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CASSAVA PROGRAM REVIEW CONFERENCE

CIAT - Cali, January 10, 11, 12, 1972

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Agricultural and economic development in the lowland tropics

SOME VIEWS OF A PROGRAM OF RESEARCH ON *MANIHOT ESCULENTA*

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Research and development directed at manioc should attempt to capitalize on the characteristics of the crop that give it a peculiar comparative advantage in tropical agriculture. These I take to be the following:

1. High potential yield of food calories per hectare, especially where the plant can occupy the land for 14 to 16 months.
2. Economic yields under relatively poor soil conditions and erratic rainfall regions.
3. Possibility under appropriate farming conditions that most plant nutrients taken up by the growing plant can be returned to the soil.
4. Possibility of low planting and cultivating costs relative to harvesting costs (especially if the plant quickly establishes a good canopy).
5. Relatively low time specificity of harvest.
6. High resistance to pests and disease (with leaf mosaic a notable exception).
7. Vegetative propagation that insures preservation of desired characteristics.

This suggests the following elements in a development program:

1. Strive for high yields *without* fertilizers, irrigation, or pesticides. (This seems to imply broad spectrum resistance, minimum of inbreeding.)
2. Strive for greater understanding of the physiology and ecology of the root system.
3. Explore farming systems that will permit the return of a maximum of nutrients to the soil.
4. Design plants that can be harvested at lower costs (e.g., modify root form and position), reduce height of tops.
5. Seek early establishment of closed canopy.
6. Seek shorter time to economic yield (e.g., 6-8 months).

Aspects of the crop that are not completely understood and that may be or have been shown to be important are:

1. Mosaic disease.
2. Amount of HCN in the products used for food or feed.

It seems obvious that mosaic needs attention, at least in tropical Africa, although the extent to which mosaic reduces yields is not definitely known. More needs to be learned about the possible effects of continued ingestion of small amounts of HCN, both directly and through possible reduction in the availability of sulphur-bearing amino acids. Considerably more information is needed about the nutritional characteristics of the products and about characteristics that are attractive to consumers.

The present character of farming in most parts of the world where manioc is important requires a crop that fits easily into labor-intensive, small-scale operations. The day will come, however, when opportunities will arise for substitution of animal or mechanical power for labor in the cultivation of manioc. This will make the form of the plant increasingly important.

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NOTES ON CIAT CASSAVA PROGRAM REVIEW CONFERENCE

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According to F.A.O. statistics the cultivation of cassava in the whole world has increased considerably in the last 20 years (see table). The cultivated area has increased by 50 percent, the total production has doubled, but the yield per ha has increased only by 14 percent. Comparison with potatoes and sweet potatoes and yams shows that the increase in yield per ha over the last 20 years of these crops has been higher than that of cassava. It is a pity that F.A.O. lumps sweet potatoes and yams together in its statistics, so no comparison can be made between sweet-potatoes and cassava.

There is no apparent reason why cassava should not show the same increase in yield per ha as the other root and tuber crops. It must be noted that after the last world war most research on cassava was either diminished or stopped altogether, as was done in Bogor and Amani. Research on this crop should be resumed as quickly as possible; for Bogor this will take a long time.

Several factors limit cassava production: a) Cassava roots are very often considered as an inferior food, which in a sense it is. b) Cassava is considered as an easy crop, which even on poor soils gives a relatively good yield. It is practically never given any manure or fertilizer. Very often cassava is cultivated on the less fertile soils, and in some regions cassava is the last crop cultivated before the soil is totally exhausted.

Total production and yield per ha can be increased by cultural practices and by use of high yielding cultivars.

Concerning cultural practices, most stress should be laid on the study of the influence of fertilizers on yield and percentage of starch. Also, which element is of the most importance: N, P or K. Moreover, too little is known about the right rotation of cassava with other crops.

Urgently needed is the formation of the largest possible collection of cultivars, imported from all parts of the world (excluding the African continent on account of the danger of importing mosaic or brown spot).

Breeding can be done for higher yield and/or better quality. Better quality means higher amounts of starch and/or protein.

In the case of breeding for starch production, a high percentage of protein will only lead to more water pollution. When breeding for consumption of roots, we should know if the protein present is sufficiently digestable.

Cultivars with edible roots should only contain low quantities of glucoside; with cultivars grown for starch production this is of less importance. Practically nothing is known about the genetics of poisonousness.

From all cultivars used as parents in crossings only a few seem to give satisfactory results. More research in this respect is indicated.

Crossing within the species M. esculenta can lead to new high-producing cultivars; the possibilities in this respect are not yet exhausted. Crossing of cassava with other species of Manihot probably only promises good results when use is made of M. glaziovii.

Area, total production and yield per ha of potatoes, sweet potatoes, yams and cassava

	Av. 1948/52	1968	increase in % of 1948/52	
Potatoes	22.580	22.808	--	a
	247.661	315.451	16	b
	110	138	16	c
Sweet potatoes	10.363	16.029	60	a
and yams	70.061	134.495	95	b
	68	84	23	c
Cassava	6.408	9.794	52	a
	42.775	85.625	101	b
	76	87	14	c

a Area in 1000 ha

b production in 1000 metric tons

c yield in 100 kgs per ha

Production Yearbook F.A.O. Vol. 23, 1969.

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SOME ASPECTS OF CASSAVA (MANIHOT ESCULENTA CRANTZ)

IN THE STATE OF SAO PAULO, BRAZIL

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I. Production and Utilization

The State of São Paulo is one of the principal producers of cassava in Brazil, harvesting in 1971 about 100,000 hectares, which gave a root harvest of 1,700,000 tons for an average yield of 17 tons per hectare.

More than 90 percent of these roots were used in the making of:

a) Chips
b) Chip flour
c) Table flour
d) Starch

These products were sold not only in the State of São Paulo but were also exported to other states in Brazil and to foreign markets. In 1970, for example, Sao Paulo exported 29,329.2 tons of cassava chips as follows:

Country	Quantity in Tons
Holland	7,299.3
United States	2,530.7
Germany	16,031.0
Canada	1,827.7
Belgium	1,703.5
Total	29,392.9

II. Principal factors which limit the production and utilization of cassava in the State of São Paulo, and studies needed

Agronomic problems exist, but none of them can be classified as the main impediment to production and utilization of cassava in the State of São Paulo.

The problems which presently impede progress within the cassava industrial sector in the State of São Paulo are those related to existing commercial, industrial and administrative structures, as well as those caused by attitudes presently taken by industrial businessmen in relation to the farmer.

Such structures and attitudes are direct and indirect consequences of historical facts dating back to practices in the agro-industrial sector of the State of São Paulo, which created a large number of small, out-of-date industries with obsolete and inefficient business policies. These practices bring about high production costs which impede exportation of the product, as well as development of new lines of cassava products, such as pre-gelatinized cassava. There is a large external market and a growing internal market for these products but they are presently dominated only by maize producers.

A grouping of these small uneconomical businesses, including the farmers, would be a solution to these problems.

Consortia to commercialize and standardize products destined for both internal and external markets are needed to lower costs and prohibit competition among firms. Modernization of methods and machinery through government financing is indispensable in bringing about a radical change in local attitudes and causing a considerable increase in the level of knowledge of producers. Without this the present situation will continue indefinitely.

Agronomic problems caused by the bacteria *Xanthomonas manihotis*, attacks of the sprout larvae *Silva pendula*, associated with a lack of crop rotation, weeding, poor soil preparation, poor selection of fertilizers and inadequate or even non-existent fertilization, all contribute to limiting the production and utilization of cassava in the State of São Paulo. Most of the time the farmer carries out neither fertilization nor weeding operations, for fear of losing money spent in these operations, since the prices paid for roots vary greatly, as can be seen in the following table:

Agricultural Year	Index of Deflated Price of Roots
1947/48	100
1948/49	122
1949/50	204
1950/51	206
1951/52	212
1952/53	284
1953/54	180
1954/55	140
1955/56	160
1956/57	170
1957/58	131
1958/59	120
1959/60	104
1960/61	150
1961/62	273
1962/63	172
1963/64	112
1964/65	89
1965/66	103
1966/67	173
1967/68	150

III. Situation of Cassava Research in the State of São Paulo

The Agronomic Institute of the State of São Paulo, located in Campinas, continues to carry out, as it has for more than 30 years, research related to cassava. Present projects include:

1) Genetic improvement by natural and artificial crossing. The Institute is trying to unite desirable characteristics found in different varieties of its collection, and has already arrived at rather significant results. Current varieties will soon be substituted by other improved varieties.

2) Fertilization. The Institute is studying the most adequate time and manner of providing chemical fertilizers for cassava.

3) Botanical characterization of the several cassava cultivars presently in the collection.

4) Identification of cultivars with resistance to shoot larvae.

As to possibilities of cooperation between the Agronomic Institute and CIAT in a cassava program, I would not like to make any comments at this time, as I am no longer a member of the Institute; however, I believe there would be few problems, since the Agronomic Institute of Campinas is presently carrying out similar activities.

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CASSAVA IN FRENCH-SPEAKING AFRICAN AND MALAGASY COUNTRIES

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I - Present state of production andutilization of cassava in Africa

1.1 Production

Cassava production in Africa represents about 34 million tons, or 39 percent of the estimated world production of 86 million tons.

Production in French-speaking Africa (including Madagascar and excluding Zaire) is 6.5 million tons. The figure was 4.6 million tons twenty years ago, thus there has been a 40 percent increase in production. During the same twenty-year period, the total population increased from 31.3 million to 44 million inhabitants, also a 40 percent increase.

The increase in cassava production has, therefore, on the average, followed the population increase.

However, if a distinction is made between the countries in the Guinean zone (Ivory Coast, Togo, Dahomey, Cameroon), where cassava is a staple food for a large part of the population, and the countries in the Sudanian zone (Senegal, Mali, Niger, Upper Volta, Tchad), where the populations are essentially consumers of cereals, it is established that cassava production has increased more vigorously in the savanna countries than in the humid African countries.

		1948-52	1966-69	Increase
Countries in the Sudanian zone	Population (1)	15.7	20.5	+ 31 %
	Cassava (2)	262	720	+ 174 %
Countries in the Guinean zone	Population (1)	9.3	14.3	+ 53 %
	Cassava (2)	2300	3400	+ 48 %

(1) Millions of inhabitants

(2) Thousands of tons

Observations on other French-speaking countries:

a) In equatorial Africa (Central African Republic, Gabon, Congo) the evolution of cassava production has exactly paralleled that of the population

	1948-52	1966-69	Increase
Population	2.1 (1)	2.75	+ 30 %
Cassava	1176 (2)	1545	+ 31 %

b) In Madagascar there has been a sharp increase in population while cassava production has remained stationary

	1948-52	1966-69	Increase
Population	4.2 (1)	6.4	+ 52 %
Cassava	866 (2)	882	+ 1.9 %

1.2 Utilization

For the most part cassava is directly consumed by humans, except in Madagascar and in Togo where it undergoes a certain industrial processing (starch) with a view to exportation.

In Madagascar, the amount processed into starch is sharply decreasing:

In 1950, 40,000 tons of starch were processed out of a total of 866,000 tons of cassava.

In 1971, 12,000 tons of starch were processed out of a total of 882,000 tons of cassava.

In Togo, a starch-works built in 1953 processes today 25 to 30,000 tons of roots.

Among the countries under consideration, only in Madagascar is cassava used as feed for animals, a usage which is increasing, though still on a small scale.

Cassava is, therefore, largely reserved for human consumption.

In those regions where it still serves as a staple food (wet areas of Africa) it is used in culinary home preparations (gari, foufou, chikouangues, etc.), a form of preservation which may be marketed.

With the projected urban development in Africa (an increase of 300 percent by 1985 as opposed to only 50 percent for the rural population) which will result in the cities representing 44 percent of the population in the country regions, there will certainly follow an industrialization of these traditional dishes.

In countries traditionally relying on the consumption of cereals, cassava is essentially used as a famine crop and for breaking the hungry-gap when the cereal stocks of the preceding harvest are depleted. But it appears more and more in human nutrition as a variety food, most often boiled as a vegetable. It is found in a form permitting preservation and commercialization. Commercialization in the form of fresh roots exists but only to a limited extent.

1.3 Systems of production

Production on large farms is very limited. This occurs only in Madagascar with a view to supplying starch works. However, its importance is decreasing.

In general, cassava is cultivated by hand in family farms and the system used is most often shifting cultivation.

In the Sudanian zone of Africa, cassava is grown in small gardens around the village or in plots preserved from straying animals; at the beginning of the growth period annual plants are frequently interplanted between cassava cuttings.

