweet varieties, and is considered by the farmers as valuable in preventing praedial larceny which is too common on the island. It is doubtful that the set of characters included in " Catch Thief " are entirely fortuitous, but rather were selected to give the incautious thief a serious tummy ache.

Today there are few tropical areas of the world where cassava is not of major importance. Any area which is frost free all year, or which has a few light frosts per year is suitable for the plants. Central Africa, where the plants are thought to have been introduced by the Spanish or Portuguese from the New World after the 15th century, has few areas in which the roots do not provide the staple starch. The Pacific Islands, to which the crop was probably introduced by Spanish travelers,(1) are great producers of cassava and the derived product tapioca. The islands of Java, Sumatra and Borneo, prior to World War II, were the main source of the tapioca utilized in the United States. Like Brazilian Rubber, which is in the same plant family, Manihot seems to have caught on and become more important in its adopted land than at its source.

Cassava has been the step-child of agricultural research until very recently. Since it was largely a home-consumed product, without too much importance in our own or in European economy, no intensive work has been done towards its betterment. Compared with the knowledge of wheat, cassava is about one hundred years behind. There has been an upsurge of activity, however, and today many aspects of the study of the plant are being carried out (2), (4).

Very recently it has been shown that the tops of the plant are valuable as sources of proteins, and as such may be used either fresh for human consumption or dried and ground as a meal for cattle. For many years, natives of Africa and Australia have eaten the young green foliage as a vegetable, but curiously enough this is little if at all practised in the New World. Tests in Central America have shown that cattle produce nearly as much milk from a diet of meal from dried yuca leaves and stems as from the best known source of protein, alfalfa. Alfalfa has so far been a failure as far as growth in the tropics is concerned. Similarly, products from one part or another of the cassava plant have been found to be satifactory food for horses, hogs and chickens. Other valuable uses of the plant include production of alcohol, lactic acid, paper pulp, and sauces show that in Manihot utilissima we have one of the most versatile of crops, and one whose full value has not been appreciated.

Bibliography

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PRELIMINARY CONSIDERATIONS ON THE INTRASPECIFIC VARIATION OF MANIHOT UTILISSIMA Pohl

This is a progress report on activities of a somewhat hybrid nature; it is not a report of a finished task. It is fitting that this first report be given on this campus, for it was here in Gainesville, only a few blocks from this spot that I first became aware of the existence of the plants which bear the name Manihot utilissima.

The systematics of cultivated plants has had illustrous beginnings with the outstanding work of such men as Liberty Hyde Bailey, Alfred Rehder, and others. These works, however, have been on the level of the higher taxa generally, and very little attention has been given to the classification of species and lower taxa. Insert from p. 4 This type of problem--of intra- and interspecific classification--had to await the development of more definitive techniques. Techniques for quantitative evaluation of minor differences are generally available now as a result of such work as Anderson's "Introgressive Hybridization" and Woodson's "Some Dynamics of Leaf Variation in Asclepias tuberosa". My work with the intra- and interspecific variation in the genus Manihot is largely an application of these techniques.

To keep away from the knotty problem of correct names, I shall hereafter refer to the group of plants under discussion as "cassava". In the British speaking West Indies, this name refers both to plant and to its products. In Spanish speaking areas of the New World, "yuca" is proper, and in Brazil, either "manioc" or "mandioca" is used. We can't call the group "tapioca plants" for "tapioca" refers only to one of many different products of these plants.

Cassava never has received a thorough systematic investigation: two studies have been made, both consisting of limited scope, and neither with the idea in mind of the problems of evolution, distribution, or other factors which modern taxonomists normally include in their studies. Quite a large number of agronomic studies of such factors as yield, fertilizer application, planting techniques, etc., have been made. These are unfortunately of little general significance since the clones used were not well described nor kept in museum plots to be made generally available for future studies. The same negative statement can be made for any aspect of the study of cassava--none, or few of significance have been made--in genetics, cytology, ethnobotany or archeology.

The cultivated cassava plants (and I have to speak only of cultivated plants since I have not had an opportunity to study possible wild relatives) are shrubs, from about 5 to about 12 feet tall. Most of these at maturity have only a tuft of leaves near the apex of the plant, but some clones are known which maintain their foliage from base to apex of the mature plants. The enlarged tuberous roots, varying in shape, size and number, produce the main source of carbohydrate food for many millions of tropical people. Maturity date of plants varies in varying environmental conditions, and the clones in the same locality are variable as to date when the roots have reached their maximum size and carbohydrate content, but an average figure for maturity of plants is from 8 to 14 months.

The plants are commonly and loosely divided into two categories, based upon the concentration of a cyanogenic glucoside in the roots: one group being known as "sweet" if the content of the glucoside is nil, or very low, and the other "bitter", if the content of the glucoside (HCN, or prussic acid) is sufficiently high to produce harmful effects if eaten before some extraction method removes the prussic acid. This division is very tenuous, the content of HCN supposedly influenced by varying environmental factors. Actually there are no two clones containing exactly the same amount of HCN. The French, in Africa, have classified the plants on the basis of HCN content as (1) "inoffensive", (2) "a little poisonous", (3) "poisonous", and (4) "very poisonous". They fail to say just what represents the point of separation for these categories.

So far, no characteristics of a morphological nature have been established which support the differentiation into two races, subspecies, species or other taxa. Some morphological characteristics may accompany this differentiation into sweet and bitter races but these are minor, and have not yet been proved.

In order to make a comprehensive study of the variation in cassava, it has been necessary to employ some slightly different methods from those used by most

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An important part of the technique is the proper arrangement of data on the herbarium sheet. The "inclusive herbarium" specimen loses much of its value if more than one sheet is required for data and specimen. So far, I have not been able to reduce my specimens to a single sheet, but that it can be done is well shown in another plant almost as unwieldy as cassava, namely corn.

The results of sampling in Jamaica have not yet been analyzed, but some interesting differences showed up when comparing the growth of one clone at the two stations. On one station in dry, hot, irrigated, alluvial soils, the plants demonstrated marked vegetative activity above ground with relatively slow development of the roots, and 90% of all clones remained in the vegetative state (Slide 10 & 11). At the other station on cooler, moister, non-irrigated, red lateritic soils, above ground development was less, while root, flower and fruit development was markedly greater (Slide 12, 13, 14). At the latter station, nearly all plants were attacked by an insect in the buds, causing die-back and heavy production of lateral branches. Now this affects the branching pattern of the plants, I have no data, but this makes one characteristic I had hoped to use- much more difficult to analyze. I had hoped to be able to present results of comparative HCN content at the two localities, but the ag. chemist has not yet completed his analyses, due to some differences in yield according to two different hydrolyzing techniques.

It is much too early to hazard a guess as to the number of, or level of the taxa involved in the complex known as Manihot utilissima. However, with the use of the described techniques, and with the fine attitudes and cooperation given this work as a stimulus, there should be some definite results in the not too distant future.