In the Guinean zone we can distinguish:

1. The forest areas, newly populated, where cassava is still the staple food. In these areas cassava is found most often in mixed culture with:

* A perennial cash plant (coffee-tree, cacao-tree).
* Perennial (banana-tree, plantain) or annual food crops.

Mixed cropping with perennial cash or food crops accounts for 75 percent of the area under cassava in South East Ivory Coast.

2. In the relatively populated areas where the forest has been destroyed, manioc tends in general to be replaced by other food crops.

Generally a three- to five-year rotation of various crops, particularly cereals, with planting of cassava cuttings in the last crop of the succession, is observed. This cassava crop is practically not weeded; it is harvested, depending on the needs, in the shrub fallow regrowth.

When the density of population becomes very high this cropping system evolves into continuous cultivation without fallow. On rich soils (West Cameroon) multiple rotations (maize, legumes, aroids, yam) and little cassava are found; on the contrary, on poor soils (South East Togo) maize is regressing in favor of the hardier cassava.

The yield of normal density crops (as a pure stand or in temporary mixed culture with short duration species) is about 5 - 12 t/ha depending on the care given to the crop and the ecological conditions. These crops require from 80 (and even less in some cases) to 150 days of work per hectare.

II - Limiting factors

The factors limiting production are economic: limited foreign markets and rather high home prices, generally higher than the prices of processed export products (starch, animal feedstuff).

Undoubtedly production for domestic consumption will keep increasing. It will not increase as quickly as the overall population (cereals competition), but probably more rapidly than the rural population (urban demand). Thus the farmers will be led to increase their productivity.

In the present state of the cropping systems, an increase in productivity (yield from 15 to 25 t/ha) can be obtained easily in using known cultural practices and improved varieties. With inevitable mechanization there will be a fixation and modernization of cultivation. The industrialization of the products which are now processed on a family scale will require the fixation of at least a part of the crops in a limited geographical area.

So far the countries and research organizations have not considered the improvement of cassava crops in Africa as a priority objective. But the exceptional potential of the species and the foreseeable evolution of production must be an incentive to research development.

Research must have the main following targets:

Varietal improvement: High-yielding varieties with a high starch and protein content, and resistance to diseases, more particularly to mosaic.

So far selection has been faced with a lack of knowledge of:

* The plant physiology (formation and storage of amylaceous reserves, type of plant to be selected).
* The genetic determinism of the desirable characters.

Mosaic control: Here again basic knowledge is required.

* Behavior of the virus in the plant (concealed or localized symptoms in a part of the plant, development of sound plant material).
* Knowledge of the virus concerned.

Technology: Study of the industrialization of cassava-based food products.

III. Organization of research on cassava in I. R. A. T. agencies in Madagascar

Since 1960, I. R. A. T. has been pursuing in Madagascar the work previously carried out by M. Cours for several years on the genetic improvement of cassava, this research directed at the requirements of small farmers rather than those of large plantations.

At present a set of high-yielding varieties, mosaic resistant and adapted to various ecological conditions and outlets, is available in Madagascar.

Simultaneously, the best crop cultivation and fertilization methods have been specified for different situations.

The focus of attention in the actual agronomic work is on the search into a mosaic resistance which would be lasting and effective under different ecological conditions.

African countries of the Guinean zone

For several years I. R. A. T. has carried out some studies on cassava (variety choice, crop cultivation methods) in Central African Republic and in Gabon. It is working on this species in Ivory Coast, Togo, Dahomey and Cameroon.

At present this work concerns more particularly:

* The study of local and foreign variety collections, especially varieties developed in Madagascar.
* The choice of adapted varieties.
* The study of cropping calendars.
* The development of production methods (cultural practices and fertilization).

African countries of the Sudanian zone

For some years I. R. A. T. has been carrying out work on cassava especially in Senegal and Niger.

In Senegal, where no mosaic is observed, selection was made from seeds of various origin and the best crop cultivation methods were specified. In Niger the collections of local and introduced varieties were studied.

At present, the interesting varieties are maintained in collection in the two countries.

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CASSAVA IN THE CARIBBEAN, AND POSSIBLE CASSAVA RESEARCH AT THE FEDERAL EXPERIMENT STATION

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The majority of the islands of the Caribbean are divided by mountain chains or characterized by mountain peaks, which influence the pattern of rainfall, and thus provide each island with a variety of climates. The crops produced in these islands are thus highly varied, so that no single starch-producing crop can be considered a staple of the whole region. Cassava is utilized on all of the islands and is a staple food in a few limited areas. Most plantings are made for home use or for selling or trading in very limited local markets. In the Dominican Republic a limited starch-producing facility exists. Frozen cassava is also frequently marketed. Nevertheless, cassava cannot be considered a major crop of the Caribbean.

Because cassava is generally grown on a small scale in most places of the Caribbean, the agronomic systems used are not adequate for realizing the full potentials of this crop. Nevertheless, systems well known in other areas should be directly applicable to Caribbean areas, if needed. The varietal situation,on the other hand, is confused. A large number of varieties exist which are poorly defined with respect to names and characteristics. Such varieties are not distributed uniformly. Introduction of varieties and replicated testing could rapidly relieve this situation, and provide superior varieties for current uses.

The principal factors limiting production, other than agronomic factors, are insect pests. A fly (Lonchoea chalybea W.) that attacks the shoot tips of cassava causes deformation of the plant and limits the use of the stems for replanting. Attacks of this pest can be considered normal in Puerto Rico, but may occur late enough in the season to avoid extensive damage. New plantings can be severely stunted. The systemic insecticide Cygon, when applied at the rate of 5 mg/gal water and sprayed lightly, controls the maggot for 15 days, when new spraying is necessary. In practice, we use spray only to protect young plants. Mature plants yield well even when heavily infested. A low level of varietal resistance has been found, and searching may yet turn up still more resistance.

A second serious pest is red spider, which seriously damages mature plants, especially during the dry season. Older leaves are weakened, and developing leaves are malformed by this pest. Yields may be drastically reduced by severe attacks. Nevertheless, rains bring relief from this problem and infested fields may return to good condition. Miticides give temporary relief from red spider, but if conditions are favorable mites continue to multiply and apparently acquire some resistance. Thus, the miticide must be changed frequently. We have not yet found resistant varieties.

We have not seen virus diseases of cassava in the Caribbean. Although preliminary tests in England revealed virus-like particles, extensive trials fail to confirm the presence of the important viruses of Africa and of South America. We seldom see any severe disease in cassava plantings.

In the Caribbean very little research is now under way with cassava and very little is likely to be planned for the future. A limited amount of varietal testing and some improvement of agronomic techniques are desirable. At the Federal Experiment Station we have developed a small collection which has been shared with CIAT. Some of these varieties produce impressive yields. We are reducing the size of the collection each year, so that we shall eventually maintain only the better varieties for our area. Seeds are produced freely in the Caribbean, and seedlings are impressive in their vigor. Both self- and cross-pollination occur..

Our present root crops program emphasizes the yam and its possibilities. We are committed to an introduction, screening, and developmental program that will probably last at least 5 more years. Meanwhile, we hope to develop a fundamental program in cassava genetics and cytogenetics. In such a program we would emphasize Manihot species, their characteristics, breeding potential, and crossability. With this prospect in mind we are beginning now to collect species, and need much help in this direction.

If a good collection of species can be assembled, we anticipate the following studies:

1. Morphology of the plant and its roots in comparison to cassava. Identification of desirable characteristics.
2. Disease and virus susceptibilities of the species.
3. Life cycle, season of flowering, breeding system, time and amount of tuberization.
4. Starch and protein characteristics, including amino acid balance; hydrocyanic acid contents.
5. Species adaptation, tolerance of climatic extremes.
6. Chromosome numbers and behavior.
7. Crossing techniques, pollen viability and storage.
8. Crossability of species, barriers to crossability.
9. Characteristics of F_1 and later generation hybrids.

THE STATUS OF CASSAVA (MANIHOT ESCULENTA) AND CASSAVA RESEARCH IN THE COMMONWEALTH CARIBBEAN

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A. Production and utilization of cassava and cassava products

The Commonwealth Caribbean countries include both the island states of Jamaica, Trinidad and Tobago, Barbados, Dominica, Greneda, St. Vincent, St. Lucia, Antigua, St. Kitts-Nevis-Anguilla and Montserrat, as well as the mainland states of Guyana and Belize (British Honduras). These countries have recently formed a free trading area (CARIFTA).

Cassava is not an important crop in the Commonwealth Caribbean, as is exemplified by the absence of any substantial interterritorial trade in cassava and cassava products in the region.

Cassava is, for the most part, grown on the holdings of small farmers (1-5 acres) as part of an indigenous intercropping system of agriculture designed to produce a supply of food for family consumption. The surplus from these small plots usually reaches the market place, where fresh tubers are sold at prices ranging from EC 10 cents to 30 cents per pound.

Cassava, sold in this way, is used in Caribbean households either boiled as a starchy vegetable or for making cassava bread, wafers, puddings (pone) or farine (flour). Such use of cassava tubers has, however, declined considerably in the last thirty years with the importation and subsequent local manufacture of convenience foods.

It is significant that although breadfruit and plantains have been used to manufacture convenience foods, the traditional home-made cassava products have generally not found their way to the factory. The production of 'casseripe' (a meat preservative) in Guyana is a minor exception. Manufacture of 'casseripe' in Guyana has, in recent years, moved from the hands of Amerindians, where it originated, to a wider section of the Guyanese population and is now bottled and marketed by a Cooperative.

Jamaica is the only country in the Commonwealth Caribbean for which national production figures for cassava are readily available. Total annual production,here, varies from 10,000 - 18,000 tons produced on some 3,000 - 4,000 acres. (Rankine 1971) (see App. 1). All of the crop is used for internal consumption and the farmgate value of the total crop is in the region of EC $1,300 - $2,600.

In Guyana, apart from a single large holding of cassava of some 70 acres on the intermediate savannahs, production is by small farmers. National production figures are not available.

In other countries of the Commonwealth Caribbean, cassava production is not documented but is most likely smaller than in Jamaica and in Guyana.

It would seem that there has been a considerable decline in cassava production in the Commonwealth Caribbean since the 1940's, at which time there were cassava starch-producing factories in Jamaica, Trinidad and Tobago and in Belize (British Honduras). The reduction in arrowroot production in St. Vincent, despite the accepted high quality of arrowroot flour, is a parallel case of the decline of a root crop-based agro-industry.

B. Principal factors limiting cassava production and utilization in the Commonwealth Caribbean

The principal factors limiting cassava production in the Commonwealth Caribbean include:

1. Failure to develop efficient methods for industrial utilization of the crop.
2. Relatively high cost of production of cassava tubers due to:
   (a) High labor costs.
   (b) Insufficient knowledge in the application of techniques of production to the cassava crop, e.g., cultivation, harvesting.
   (c) Failure to develop a high yielding variety of short crop duration with tubers and tuber distribution suitable for mechanical harvesting.

3. Relatively small acreages of available arable lands in the island states of the Commonwealth Caribbean.
4. The assumed necessity for cassava to compete for available arable lands with more established crops.

In the face of these constraints, it is felt that the research needs for cassava in the Commonwealth Caribbean are:

1. A multidisciplinary research program aimed at:
   (a) Increasing production and productivity of the cassava crop by introduction of both superior varieties and improved methods of cultivation, designed for fertile as well as marginal lands.
   (b) Demonstration of the economic and technical feasibility of already developed methods of industrial utilization of cassava starch, e.g., animal feeds, wheat flour substitution, dextrins, adhesives, etc.
   (c) Development of new methods of industrial utilization of cassava starch relevant to the Commonwealth Caribbean, e.g., in oil and bauxite mining.
2. Encouragement of Ministries of Agriculture, farmers in the private sector, and industrialists to cooperate in the development of a cassava agro-industry designed to reduce as much as possible the importation of starch and starch products into the Commonwealth Caribbean. Such cooperation is envisaged even at the research stage of crop development.

C. Cassava research in the Commonwealth Caribbean

Although there has been little research on cassava in the Faculty of Agriculture, U.W.I. (St. Augustine) considerable experience has been gained in investigations on other root crops, e.g., yams. (*Dioscorea alata*) sweet potatoes *Ipomoea* (*batatas*) and Aroids (*Xanthosoma* spp.) have clarified the research objectives and the approach necessary to achieve them in root crops, including cassava.

Despite the absence of a Cassava Research Program at St. Augustine, small but significant research projects on the crop have been started as follows:

1. Cassava leaves have been rooted by Dr. J.A. Spence. (see App. 2).
2. Available local cassava varieties have been cultivated by Mr. P. Haynes.
3. Nitrate reductase activity has been demonstrated in cassava leaves despite high levels of HCN therein, by Dr. L.A. Wilson.

In addition, a preliminary analysis of cassava production in Jamaica has been completed by Rankine and Hee Hong (1971).

The use of rooted leaves initially developed for studying metabolism in sweet potato varieties at St. Augustine by Wilson (1967) provides an elegant 'phytomodel' for examining carbohydrate metabolism (Wilson 1967), tuberisation (Wilson 1971) and photosynthesis (Spence 1971), which could now be applied to the cassava species.

The technique lends itself to rapid screening of large numbers of cassava cultivars for the above mentioned parameters of growth and development. Recent demonstration of nitrate reductase in cassava leaves now adds nitrogen metabolism to the parameters that may be easily examined using the rooted leaf technique.

In the only analysis of cassava production in the Commonwealth Caribbean, Rankine and Hee Hong (1971) showed that the average yield of cassava in Jamaica was low (2.8 - 5.4 tons/acre).

In view of the relatively small acreages of arable land in the region, it is felt that cassava production in the Commonwealth Caribbean must be based on intensive cultivation practices, using high yielding varieties.

Ministries of Agriculture in the region have also hitherto neglected cassava as a crop deserving serious consideration. The collection of national production data for the crop in Jamaica and the development of a mill for 'chopping up' cassava tubers suitable for use by small producers in Trinidad (Percy and Redman 1965) are, however, signs of increasing interest in the crop.

More recently, proposals for funding a multidisciplinary Root Crop Research Program have been made by the Faculty of Agriculture U.W.I. (St. Augustine) to the IDRC. This program includes a cassava investigation component in which the following areas of work are envisaged:

(a) Breeding of superior varieties in terms of:

(i) Higher yields on a range of soil and climate conditions.

(ii) Shorter crop duration.

(iii) More efficient shoot/tuber ratio.

(iv) Tuber shape and distribution more suitable for mechanical harvesting. (Lowe 1971.)

(v) Disease and pest resistance.

(b) The agronomy of the cassava crop including more efficient methods of cultivation of existing varieties and new cultivars.

(c) The physiological potential of the cassava species including:

(i) Examination of the consequences of artificial alteration of shoot/root ratios with growth substances.

(ii) Examination of the mechanism of tuber initiation and tuber growth and development in cassava varieties in relation to final yield.

(d) Biochemical parameters of high tuber yield including enzyme systems, specific proteins and other plant metabolics. (Imbert and Wilson 1970, 1971.)

(e) Utilization of cassava tubers for pig feeding and cassava flour for bread making using already existing technologies as far as they are applicable to Caribbean conditions.

It is planned to include Ministries of Agriculture in the Commonwealth Caribbean in research studies at their onset so as to facilitate subsequent government participation in the development of the crop in the region using research results from the program. The project proposal to IDRC also includes close collaboration with CIAT, particularly in the fields of animal nutrition and plant breeding. The Root Crop Program of the Faculty of Agriculture is, however, willing and able to enter into joint programs of research in any of the areas of work in which it is engaged. (see Report Root Crop Program 1970. App. 3.)

ACKNOWLEDGMENTS

The author wishes to thank Dr. L. B. Rankine of the Department of Agricultural Economics, and Farm Management, (U. W. I. St. Augustine) for making available data on cassava production in Jamaica, while a paper on the subject was in preparation. The provision of a photograph showing a rooted cassava leaf by Dr. J. Spence of the Department of Biological Sciences (U.W.I. St. Augustine) is gratefully acknowledged.

REFERENCES

Imbert, M. P. and Wilson, L. A., 1970. Stimulatory and inhibitory effects of scopoletin on IAA oxidase preparations from sweet potato. Phytochem, 9, 1787-1794.

Imbert, M. P and Wilson, L. A., 1971. IAA oxidase preparations from sweet potato roots, (1) pH optima of different enzyme preparations. Phytochem (in press)

Lowe, S. B., 1971 Tuberization in sweet potato (Ipomoea batatas (L) Lam) M. Sc. thesis U. W. I. Library, St. Augustine, Trinidad.

Percy, M. J. and Redman, S., 1965. Development of a cassava mill for small processors. Trop. Agric. Trinidad, 42. 2. 105-109.

Spence, J. A., 1971. Cultivation of detached sweet potato (Ipomoea batatas) leaves for photosynthetic studies. Photosynthetica 5. 4. 424-425.

Rankine, L. B. and Hee Hong, M., 1971. A preliminary view of cassava (Manihot esculenta) production in Jamaica. Department of Agricultural Economics, Farm Management, Faculty of Agric., U. W. I., St. Augustine.

Wilson, L. A., 1967. The use of rooted leaves and grafted plants for the study of carbohydrate metabolism in sweet potato. Proc. Inter. Symp. Trop. Root crops. 1, 46-57.

Wilson, L. A. 1970. . The process of tuberisation in sweet potato (Ipomoea batatas (L) Lam). Proc. 2nd Inter. Symp. Trop. Root and Tuber Crops, Vol. 1. 24-26.

APPENDIX I

ESTIMATES OF PRODUCTION AND ACREAGE OF CASSAVA 1965 - 1968

J A M A I C A

	Quantity Reaped (short tons)				Yield per Acre (short tons)			Acreage Reaped Acreage Reaped			
	1964	1966	1967	1968	1965 - 66	1967	1968	1965	1966	1967	1968
Cassava (bitter)	6626	10178	13567	6606	3.50	5.43	4.06	1778.9	2908	2498	1631
Cassava (sweet)	2816	3400	3307	2679	2.80	3.72	3.05	1005.7	1214.25	888	876

ESTIMATE OF PRODUCTION 1968 VOLUME AND VALUE @ FARMGATE

CROP	TOTAL VOLUME	VALUE PER SHORT TON £	TOTAL VALUE £
Cassava, Bitter	6606	25	165,150
Cassava, Sweet	2679	33.3	89,300

from Rankine and Hee Hong (1971)

THE STATUS OF CASSAVA PRODUCTION, UTILIZATION AND RESEARCH IN SIERRA LEONE

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Cassava is the second most important crop in Sierra Leone; its importance in relation to the rest of root and tuberous crops is emphasized by the following data:

Table 1 Patterns of cultivation and cultivated acreages in Sierra Leone

Crop	Acres		
	Pure Cropping	Mixed Cropping	Total
Cassava	23,000	374,600	397,600
Sweet potato	2,400	21,300	23,700
Cocoyam	100	28,900	29,000
Chinese yams	-	2,200	2,200

Table 2 Patterns of cultivation and acreages in the Provinces

Crop	Southern Province		Eastern Province		Northern Province	
	Pure Cropping	Mixed Cropping	Pure Cropping	Mixed Cropping	Pure Cropping	Mixed Cropping
Cassava	7,300	146,700	2,700	115,900	13,000	112,000
Sweet potato	400	10,300	400	9,000	1,600	2,000
Cocoyam	100	13,200	-	15,000	-	700
Chinese yam	-	2,200	-	-	-	-

Source: Agricultural Statistic Survey of Sierra Leone 1965/66.
Table 26, Central Statistics Office, Freetown, March 1967.

Table 3 Cassava crops reported, grown mainly for consumption and sale for Sierra Leone and by Provinces

Sierra Leone		Southern Province		Eastern Province		Northern Province		Western Area	
% Consumption	% Sale	% Consumption	% Sale	% Consumption	% Sale	% Consumption	% Sale	% Consumption	% Sale
85	15	84.3	15.7	79.2	20.8	93.0	7.0	100	-

Source: Agricultural Statistic Survey of Sierra Leone 1965/66. Table 25, Central Statistics Office, Freetown, March 1967.

Table 4 Quantity and value of cassava production

Year	Production (000 tons)	Value (000 Le)
1967/68	60	3360
1968/69	60	3360

Source: National Accts. of Sierra Leone 1963/64 to 1968/69. Pp. 42-3 Central Statistics Office, Freetown, June 1970.

Utilization

Both *M. esculenta* (Crantz) and *M. utilissima* (Pohl.) are used for food.

Bitter cultivars available in the country are: Kande, Cotton Tree, Kanda Bendu. They are either cooked for 3 days, placed again in water and reboiled and then eaten as boiled cassava or they are processed into foofoo, gari and starch.

Sweet cultivars available in the country are: Mayube, Two-cent, Kono, Cocoa. Two-cent corresponds to the Kru cultivar in Ghana; Cocoa corresponds to Queen in Ghana and is very popular. They are used for foofoo, gari, starch and as boiled cassava. Foofoo, gari and starch made from bitter cultivars are believed to taste better than sweet cultivars.

Foofoo is prepared by soaking the peeled cassava and grating through a mesh; pulp is bagged and weighted to extrude the hydrocyanic acid, and allowed to ferment for 3 - 4 days. The residue is pounded, mixed with water and strained. The solution is allowed to settle, the supernatant solution drained and the residue steam-cooked. Gari (farmina) is prepared by peeling the cassava, grating through a mesh, bagging the pulp and weighting it for 3 days to remove hydrocyanic acid and starch before being roasted in a hot pan.

Research

Agronomic research on age of planting setts, cutting length, planting time, spacing, planting depth and type of planting has been done and information is available on all these.

The two most urgent problems facing Sierra Leone are the fertilizer requirements of cassava on the most widely-spread upland soils, and the mosaic virus which is rampant in the country. The nature of the upland soils has been described by Odell & Dijkerman (1967). Experiments to determine the fertilizer requirements of cassava in rotation and on newly cleared land in relation to tuber yields, root density and starch yield have been established. Selection of mosaic resistant, high-yielding cultivars is taking place and it is hoped that mosaic-resistant cultivars will be virus-indexed by the field serodiagnostic method of Ganguly et. al. (1970) and mosaic-free material certified and multiplied for farmers. This mosaic disease is posing a serious threat to the cultivation of cassava in Sierra Leone.

REFERENCES

1. Ganguly, B., Raychaudhuri, S. P., & Sharma, B. C. (1970). Serodiagnostic method for detecting mosaic infected cassava plants in field. Curr. Sc. 39; 8:191.

2. Odell, R. T. & Dijkerman, J. C. (1967). Properties, classification and uses of tropical soils with special reference to those in Sierra Leone, Njala University College, University of Sierra Leone.

A PROPOSED CASSAVA IMPROVEMENT PROGRAM

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In Africa, about 30 million tons of cassava are produced annually on about 5 million hectares. This comprises about 35 percent of the production and approximately 50 percent of the area devoted to this crop throughout the world. About 80 percent of the production and 70 percent of the acreage of cassava in Africa is grown in tropical West Africa. In this region cassava is often used as a preferred staple food and is regarded as the most important among the root and tuber crops including yams, cocoyams, and sweet potatoes.

Cassava is primarily used as human food in tropical Africa and to a much lesser extent for livestock feed and industrial purposes. The most important and preferred food preparations in tropical West Africa are gari and fufu but it is also often eaten boiled and roasted, though to lesser extent. Moreover, cassava leaves are frequently cooked as a leafy vegetable in this region.

The principal factors limiting production in tropical Africa should be viewed in relation to technical and socio-economical factors. Perhaps the most urgent need is for the varieties with high yielding ability, fertilizer responsiveness, early maturity, resistance to the major diseases (especially cassava mosaic virus) and insect pests, and suitable for mechanization and processing. Agronomic practices including cultivation, high applications of fertilizer and use of agricultural chemicals are not well developed. There are many complex technical and socio-economical factors involved in changing the basic traditional farming system or shifting cultivation to permanent cultivation. Most of the agricultural improvement effort has been focused on export crops, resulting in comparative neglect of the major food crops, such as cassava. Transportation, marketing systems, and processing are also limiting factors. Power for cultivation is frequently unavailable; even draft animals are seldom used. Agricultural education, research and extension are less developed. Generally there is a shortage of qualified manpower for farming.

The research goals at IITA will be to improve varieties maximizing productivity per unit of area and time; develop widely adapted plant types responsive to intensive management and more efficient carbohydrate assimilation; breeding genotypes better suited for mechanization; incorporating resistance to major diseases and insect pests; and introducing better quality and nutritional values. Cultural methods and cropping systems will be studied intensively. Soil fertility maintenance and/or improvement, plant protection, identification of the physiological parameters basic to yielding potential would also be important problems to be dealt with. Investigations on the possibilities for processing and mechanization of cultural practices and on the socio-economical aspects mentioned earlier together with studies on immediate and longer term production economics will also form important components of this program.

Cassava improvement at IITA includes the disciplines such as Agronomy, Breeding Entomology, Plant Pathology (Virology), Plant Phisiology, and Biochemistry. In addition to these fields, it will be supported by Agricultural Economics and Agricultural Engineering. Investigations on this crop at the Institute were initiated in May 1971 with major emphasis on germ plasm collection and breeding for resistance to diseases (CMV) and insect pests, higher yields, earlier maturity, more efficient plant types, wider adaptation, and better quality of product for food and industrial purposes. Improved cropping systems including cassava, favorable environmental factors,the possibilities for food processing, mechanization of cultural practices and socio-economic aspects associated with cassava production will also be studied.

IITA is located in the most ideal place to test for resistance to cassava mosaic virus under field conditions. Therefore, major emphasis will be placed on identifying and incorporating resistance to the disease. Improvement of nutritive qualities and aspects of protein complementation and supplementation principally from plant sources (grain legumes) will also receive major attention from the outset. The Institute will attempt to develop the most modern and efficient breeding system in meeting these objectives on both the qualitative and quantitative levels. Specific methods will include recurrent selection through population improvement, wide (interspecific) crossing, selecting and testing over a broad range of environments, and "chromosomal engineering".

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NOTES FOR CIAT CASSAVA PROGRAM REVIEW CONFERENCE

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Research endeavors, results, and areas of cooperation

A. Major research areas. Over the last 19 years I have devoted my research efforts with cassava to three major endeavors. These are: (1) basic botanical research (classification), (2) computer systems development, and (3) integrated research systems (or systems analytic approaches). In addition, I am at the moment in the process of writing a general book on cassava, in the style of the World Crop Series of texts.

B. Basic botanical research. In this area, I have had the objective of discovering the parameters of variation within the cultivated *Manihot esculenta* complex, and to imbed the cultivars within a classification scheme of general applicability no matter in what geographic area the variations are found. As a necessary corollary to this objective, it was necessary to make a classification of all the species of the genus *Manihot* to show the relation of the cultigen to its wild congeners. I felt that such a basic study was needed as a prerequisite to future work in plant-breeding, and other important agricultural efforts. My classification provides information on the kinds of variations that occur in the tropics of the Western Hemisphere, where these variations occur, and how the variations are related within the complex. I have sampled the variation in most of the growing areas within the Western Hemisphere, from the West Indies, Mexico and Central America, and South America. Five hundred population samples representing variation in many habitats and countries have been collected, and these formed the basis for making the classification. Representatives of these samples are maintained as herbarium specimens which are now deposited in the herbarium of the National Arboretum, Washington, D. C., and may be consulted by any worker who wishes to use them.

Since much of the variation within the cultivated species is apparently caused by hybridization with various wild species, I also felt that it was important to show the relations of the cultivated species to the numerous wild species in the genus Manihot. To accomplish this classification, I collected samples of wild species in many of the areas where they are found as natives. In addition to my own samples, I studied 4,500 herbarium collections from most of the world's important herbaria. Previous classifications of the genus were completely inadequate, and much confusion occurred because the precise limits of the species had not been established. Classification of both the cultivars within the species M. esculenta and of the species in the genus Manihot was accomplished using computerized systems.

As a result of these endeavors, I have completed the classification of the cultivars of M. esculenta, and the manuscript is in the hands of the editor of the journal Economic Botany. The manuscript for the species of the genus is in its final writing stage, and will soon be submitted for publication.

The classification work is important in that it provides documentation for the types of variation that exist in the cultigen and its wild relatives. The documentation does not claim completeness-- that can only be achieved by continued effort, and I see this continuation as one of the areas for cooperation. If we continue work on classificatory documentation, we can be more assured that the work of individuals in various areas can be correlated with the results of others. This should prove important in plant breeding and other improvement procedures. Furthermore, with the knowledge at hand, I can aid by recommending certain types of cultivars and wild species to be used in breeding programs, and by more efficiently collecting propagating material. The documenting system also makes the work of gene banks more efficient.

C. Computer systems development. I shall not give a lengthy description of this work, but describe only the major aspects of it. I undertook the development of programs for computers tailored for studies of cassava in order to be able to deal with the very large data banks necessary to study the crop in an efficient and objective manner. The three major computer programs give cassava workers an opportunity to correlate their data, determine inter-relationships between hybrids or other groups, and to store and retrieve information rapidly. These programs, of course, require large scale computing facilities, but by appropriate scheduling, users can be given service from nearly any point where workers are. The computer programs are very powerful allies to the work mentioned above, and I should be glad to offer these services in aiding the development of cassava research.

D. Integrated research systems. Over the past few years, scientists have found that their own work is integrated into developments more rapidly if they work as members of interdisciplinary teams, where the problems of development dictate the actual direction of the research to be accomplished. For example, the work of nutritionists is much more meaningful in producing balanced diets if these scientists work in conjunction with economists, plant or animal breeders, anthropologists, social and medical scientists. The aim of producing adequate diets in countries with high carbohydrate and low protein food resources is best accomplished when the nutritionist is aware of the potentials in the marketplace and the potentials from various native resources of usual and unusual food substances. The plant breeder can gain better perceptions of his breeding objectives in the same manner. I recently worked in the Congo with nutritional biochemists, market research specialists, and biologists, in the development of a system to provide high protein supplements for children in an area with a largely cassava-based diet. In this milieu, it was discovered that the objectives of plant breeding should be focussed on disease resistance of cassava cultivars (particularly to mosaic viruses), and that no attempt be made to breed higher-yielding protein in the roots of cassava because the protein requirements could best be met by combining other local resources, such as leguminous crops, the foliage of cassava, dried fish, and even dried caterpillars (a local delicacy). Cassava itself could be a better source of proteinaceous material if there were more development of post-harvest fermentative processing techniques, a process requiring the skills of microbiologists, food technologists, and students of systems analysis. Each discipline gains better insight into its own research priorities when each is integrated through the efforts of the systems analyst. Of course, the basis of all such endeavors requires that information exchange is accurate and rapid. Since we must realistically anticipate that cassava workers will not all be assembled in one research and development facility, the need for information exchange becomes more imperative. We have made an informal design for an information exchange system amongst cassava (and other root crop) workers, but have gone no further with implementation. Hopefully, we can aid in the development of such an exchange system.

Summary

We now have a basic botanical classification structure for the improvement of the plants in the cassava gene pool. We know something about the relationships within the species complex and between the cultigen and its wild relatives. Actually, this is a bare-bones system which needs much more work to make our classification system more accurate. There are many data that should be correlated but which cannot be done until there is a decision that the work is sufficiently important to be continued. We know very little about other basic botanical information, such as the cytogenetic variability within *M. esculenta* and the wild species. We know very little about the physiology of the plant, including starch production. Realistic work on the important poisonous properties has just recently been started. If we are to make forward strides in cassava development, we must carry on some basic botanical research along with the more practical agricultural work. We must integrate our knowledge, and greatly improve our means of data and literature exchange, so that workers anywhere in the world may be kept abreast of the results of their fellow workers.

Appendix

Suggestions on Education for Cassava Workers

With respect to education and/or training of students of cassava, I think that we need to give individuals in various agricultural centers a review of what is known about cassava presently, so that these individuals have a base from which to continue their own work, whatever their own needs. I think we need to encourage at least a few students to become oriented to cassava work for their advanced degrees, and in various disciplines. There is no need for me to emphasize to this group the importance of the several agricultural disciplines, so my emphasis is on an area close to my own, botanical. We tend to forget that there have been many important developmental aspects which grew out of basic botanical research with most of the major crops. We know that there are relatively few students who have done good botanical research on cassava. I do not wish to offend those few who have made such studies, but we need much more thorough anatomical, cytogenetic, physiological and ecological studies. We definitely need to define the classification of the species. Much of this work can be supplied by advanced degree students, who will concentrate on cassava for their thesis research.

At the same time, such students should be made aware of the various other types of investigations through interdisciplinary educational programs. It is as important to the botanist as to any other scientist that he be aware of the economics of cassava, and of the anthropological and ethnological work that has been done and needs yet to be done on cassava.

To accomplish the above suggested goals, two types of programs can be recommended. Training programs of short duration--two or three weeks, for those who already have received degrees, carried out under the auspices of CIAT (and perhaps IITA), where experts could review the cassava literature in certain disciplines, and provide a reading list for those attending the training sessions.

The second type of educational program would be of longer duration, and students would matriculate in various universities where the educational program is already directed towards various important botanical and agricultural studies. The student would work on thesis research specifically related to cassava for his advanced degree. There are a number of universities in the world where such work could be done. Perhaps the field work for thesis research could be done from bases at Cali or Ibadan, whichever is more appropriate for the particular student.

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MEMORANDUM ON CASSAVA PRODUCTION AND UTILIZATION IN INDIA

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1. Status of cassava production and utilization in India

Cassava is an important subsidiary food crop of India and a well recognized source of industrial starch and high energy livestock feed. Only 150 years after its introduction into this country, it has emerged as a crop of considerable importance. In Kerala State, which accounts for about 80 percent of the total acreage of this crop in India, about 0.7 million acres are now under cassava. In Tamil Nadu, over 71,000 acres are devoted to this crop. Its cultivation has now spread to other parts of Peninsular India, where conditions are suitable. The average yield of this crop in the country, about 12.5 tons per hectare, is very low. In Kerala State, the annual production of raw cassava tubers is about four million tons — the bulk of which is consumed as a staple food in combination with fish by a large segment of the population. It is commonly used as fresh tubers, boiled and prepared in the same way as potatoes. Among conserved cassava products, the more important is dried chips (plain dried or parboiled chips), which are also cooked in several ways before consumption. Cassava flour (15 to 20 percent) is mixed with wheat flour in the preparation of 'puris' and 'chappatties' and in varying proportions in the preparation of biscuits. 'Tapioca suji' is used as a substitute for wheat 'suji' in the preparation of sweet and savory dishes. In Kerala, cassava chips contribute about 36, 32 and 17 percent of the balanced feed for pigs, poultry and cattle, respectively. Even though of low nutritive value, the spent pulp (after starch extraction), locally known as 'tippi', is also generally fed to animals. Approximately 0.6 million tons of raw tubers are consumed for starch extraction, which finds extensive use in sizing and finishing operations in textile and paper industries and in glucose and alcohol production. Cassava flour (more than 25,000 tons), is also extensively used in the veneer-wood industry and a similar quantity in the manufacture of adhesives and gums. In the Salem district of Tamil

Nadu, where over 30,000 acres are under cassava, several small factories are engaged in the manufacture of 'sago'.

2. <u>The principal factors limiting cassava production and utilization in these areas and the related research needs</u>

A. <u>Major factors limiting production</u>

i) <u>Lack of high-yielding varieties</u> The currently cultivated cassava varieties are either chance seedlings or bud mutations, selected for desirable characteristics and maintained by vegetative propagation. Most of them are potentially poor yielders. Evolution of high-yielding varieties with favorable morphological architecture and developmental pattern contributing to greater "photosynthetic efficiency" by promoting efficient utilization of sunlight, water and nutrients, is of utmost importance.

ii) <u>Lack of efficient crop management</u> Cassava until recently was predominantly a subsistence crop grown under sub-optimal conditions of nutrition and inferior agronomic practices, mostly in small holdings for domestic and local consumption. Since higher yields in cassava are also linked with heavy fertilization, unlike the current commercial indigenous varieties which by and large do not adequately respond to higher levels of fertilization, new varieties must excel in their response to fertilization. It is, therefore, obvious that breeding for higher fertility conditions will have to be a prerequisite if any substantial improvement in the yield of cassava is expected within a short period.

iii) <u>Lack of disease- and pest-resistant varieties</u> Among the diseases infecting this crop, 'cassava mosaic' is a factor seriously limiting its production in India. Likewise, some of the pests may also assume importance with intensive cropping. In high-yielding varieties, to secure the envisaged yield, built-in resistance to these hazards needs to be incorporated so as to mitigate the damages caused by these factors. Hence, resistance breeding needs to be given priority along with production breeding.

iv) Lack of early-maturing and drought-resistant varieties A majority of cultivated cassava varieties take about 9 to 12 months to mature. Greater attention will now have to be paid to developing early-maturing varieties so that they can be effectively utilized in crop rotation programs now in vogue in the country. Further, since cassava is even spreading to sub-tropical regions with cold winters, short duration varieties have a definite advantage so as to utilize the shorter warm period to take a crop. Similarly, since cassava is being largely grown under rainfed conditions subjected to the vagaries of weather and other uncertainities, and for successful spread of its culture to drier regions of India, breeding for drought resistance needs to be given special consideration.

B. Major factors limiting utilization

The factors limiting cassava utilization are inextricably interwoven with those limiting production. Additional factors inter alia include:

i) Problems in utilization as food Owing to its current major role, as a staple food for poor masses, in addition to meeting the calorific needs, it must partially meet the other nutrient requirements such as protein, minerals, etc., to serve as a wholesome food. In this context, low HCN content in tubers is also of paramount importance. Thus improved varieties must also fulfill all these requirements for their wider acceptance and greater utility. Breeding for tuber quality with special reference to low HCN content, high protein content, including pattern of essential amino acids, high starch content, etc., thus assumes importance.

The poor keeping quality of tubers limits storage life of fresh tubers and leads to inevitable compromise on its quality when conventional preservation methods are used. Through standardization of suitable food processing techniques, the low protein content of cassava can also be advantageously augmented. Large scale industrial processing of cassava tubers during peak periods of harvest and reinforcement of their nutrient status by special processing methods could contribute to better utilization, less wastage and increased nutritive value.

Fresh cassava leaves are rich in protein, calcium and vitamins A and C but high in HCN content. Investigations have indicated that the prussic acid content of leaves can be brought to safer levels by boiling and other processing methods and thus the use of leafy tops as food and feed deserves greater attention.

ii) Problems in utilization as feed Due to the current low level of cassava production and greater demand of its tubers for human consumption, availability of cassava for feed purposes at present gets low priority even though the feeding value of tubers as a high carbohydrate source in rations for poultry and all classes of livestock is well recognized. Cassava as animal feed is ideally suited to Indian conditions (with its record livestock population of over 340 millions in addition to 120 millions poultry) because it will not only provide a low cost ration to animals and thereby reduce the cost of milk, eggs, beef, etc., but will also release more cereals, pulses, etc. (at present used as animal feed) for human consumption. Therefore, greater production of raw cassava tubers and its products, the development of a livestock feed industry on modern lines, and research work on several aspects of utilization as feed, need to be stressed.

iii) Problems limiting industrial utilization Increased utilization of cassava as raw material for starch, food and other industries is largely handicapped by seasonal supply of inadequate quantities of raw tubers and chips, cultivation in small holdings, distant location of production and processing centers contributing to higher transportation costs, higher cost of raw material, deterioration in raw material quality, lack of coordination between the centers in respect of demand and supply of tubers, etc., fluctuating market demands and price, lack of suitable machinery for production of quality products and competition with well-organized starch industries based on maize and having useful by-products.

Therefore, in providing a viable and prosperous industrial base for for cassava, stepping-up production from existing areas as well as extending cassava cultivation into new areas utilizing superior varieties having high starch contents under improved agronomic practices, staggered planting and harvesting, cultivation in larger holdings and mechanization, stabilization of prices, testing, grading and quality marking of the products, sustained supply of tubers and chips, improvement of techniques and proximity of production and processing centers are the essential steps that need urgent attention.

3. The status of cassava research in the institution or area and the ability or interest with respect to cooperation in the proposed program

A multi-discipline, coordinated, problem- and production- oriented cassava improvement program was intensified in 1963 following the establishment of Central Tuber Crops Research Institute in Kerala.

As a result of intensive research conducted on several aspects of improvement, results of great practical utility have been achieved, which inter alia include:

i) Assembling, screening and classification of genetic stocks An exhaustive germ plasm bank of cassava has been built up from diverse sources within the country and several countries abroad. These collections are continuously being screened for desirable characters and studied for their morphological (floral, vegetative and tuber), biochemical, physiological, agronomical and other characters including chromosomal homology and differentiation at pachytene, with a view (i) to determine if any of these exotic varieties could be directly adopted for cultivation, (ii) to effective utilization of these materials as breeding stocks, and (iii) to develop a sound classification of so-called types or races or forms or varieties of cassava based on ancestral relationships and employing multiple criteria.

ii) Breeding methodology Some of the important breeding procedures so far employed by us are (a) selection, (b) inter-varietal hybridization (including matings among superior combiners, diallel crosses, multiple crosses, crosses between one generation selfed lines with good pollinators, test crosses, etc.), (c) inbreeding, (d) interspecific hybridization, (e) genome approach, (f) production of chromosomal races, and (g) mutation breeding.

iii) Evolution of high-yielding hybrids As a result of an intensive breeding program carried out at the Institute and through application of biometrically rationalized selection procedures, a number of promising hybrids have been identified. Seven hybrids and five seedling selections have proved outstanding in both local and multilocation trials conducted under different agroclimatic conditions for over four years. In these trials, these improved strains recorded consistently two to three times higher tuber yields ranging from 23.5 to 84.7 tons/hectare as compared to a range of 10.0 to 31.0 tons/hectare of the controls under uniform conditions. In addition to superiority in yields, these improved strains excel many of the local varieties in other characters of economic value, such as field resistance to 'cassava mosaic', scale insects and red mites; desirable tuber size, shape, color, low HCN content, good cooking quality; moderate to high starch content; adaptability to a wide range of agroclimatic conditions. Their response to fertilization was also found to be excellent. One of the strains also possesses as high as 6.25 percent crude protein on a dry weight basis. Three of these improved strains have now been released for general cultivation along with the necessary information on the improved package of practices standardized for maximizing production.

iv) Basic studies Concurrently, a comprehensive program on the acquisition of relevant basic data vital to cassava improvement has also been initiated, which has provided valuable information including (i) the extent of chromosomal differentiation between cassava and its wild relative, Manihot glaziovii, used as donor parent for genes conferring disease and drought resistance, (ii) the possible polyploid origin of present-day cassava cultivars and appropriate breeding methodology, (iii) useful basic information for genetic manipulation of some of the important biochemical constitutuents of tubers, (iv) data on general and specific combining ability, (v) causes underlying male sterility and mode of its inheritance, (vi) association among some desirable economic and other characters, and (vii) the nature of chromosome pairing in induced triploids and induced auto-tetraploids of cassava.

v) Other studies Investigations in the fields of agronomy and soil science relate to standardization of cultural techniques and determination of the response of promising cassava hybrids and selections to various nutrient levels, efficacy of different carriers, their time and method of application. The studies on the basic nature and fertility of soils and their subsequent effect on the quality of produce and the chemistry of crop nutrition are also other items of work.

Crop physiology and biochemistry investigations relate to nutritional requirements, tuber quality constituents such as starch, protein, HCN content, factors contributing to yield, physiology of flowering, drought resistance, photo-periodism, etc.

Further researches on viral, fungal and bacterial diseases including the mechanism of tuber rots and formulation of control measures are underway. A program on the biology and bionomics of insect pests and devising of inexpensive and efficient measures for controlling them has been taken up.

Cooperation

The details of the nature and extent of collaboration sought will be discussed at the conference.

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MANIHOT RESEARCH AT THE TAXIMETRICS LABORATORY

University of Colorado
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<u>Research Team</u>

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Some of the major areas of current research on <u>Manihot</u> at the Taximetrics Laboratory are briefly described below.

1. <u>Computer-aided classification of the cultivars of Manihot esculenta</u>

The large number of variants of this cultivated species, differing in some cases only in one biochemical property, maintained only by intercession of man's conscious cultivation, exhibit an apparent continuum in their phenotypic properties, in contrast to members of wild species which are constantly subjected to selection pressures maintaining a high frequency of genotypes manifesting phenotypic properties varying within specific limits conferring maximum fitness. In order to discover constellations of cultivars reflecting natural relationships within the cassava gene pool, powerful computer-aided procedures for analyzing the multidimensional variation embodied in a large number of phenotypes with respect to numerous phenotypic attributes were developed at the Taximetrics Laboratory. By employing these procedures the cultivars constituting the cassava gene pool were divided in two major subdivisions. Below this category the cultivars are clustered into 19 world-wide types. This computer-aided classification provides a sound framework for 1) developing a universal catalog of cassava cultivars describing their economically significant phenotypic attributes; 2) efficiently designing cytogenetic investigations to understand the karyological mechanisms of differentiation in this group of cultivars; 3) building computer banks of phenotypic and cytogenetic information so as to enable breeders to search and pick appropriate genetic stocks by manipulating the bank.

2. Computer-aided delimitation of the closed gene pools of the genus *Manihot*

The numerous wild species of *Manihot* represent a rich, practically unexplored and unexploited reservoir of potentially valuable genetic variability. In order to put this wealth of wild genetic potential to proper use, it would be necessary to undertake a systematic evaluation of the biological properties of the wild *Manihot* species, especially the qualities significant from a cassava crop improvement point of view. Closed gene pools, being the largest interbreeding units in natural populations, represent the most efficient sampling units for evaluation studies. Employing the computer-aided Taximetric methods developed at the Taximetrics Laboratory, the closed gene pools which together constitute the entire genus *Manihot* have been delimited. Their geographical domains have been delineated, and their phenotypic attributes, including morphological features, ecological adaptations, and preliminary cytogenetic and biochemical properties, have been defined. The computer output of the similarity graph clustering program provides graphic indications of the patterns of the genetic structure of the populations, a knowledge of which is critical in designing plant-breeding strategies. The 96 closed gene pools so described include 12 newly discovered ones.

3. Computer information bank of Manihot germ plasm resources

The data generated in the above two projects are being stored in computer banks in order to facilitate an efficient use of this information in the second phase of the envisaged program, i.e., intensive cytogenetic studies and evaluation of the genetic potential of the gene pools. The bank is accessible to easy and rapid retrieval of pertinent data through any of the three modules of PROGRAM TAXIR designed for use in CDC 6400 or IBM 360 computers. This bank is intended to serve as a central source of *Manihot* germ plasm information for cassava workers all over the world. When completely built and operational it would have several applications such as:

1) It will enable a worker to identify the closed gene pool or the introgressive hybrid population which his experimental material represents, and in the case of cassava cultivars to relate his material to any one of the 19 world-wide basic types in the *Manihot esculenta* gene pool.

. 2) It will enable a breeder to search the bank on any one or a combination of criteria (cytogenetic, ecological, biochemical, etc.) and pick the germ plasm possessing the desired genetic potential.

4. Systems analytic studies of cassava-based nourishment generating system capable of functioning in ecologically and economically impoverished areas

Ecological deterioration imposes major constraints on the capability of the biosphere to generate nourishment to support mankind. On the one hand we are realizing that internal combustion engines, inorganic fertilizers, and pesticides are major causes of today's environmental pollution, whereas in the developing countries the green revolution places heavy emphasis on promoting the use of these. Economic impoverishment is the primary obstacle in developing countries in transforming the traditional to modern agriculture for unlocking the food potentials, but when modern technology is employed it tends to promote indiscriminate use of the causal agents of pollution, leading to further and further deterioration of our environment and thus we get trapped in a vicious cycle. In this perspective, systems with potential ties of efficiently generating nourishment from deteriorated environmental pockets and/or under economically impoverished conditions are bound to become increasingly valuable to support man's enlarging need for food. The cassava-based nourishment generating system appears to be capable of efficiently generating protein-rich human sustenance from depleted and disrupted ecological niches under primitive conditions of economy and technology. A preliminary evaluation of this system indicated that in certain areas of South America the natives take advantage of the ability of this crop to produce abundant carbohydrates from ecologically depleted areas, and enhance the protein content through a processing system involving micro-organisms. Thus conventional protein-rich human sustenance, acceptable without any objection to the palate (the activity of the micro-organisms in fact is reported to give a meaty flavor to the otherwise bland product), is generated from economically and ecologically depauperated areas. The system appears to be remarkably efficient in that the cyanogenic glucosides present in cassava roots are reported to be linked by chemical pathways with protein and as such it is probable, but should be demonstrated, that this ingenious system innovated by American Indians modifies the poison into valuable protein thereby not only detoxicating the roots but also enhancing the protein content. Such systems of microbial conversion of carbohydrates into protein are reported to be 15 times more efficient than beef, 12 times more efficient than poultry, and 4 times more efficient than milk. The system appears to have tremendous potential, and the Taximetrics Laboratory is in the process of outlining a research project for intensive computer-aided systems analytic studies of this system and to build models based on it to elucidate the problems, feasibility, scope, efficiency, and values of systems with potentialities of making the ecologically deteriorating biosphere support human populations.

A.I.D. Project. Preparation of a plan for the orientation of future research on cassava

The Taximetrics Laboratory is collaborating with the University of Georgia in preparing a report analyzing the potentialities, limitations, and scope of cassava as a food and industrial crop, and recommending a plan for the orientation of future research in this crop.

Some publications on Manihot from the Taximetrics Laboratory

Appan, S.G. 1969 - North American species of Manihot delimited by computer-aided taximetric methods. Doctoral dissertation, University of Colorado, Boulder, Colorado.

Appan, S.G. and D.J. Rogers 1969 - Taximetric methods for delimiting biological species. XI International Bot. Congress, Seattle. Abstracts of papers, p.5.

Appan, S.G. and D.J. Rogers 1970 - The closed gene pools of Manihot delimited by computer-aided taximetric methods to aid utilization of the wild genetic wealth in cassava improvement programs. Tropical Root and Tuber Crops Newsletter 3: 16-18.

Appan, S.G.; D.J. Rogers; G.N. Hersh; and H.S. Fleming 1970 - A strategic program for genetic engineering of cassava. Proc. Second International Symp. Tropical Root and Tuber Crops 1: 79-82.

Fleming, H.S. and D.J. Rogers 1970 - A classification of Manihot esculenta using the information-carrying content of a character as a measure of its classificatory rank. Proc. Second International Symp. Tropical Root and Tuber Crops. 1:66-71.

Fleming, H.S.; D.J. Rogers; and S.G. Appan. In press - Computer information bank of Manihot germ plasm resources. Tropical Root and Tuber Crops Newsletter.

Rogers, D.J. 1953 - Variation in Manihot utilissima and related species. Yearbook of American Philosophical Society. p. 166-168.

Rogers, D.J. 1963 - Studies of Manihot esculenta Crantz and related species. Bull. Torrey Bot. Club. 90: 43-54.

Rogers, D.J. 1965 - Some botanical and ethnological considerations of Manihot esculenta. Econ. Bot. 19:369-377.

Rogers, D.J. 1967 - A computer-aided morphological classification of Manihot esculenta Crantz. Proc. International Symp. Tropical Root Crops, Trinidad. 1: 57-80.

Rogers, D.J. 1969 - Manihot, Man, and Computing machines. Summary of the Fairchild lecture. Fairchild Tropical Garden Bull. 24: 11-13.

Rogers, D.J. and S.G. Appan 1969 - Taximetric methods for delimiting biologic species. Taxon 18: 609-624.

Rogers, D.J. and S.G. Appan 1970 - Untapped genetic resources for cassava improvement. Proc. Second International Symp. Tropical Root and Tuber Crops. 1: 72-75.

Rogers, D.J. and S.G. Appan. In press - Monograph of genus Manihot.

Rogers, D.J. and S.G. Appan. In press - Chapter I in Plan for the orientation of future research on cassava (Manihot esculenta). Report to the Agency for International Development.

Rogers, D.J. and S.G. Appan. In press - Cassava-based nourishment generating system capable of functioning in ecologically and economically impoverished areas. Tropical Root and Tuber Crops Newsletter.

Rogers, D.J. and H.S. Fleming 1964 - A computer program for classifying plants. II. A numerical handling of non-numerical data. Bioscience 14: 15-28.

Rogers, D.J. and H.S. Fleming. In press - A computer-aided classification of Manihot esculenta cultivars. Econ. Bot.

Rogers, D.J.; H.S. Fleming; and G.F. Estabrook 1967 - Use of computers in studies of taxonomy and evolution. in Th. Dobzhansky, M.K. Hecht, and Wm.C.Steere (eds.) Evolutionary Biology 1: 169-196.

Rogers, D.J. and Milner M. 1963 - Amino acid profile of manioc leaf protein in relation to nutritive value. Econ. Bot. 17: 211-216.

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MEMORANDUM ON CASSAVA PROGRAM REVIEW CONFERENCE

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1. Status of Cassava Production and Utilization

Cassava, viewed globally, is the eighth most important crop, total production being exceeded only by wheat, rice, potatoes, maize, barley, millets and sorghums, and sugar. Average production for the years 1967/69 according to FAO statistics was 87.2 million tons/annum: this represents an increase of 24.5 percent over the annual production for the period 1959/61. These figures do not include production in mainland China, which has been estimated (Anon 1968) as more than 10 million tons: the total production in the world is thus probably over 100 million tons/annum.

Though cassava is extremely widely distributed in the tropics, a substantial amount of production is concentrated in certain specific areas, and 9 countries account for almost three quarters (74.2 percent) of the total production as recorded in FAO statistics. Details are given in Table 1.

Table 1. Major Cassava Producers

Brazil	28.8	125	327	Congo (K)	8.2	105	489	Indonesia	11.0	-7	97
Paraguay	1.5	51	647	Nigeria	6.9	-19	109	India	4.4	141	?
Colombia	0.9	350	45	Uganda	2.1	?	?	Thailand	1.9	101	55

First column - Total production, 10^6 metric tons/annum (1967/69)
Second column - Percentage increase in production 1959/61 to 1967/69
Third column - Production per capita (kg/head/year)

Cassava is thus the most important of the tropical root crops and has been shown (Coursey and Haynes 1970) to account for approximately half the global production of such crops. Although originating in tropical America, it has spread in cultivation throughout the tropics, and is now produced in roughly equal quantities in the three main tropical areas of the world (see appendix 1).

Cassava is principally a carbohydrate staple food used where it is grown, but there is an export of dried cassava products from certain producer countries, notably Thailand, to the developed world for use as industrial starch and animal feeding stuffs (Anon 1968). However, the total industrial utilization of cassava is probably only of the order of 6 or 7 million tons of fresh cassava. The rest is utilized as has already been indicated, as food in the countries of production. Thus, though the development of cassava as an export crop should not be overlooked, its utilization needs to be considered mainly in the context of a food crop for local consumption. In the context of the "population explosion" where we are faced with the likely doubling of world population in the next 30 years, much of this increase occurring within the tropics, the capacity of cassava to produce large amounts of food at low labor input and under marginal conditions, is a factor which warrants serious attention.

In spite of the predominant position of the countries mentioned in Table 1, many smaller countries with much lower <u>total</u> production have much higher <u>per capita</u> production of cassava, indicating that the crop plays important, or even vital, roles in the nutrition of those countries (see appendix 2).

2. Factors limiting Cassava Production and Utilization

(a) Limitation on production

Cassava production is limited by the factors that apply more or less generally to tropical agriculture; lack of capital, lack of expertise at the farmer level and lack of access to improved varieties, fertilizers, etc. The amelioration of these factors lies with the extension worker more than within agricultural research.

From the research point of view, the outstanding feature of cassava (and other tropical root crops) is the small amount of research on any aspect of the crop which has been undertaken. This may stem partially from socio-anthropological factors related to the unfamiliarity of crops such as cassava to "European-oriented" ethnic groups, and the difficulty of conducting research on vegetatively propagated crops within the conceptual framework which has been developed for the major temperate crops. There is thus a fundamental lack of basic knowledge of cassava as a crop. Those investigations which have been undertaken have mostly been conducted by individual workers in comparative isolation, on local varieties of material which have not been related to the overall genetic pool of the crop species. Cassava is extremely variable and this has not always been appreciated by those who have worked upon the crop, or, at best, variability only within a limited range of cultivars has been considered.

A major limitation on cassava is the fact that although economical in terms of labor for the peasant cultivator, it is poorly adapted to mechanical agriculture, and is difficult to grow on an industrial scale. The problem arises from the lack of suitable equipment for mechanical harvesting: the form of the cassava plant is such as to render it an extremely difficult one. It is suggested that a major research effort to develop means of harvesting cassava mechanically should be undertaken: an approach needs to be made jointly by plant breeders working on the form of the cassava plant and by agricultural engineers studying the mechanical angle.

Another subject which needs detailed investigation is the question of fertilizer response in cassava. This needs to be tackled, not as it has been in the past with limited numbers of cultivars, but with material representing as wide a spectrum of the known types as is feasible. Experience with other crops indicates that strains can differ greatly in their response, and for production under industrial conditions it is essential to locate strains responsive to high fertilizer input. Allied to this, the study of trace element nutrition of cassava is a virtually untouched field badly needing attention.

More detailed investigations of disease problems, particularly cassava mosaic disease in Africa, need to be undertaken. Although much work has been done, there is still a lack of basic information, both fundamental pathology, and possible control measures. The question of resistant (or symptom-free) strains in relation to yield and crop quality needs detailed further study.

(b) Limitation of utilization

The limitations to the mechanical harvesting of cassava already touched upon also apply to cassava utilization in that industrial development based on the crop is inhibited. Another factor which imposes limitations on the development of agro-industry based on cassava, is the fact that cassava tubers cannot be stored for any appreciable length of time. This makes it virtually impossible to carry adequate buffer stocks for any large scale processing operation. The post-harvest behavior of fresh cassava has been remarkably little studied and it is suggested that a major research effort could be extremely productive. This could be oriented: firstly, in the context of the limited extension of storage life for buffer stocks at factories; and secondly, longer-term storage in the context of use as a subsistence food crop. The current practice of leaving the crop in the ground is wasteful of land and has a deleterious effect on quality.

Studies of traditional methods of preparing cassava for food in different parts of the world are needed to provide bases for attempts to industrialize the manufacture of such products. Work has already been done in West Africa in connection with gari, but this needs to be extended to other cassava-based foods. Against the background of growing urbanization of nearly all tropical countries, the industrial manufacture of traditional type foods is a subject warranting serious attention.

Changing food habits in the tropics, with growing emphasis on imported, European-type foods, is tending to confer a low status on cassava as a food; the incorporation of cassava into European-type foods (particularly bread, for which it appears well suited) should increase cassava utilization. Much work needs to be at the extension level, to ensure the utilization of existing knowledge, although further basic food technology is needed.

Perhaps the most important limitation on cassava utilization is its protein content. Not only is the natural protein content low, but most of the little protein present is often removed by the traditional processing methods. Two approaches are necessary to this problem; firstly, the isolation of cassava varieties of naturally higher protein contents (e.g., Llanera), and their development in cultivation and in hybridization: secondly, the fortification of traditional cassava-based foods from other relatively cheap protein sources (e.g., soya bean; fishmeal). This could be linked with the food technological investigations already mentioned. Related to this subject is the possibility of using cassava (which in tropical countries is usually one of the cheapest available sources of carbohydrate) as a substrate for the manufacture of unconventional protein foods; and, through its use in feeding stuffs, for the production of animal protein. In all food technological studies it is essential that attention is paid to the acceptability of the manufactured product: this has not always been done in the past.

Apart from the low nutritional quality of cassava, further attention needs to be given to the subject of pathological conditions ("tropical neuropathy") apparently related to habitual consumption of cassava as a staple food. Studies in West Africa and elsewhere strongly suggest a causative link between habitual ingestion of trace quantities of cyanide from cassava and the development of neuropathic conditions. In addition to further clinical studies, direct experimental work (presumably using non-human primates) needs to be undertaken to establish the causative factors more closely. Arising from such work could be the need for plant breeding attempts to produce low or ideally zero cyanide-containing cassava.

3. The Status of Cassava Research at the Tropical Products Institute

Until the last few years, little attention has been given to cassava at this Institute, beyond a market survey (Walker, 1966) and waste product utilization (Flaws and Palmer, 1968). Recently there has been a considerable expansion of interest.

An extensive documentary study of cassava is in hand and, as a first stage, a bibliography has been published (Ingram, 1970). As a second stage, a review of the storage problems of cassava in both fresh and processed conditions has been prepared (Ingram and Humphries, in press).

Future items in this program will include reviews of traditional processing methods for cassava-based foods; of machinery available for cassava processing; and other topics.

Much research effort has been devoted to the use of cassava as a substrate for fermentation by *Rhizopus* spp. to produce high protein food from carbohydrate and inorganic nitrogen sources (Stanton and Wallbridge, 1969). Difficulties have been experienced but it has been shown that it is possible to synthesize edible materials free from fungal toxicity, containing around 7 percent protein. It is, however, too early to make any definite statement about the practical usefulness of this process.

Studies are in hand on the manufacture of bread containing varying amounts of cassava as a substitute for wheaten flour. The TPI research effort has been directed towards partial substitution of wheat by cassava, rather than complete substitution by non-wheat flours as investigated by the Dutch workers of the TNO group. Substantial success has been obtained in making acceptable breads containing significant proportions of cassava starch using conventional bread-making methods. Experimental bakeries to extend the use of this process are being developed in both Nigeria and Ceylon under the aegis of the Tropical Products Institute (Dendy *et al.*, 1970). It is planned to initiate a major research project on the storage problems of fresh cassava from both physiological and pathological viewpoints. It is impossible to carry out more than part of this work in Britain and it is hoped to establish collaboration with one or more research organizations so that investigations can be pursued in the tropics.

In addition to his involvement with work on cassava through his position as Head of the Food, Vegetables and Root Crops Section of the Tropical Products Institute, the writer wishes to draw attention to the function of the newly-formed International Society for Tropical Root Crops, of which he is First Vice President, in stimulating and coordinating work on tropical root crops including cassava and in providing for discussion of research and other work at its Symposia and through its newsletter.

APPENDIX 1

Principal Cassava-Producing Countries

Tropical America			Africa			Asia		
Brazil	28.8	175	Congo (K)	8.2	105	Indonesia	11.0	-7
Paraguay	1.5	51	Nigeria;	6.9	-19	India	4.4	141
Colombia	0.9	350	Uganda	2.1	--	Thailand	1.9	101
Peru	0.4	41	Mozambique	2.1	--	N. Vietnam	0.7	--
Ecuador	0.4	67	Angola	1.5	--	Philippines	0.5	13
Venezuela	0.3	29	Ghana	1.5	35	Ceylon	0.4	109
Argentina	0.3	15	Togoland	1.3	120	Taiwan	0.3	107
Cuba	0.2	--	Tanzania	1.2	--	W. Malaysia	0.3	--
Bolivia	0.2	132	Dahomey	1.1	42	S. Vietnam	0.3	34
Dominican Republic	0.2	-2	Central Afr. Rep.	1.0	--	Cambodia	0.03	88

N. B. Production in mainland China is approximately 10 million tons

First Column - Total production, 10^6 metric tons/annum (1967/69)

Second Column - Percentage increase in production, 1959/61 to 1967/69

APPENDIX 2

Countries with highest per capita production of cassava

Tropical America		Africa		Asia	
Paraguay	674	Central Afr. Rep.	672	Indonesia	97
Brazil	327	Togoland	638	Thailand	55
Ecuador	64	Congo (K)	489	Ceylon	34
Colombia	45	Congo (B)	460	N. Vietnam	34
Dominican Rep.	38	Dahomey	441	W. Malaysia	33
Peru	37	Comoro Islands	350	Taiwan	24
Bolivia	33	Liberia	328	S. Vietnam	18
Venezuela	33	Angola	287	Timor	17
Cuba	26	Mozambique	284	Philippines	14
Haiti	24	Gabon	263	Sabah	14

(Figures represent kg/head/year)

REFERENCES

Anon (1968) The markets for manioc. Int. Trade Centre, UNCTAD-GATT, Geneva.

Coursey, D. G. and Haynes, P. H. (1970) Root Crops and their potential as food in the tropics. Wld. Crops, 22 (4) 261-265.

Dendy D. A. V., Clarke P. A. and James A. W. (1970) The use of blends of wheat and non-wheat flours in breadmaking. Trop. Sci., 12 (2) 131-142.

F. A. O. (various dates) Production Yearbook F. A. O., Rome.

Flaws, L. J. and Palmer, E. R. (1968) The production of particle board from cassava stalks. TPI Report G34.

Ingram, Jean S. (1970) Selected bibliography on cassava. TPI Report No. G51.

Ingram, Jean S. and Humphries J. R. O. (in press) Cassava storage - a review

Stanton, W. R. and Wallbridge, Anne (1969) Fermented food processes. Process Biochem. 4 (4) 45-51.

United Nations (various dates) Demographic Yearbooks.

Walker, Heather (1966) The Market for Cassava. TPI Report G21.

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MEMORANDUM ON CASSAVA IN MALAGASY REPUBLIC

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1. Actual status of cassava production and utilization

In the Malagasy Republic in 1971, about 330,000 has (815,000 acres) of cassava have been cultivated with a production in the region of 1,000,000 tons, the mean yield being about 3 T/ha. Production areas are very difficult to estimate, because of their dispersion, family contribution cultivation, and of the high frequency of companion crops. This yield is nevertheless very variable: less than 2 T/ha in mixed cultivation (with Leguminous or Graminaceous plants) in southern dry areas, to more than 35 T/ha in modern cultivation fields.

Cultivated for direct consumption in all regions with an altitude of less than 4,500 feet and more often with traditional methods (low manuring, high planting density, long cuttings), cassava is the subject of industrial cultivation to obtain starch and tapioca. However, only 2,000 and 6,000 tons, respectively, are produced in three factories in local areas.

Consumption is essentially a family one, bought in the markets at from 2 to 5 FMG (1 to 2 cents) a kilo. It is also a famine crop, valuable in soil reserve and takes the place of rice when rice is scarce. In cattle nutrition, it is sometimes used fresh, but only in small quantities. Dried, it is mixed with corn and rice bran, particularly for pigs and sometimes for poultry.

It should be observed that sweet cassava generally has particular flavors according to regions and is not submitted to special preparations (such as steeping) before consumption. Sometimes taken raw, but more commonly boiled, roots are peeled and cut into pieces.

2. Principal factors limiting cassava production and induced problems

2.1 Quantitatively

Three series of factors are called into play.

Ecology:

- Drought in the south (problems of resistance to drought)
- Soil often poor and deficient (problems of plant nutrition) in all regions.

Cultural practices:

- Essentially manuring. If our knowledge with regard to basic ingredients (N, P and K) is relatively extensive, others have virtually not yet been studied (Ca and trace elements in particular). It is probable that these deficiencies are sometimes the cause of some low yields (Zn, Mg, B, etc.).

Plant characteristics:

- Essentially diseases, more particularly virus (mosaic), and root rots (elementary studies in progress on mosaic).
- Morphology (habit, leaves, etc.).

2.2. Qualitatively

- Amount of dry matter rather low, starch storage speed rather slow and starch content rarely high.
- Amount of hydrocyanic acid, inducing a redhibitory bitterness.
- Low protein content.

2.3 Popularization and marketing problems, including those relating to the multiplication of useful varieties.

3. <u>Status of cassava research and international cooperation</u>

3.1 Present status of cassava research

- Advanced with regard to gross yield (our best popularized varieties at 80 T/ha, some studied hybrids at 150 T/ha on experimental plots); future incorporation of mosaic and root rot resistance when it is possible.
- Fertilization: basic common formulae have taken shape.
- Mosaic disease: seeds coming from natural hybridizations are being grown and screened in very infected areas: 20.000 hybrids are thus observed each year.

3.2. International cooperation

The Malagasy Republic, because of its geographic location, is a valuable study center for cassava (cultivation very spread, very diversified ecological conditions). Moreover, existing varieties, either in collection or popularized, are forming valuable plant material — some showing high yield in local areas and also in continental Africa.

Through this plant material, the Institute of Agronomic Research of Madagascar, and its agency, the Institute of Tropical Agronomic Research, will be able to make an important contribution to international cooperation.

With plant material transfer contribution and, possibly, foreign varieties introduced in trials, phytosanitary problems will doubtless arise.

If financial support, in the form of staff and budgetary assistance, will permit extension of the relatively small present program, it will be possible to operate a laboratory to study the next problems which are considered as having priority:

- Mosaic resistance
- Drought resistance
- Food value in relation to dry matter amount, without woody roots, protein amount, and taste qualities.

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THE STATUS OF CASSAVA (MANIHOT ESCULENTA CRANTZ) PRODUCTION AND UTILIZATION IN SOME PARTS OF THE COMMONWEALTH CARIBBEAN

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Introduction

Cassava is grown throughout the Commonwealth Caribbean as a source of food for man. While its potential as a livestock feed is appreciated, there is little organized feeding of cassava to animals. This crop is grown principally by subsistence farmers, frequently in mixed cropping. In Trinidad and Grenada it is sometimes used as ground shade in the establishment phase of cocoa. When grown in this way the tuberous roots are not always harvested.

The types grown have variable hydrocyanic acid content and are crudely grouped as 'sweet' and 'bitter' according to the level of toxin. 'Sweet' types are eaten boiled or roasted, while 'bitter' types must be processed to deactivate the hydrocyanic acid before they can be safely used. In comparing these types it is useful to remember these differences since one competes as a fresh root vegetable whereas the other is a partially processed food.

Cassava was well established as a staple food in the region prior to the period of European exploration. An interesting account of the processing of tubers is given by Ligon (1657), the method described being in general use by the Amerindians at that time. The stages included peeling, grating, starch extraction and drying to remove hydrocyanic acid. It is worth noting that this is still the basis of starch and farine production at the present time. Even at that time they followed the practice of heating the separated pith to bring about some dextrinisation and partial gelatination of the starch. There was also appreciation of the need to mill the cassava and to use the farine separately as flour in pastry-making. The binding properties of this flour were improved by gelatination of the starch with water prior to mixing. That there has been no substantial change in the technology of cassava processing in the Commonwealth Caribbean since those times, is an interesting commentary on the development of this crop in the region.

Current Production

The Commonwealth Caribbean, like many other regions, suffers from insufficient information on cassava production. Furthermore, such data as may be available are not always reliable. Frequently these originate from trade returns or rough estimates of cultivated areas. The data may fail to reflect the substantial production from subsistence and family farms. Production data is available in the FAO Production Yearbook (1971) for Barbados, Jamaica and Trinidad and Tobago (Table I). Of these, the Jamaica production is the most substantial, some 10,000 metric tons of tubers per year. In the period 1948-52 Jamaican production was substantially higher, averaging 17,000 metric tons for this period. Since 1961 the Trinidad and Tobago production has been reported as 5,000 metric tons, and in Barbados about 1,000 metric tons.

There are few detailed analyses of cassava production for these countries. A recent paper (Rankine and Hee Houng, in press) discusses production in Jamaica. For Trinidad there is a discussion of some factors affecting the demand for starchy roots and tubers (Alexander, 1967).

Table II shows the proportion of the total root crop production in Jamaica which is supplied as cassava. For the years 1965-68 this has fluctuated between 10 percent and 15 percent. In addition, over the same period 10 percent and 15 percent of the land area devoted to root crops was occupied by cassava. Other data from Rankine and Hee Houng show that for the years 1967 and 1968, 80 and 71 percent of cassava produced were from 'bitter' types. The data also show some local variability in yield and profitability between 'bitter' and 'sweet' cassavas. At the present levels of production in certain areas of Jamaica there appears to be an advantage in favor of 'sweet' cassavas.

The Trinidad study (Alexander, 1967) is interesting since similar relations could, in the opinion of the writer, exist in the other countries under review. It has been shown that Trinidad consumers prefer root crops in the order tuberosum potato, sweet potato, dasheen, cassava, yam and eddoes. Alexander has also presented datawhich show cassava roots to be 63 percent edible. The high proportion of loss in preparation for eating may, in part, explain the relatively low preference for cassava.

Future trends and prospects

In the opinion of the writer 'sweet' cassava has limited competitiveness with other roots as a fresh vegetable. The real potential for cassava appears to be in one or more of the following: a substitute for wheat in flour, as starch for use in industrial processes or as a carbohydrate food in livestock rations.

The uses to which cassava will be put in the Commonwealth Caribbean will depend largely on the prices paid for fresh roots. The region has a large labor supply but this is relatively high priced. At the same time there is a marked shortage of land area. These factors make for production difficulties. Labor intensive practices are normally adopted where there is a large labor supply. It is doubtful whether at the current wages in the region local cassava could be processed or fed to livestock competitively. It may be that the governments involved can provide the necessary support for the establishment of substantial cassava production. This would, however, be a political decision which is beyond the scope of this presentation.

At the technical level attention could be given to ensuring new outlets for cassava products and to the stimulation of increased productivity of the crop.

Acknowledgments

Thanks are due to Dr. Spence for reading and commenting on the text and to Dr. Rankine for making information available from an unpublished paper by Rankine and Hee Houng.

References

1. Alexander, H. F. (1967). Some factors affecting the demand for starchy roots and tubers in Trinidad. Proceedings of the International Symposium on Tropical Root Crops U. W. I., St. Augustine, Trinidad.

2. F.A.O. Production Yearbook (1970). Vol. 24, Rome.

3. Ligon, R. (1957). A true and exact history of the island of Barbados. New Impressions of 2nd Edition. Frank Cass & Co., London 1970.

4. Rankine, L. and C. Hee Houng (in press). A preliminary view of cassava <u>Manihot esculenta</u> production in Jamaica. Occasional Survey No. 6 Dept. of Agricultural Economics and Farm Management.

Table I. Production of cassava in some territories in the Commonwealth Caribbean.[1]

Country		1948-52	1961-65	1965	1966	1967	1968	1969
Barbados	Production[2]	2	1	1	1	1	1	1
	Yield[3]	101	302	304	280	280	300	267
Jamaica	Area[4]	5	4	4	4	4	4	4
	Production	17	11	9	9	10	10	10
	Yield	36	29	26	25	24	23	23
Trinidad and Tobago	Production	3	5	5	5	5	5	5
	Yield	83	120	111	111	111	111	103

[1] Taken from FAO Production Yearbook 1971

[2] Production in 1,000 metric tons

[3] Yield in 100 kg. per hectare

[4] Area 1,000 hectares - area not available for Barbados and Trinidad and Tobago.

Table II. Cassava production and land use relative to other root crops in Jamaica.[1]

Year	Cassava production as percentage of total root. crops	Percentage of root crop acreage in cassava
1965	10.5	11.9
1966	11.6	15.5
1967	15.0	10.4
1968	10.5	11.7

[1] Calculated from data in Rankine and Hee Houng (in press).

PRODUCTION AND UTILIZATION OF CASSAVA IN BRAZIL

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Production

According to statistics, Brazil is the world's largest cassava producer with an area close to 2,000,000 hectares under cultivation, and a production of about 27,000,000 tons of roots. This figure represents 32 percent of world production. Average production per hectare has been estimated as follows:

Production	Ton/hectare	Area
World	8.4	9.1 millions of has
Brazil	13.5	2.0 millions of has
Sao Paulo	17.5	(up to 140 thousand hectares)

The lower limits of economic production vary by region. However, for industrial purposes, two-vegetative-cycle cassava (18-24 mos.) must produce at least 20 tons of roots per hectare. Commercial yields of 30-40 ton/ha have already been obtained in rather extensive operations.

In the attached tables, data on the production of cassava in Brazil and on exportation of cassava products are presented for various years. These data include volumes and values in US$, FOB Brazilian ports, for chips ("raspas"), chip flour, table flour, cassava starch, and sago ("sagu").

Utilization

Cassava is widely cultivated in Brazil for industrial purposes, as a forage crop, and also as human food. In summary, the use of roots is as follows:

Roots as food

a) Simply cooked with salt or sugar.

b) Cooked first, then fried in grease.

c) Cooked and mashed for making soups.

d) Cooked, to make fried dishes, etc.

e) Roughly grated for use in sweets and puddings.

Fresh roots as animal feed

a) Chopped, in swine and dairy cattle rations.

b) Grated, for the same purpose.

c) Grated, together with aerial part (whole plant) for the same purpose.

Chips (chopped, pressed and dried roots)

a) Grated, for swine and dairy cattle rations.

b) Raw material for chip flour.

c) Material (pelleted or not) for export to the European Common Market.

Chip flour (ground and sifted chips)

a) For mixing with wheat flour (5-10 percent) and used in making bread.

b) For various cardboard industries.

c) For making poultry, dairy cattle, and swine rations.

d) For the preparation of some types of adhesives.

e) As export material.

Per capita consumption of various commodities in Brazil in kg per inhabitant per Annum. 1962-1963

Commodity	Region Rural	Region Urban	National Average
Cassava	199.6	40.0	124.6
Rice	40.3	38.4	39.4
Beans	34.8	19.6	27.7
Maize	29.6	4.0	17.6

Source: Brazilian Economic Institute. F.G.V.

Area, production and yield of cassava in Brazil, 1950-1968

Year	Area (ha)	Production (t)	Yield (kg/ha)
1950	957, 493	12, 532, 482	13.089
1951	964, 337	11, 917, 560	12.358
1952	1, 015, 327	12, 809, 263	12.616
1953	1, 061, 915	13, 441, 421	12.658
1954	1, 101, 898	14, 492, 961	13.153
1955	1, 149, 123	14, 863, 193	12.934
1956	1, 178, 150	15, 316, 002	13.000
1957	1, 193, 411	15, 442, 747	12.940
1958	1, 225, 818	15, 353, 604	12.525
1959	1, 239, 366	16, 575, 124	13.374
1960	1, 342, 403	17, 613, 213	13.121
1961	1, 381, 331	18, 058, 378	13.073
1962	1, 476, 206	19, 843, 422	13.442
1963	1, 617, 810	22, 248, 644	13.752
1964	1, 715, 857	24, 355, 602	14.194
1965	1, 749, 960	24, 992, 579	14.252
1966	1, 779, 806	24, 710, 041	13.884
1967	1, 914, 439	27, 268, 193	14.243
1968	1, 998, 197	29, 203, 229	14.615

Source: Getulio Vargas Foundation. Center for Agricultural Studies

Exportation of cassava products in Brazil
(CACEX - Carteira do Comêrcio Exterior)

Products	Tonnage		Value FOB, US$
	1965		
Chips	41,800		1,877,195.00
Cassava flour	23,513		982,248.00
Cassava starch	31,911		2,121,806.00
Tapioca	1,082		189,161.00
		Total.........	5,170,410.00
	1966		
Chips	27,051		1,317,664.00
Cassava flour	24,269		1,158,710.00
Chip flour	19,583		1,028,958.00
Cassava starch	16,088		1,392,620.00
Tapioca	1,158		217,318.00
		Total.........	4,897,952.00
	1967		
Chips	711		40,727.00
Cassava flour	80		8,991.00
Chip flour	13,931		838,765.00
Cassava starch	5,557		558,433.00
Tapioca	1,024		211,658.00
		Total.........	1,658,574.00
	1968		
Cassava flour	754		78,645.00
Chip flour	7,887		509,825.00
Cassava starch	7,171		647,799.00
Tapioca	1,014		210,603.00
Sago	42		6,213.00
		Total..........	1,453,085.00
	1969		
Chips	38,124		1,629,722.00
		Total.........	1,629,722.00
	1970		
Chips	24,271		1,254,474.00
Cassava flour	25,549		1,213,151.00
Chip flour	8,689		520,727.00
Cassava starch	8		794.00
Tapioca	6		1,200.00
Sago	145		21,523.00
		Total.........	3,011,869.00

Chip bran (residue of sifted chip flour):

Used as a component in poultry and cattle rations.

Table flour (Grated, pressed, sifted and dehydrated or roasted roots):

a) For culinary uses in various forms ("farofas", "tutú", "virado","pirão")

b) In the northeast region of Brazil it has been used on oil sludge at drilling sites.

c) Export material for Europe (rations)

Water flour of the Amazon region (roots macerated for 3-4 days in water, film removed, pressed, sifted, roasted)

For culinary uses.

Pará flour:

Obtained by mixing the dough of "water flour" with a dough of dried or common flour, before pressing.

Used for culinary purposes in the state of Pará. On the south coast of the state of São Paulo, this preparation is called "farinha de Manema" ("Manema" flour).

In the state of Pará, "Tucupí" is obtained as a traditional by-product in the making of common, dried, or table flour, preferably using yellow pulp roots.

"Tucupí"

By lengthy boiling of the pressing water, after removing the "gum", it is utilized in preparing a typical dish known as "duck a la Tucupí", and also to make "tacacá".

"Tacacá"

"Tacacá" is a kind of infusion, porridge or drink made with "tucupí", pepper, basil, myrtle, salt, shrimp, and a gum porridge, and eaten in the north, especially in Belém do Pará.

Starch uses

a) In the food industry.

b) In the paper and cardboard industry.

c) In the textile industry.

d) In the pharmaceutical industry.

e) In the making of ice cream cones.

f) In the preparation of tapiocas, sago, Beijus (cassava pancakes), gum and adhesives.

g) For exportation, principally to the United States.

h) Used to a limited extent in the preparation of dextrines,and pre- jelled starch.

i) Used in meat and sausage derivatives.

Fermented starch, commonly known as "sour powder" (polvilho azêdo)

Obtained as a by-product of the cassava flour and chip flour industries, from pressing water.

a) Used in the food industry for the preparation of starch biscuits, "sequilhos", "pao de queijo" (cheese bread), etc.

b) In the preparation of glues.

About 30 years ago, millions of liters of ethyl alcohol from cassava were being produced in the states of São Paulo and Minas Gerais, for internal use in the forms of burning alcohol and fuel alcohol for combustion engines (motor alcohol).

However, it could not compete economically with the traditional products.

Dextrines, pre-jelled starch and glucose, have also been obtained on a small commercial scale from cassava in Brazil, but they cannot compete with similar products obtained from corn starch.

In Brazil, corn is the major competitor of cassava as a source of carbohydrates in the composition of animal rations.

In the international market, this cereal competes with cassava chip exports for the European Common Market (as is happening this year, as a result of the overproduction of corn in the United States).

Principal factors limiting production

Economic Factors

Price Variability of the Roots

In years of lower prices, caused by a large supply of roots, the planting area is reduced (limiting factor: price), whereas in years of higher prices, because of the scarcity of raw materials, planting is stimulated.

The shortage of roots in a given Brazilian area could be more apparent than real, because when there is a large demand for roots, the making of table flour would be intensified in another state (e.g., São Paulo, to be shipped to the Brazilian northeast) where, due to adverse climatic conditions, the harvest of cassava is reduced. In this case, the demand for roots by table flour factories increases, raw material prices rise, and there is a shortage of roots for the chip and starch factories.

In the state of São Paulo there is a general trend to increase the planted area. In 1952, 36.3 thousand hectares were cultivated, whereas in 1963, close to 172 thousand were planted, although in subsequent years the area has been slightly reduced.

Lack of financing

This factor may limit production in those years when incentives for increasing the planted area prevail, and farmers do not find sources for financing their production.

However, the government is financing agricultural production through the Office of Agricultural Credit of the Bank of Brazil, state banks, and also private banks.

Costs of production

Production costs are relatively high in Brazil, and do not permit intensive competition in the international chips and starch markets. In this manner, costs limit or even impede an increase of the cultivated area in order to participate more strongly in the rising foreign market. However, efforts are being directed towards reducing agricultural and industrial costs.

Agronomic Factors

Soils

In certain areas productivity is limited by the lack of natural soil fertility. In these soils, only correcting of soil acidity and mineral fertilization can increase productivity levels.

Climate

In some years, adverse climatic conditions may limit productivity or planting at the most appropriate time, such as when a prolonged dry period occurs at the planting season, or even during the planting season. Consequently, the climatic factor has been responsible in certain years for an enormous limitation or disruption of cassava harvesting in the Brazilian northeast. In this case, it becomes very profitable for the southern states to produce and sell cassava meal or flour to the northeast.

Pests and diseases

A bacteriosis caused by *Xanthomonas manihotis* is a disease that frequently limits productivity (especially in central and south Brazil). The same can be said of the shoot larvae of the diptera *Silba pendula* and of the larvae ("Colebrocas") of some species of the genus *Coelosternus*.

Cultural factors

An important factor which also limits productivity and keeps the harvest from reaching its production potential is the lack of technical knowledge on the part of the majority of farmers or the lack of acceptance of government orientation and infrequent supervision by agronomists.

Factors limiting a greater utilization of cassava in Brazil

In human nutrition

The limiting factor is probably the lack of types with roots that can be kept for a long time and that possess better culinary characteristics, superior palatability and greater nutritive value. On the other hand, the known toxicity of numerous cultivars may have a negative influence on the choice of this food. Despite this, it is widely consumed in the country as roots or by-products.

In animal nutrition

The lack of cultivars with fresh roots or by-products of greater nutritive value, which can substitute completely or partially for corn under the same agronomic and economic conditions, is limiting for animal nutrition. Probably in agreement with the literature, the presence of the cyanogenic glycoside in the fresh roots or in the products of dehydration and milling of the roots, although present in minimal dosages, may be responsible for a lower use of the sulphur amino acids in animal diets.

Starch and starch- derivatives industries

The utilization of cassava is limited by the competition of similar products obtained from corn -- starches, dextrines, glycose, etc.

Similarly, the lack of technical knowledge in obtaining derivatives which could be more important and useful may be limiting a greater utilization of industrial cassava.

Research needed in the area of factors limiting production

1. Better knowledge of the causes generating price variability of industrial roots from year to year, and of those which determine regional price differences within the country.
2. Assessment of actual agricultural and industrial financial needs and better ways of fulfilling them which take into consideration the opinions of industrial producers.
3. Knowledge of factors which, in order of importance, more heavily tax agricultural and industrial production in order to establish the causes, and propose measures to reduce expenditures and unit costs.
4. Intensification of soil fertilization studies, covering methods and time of application, knowledge of nutritional deficiencies and economics of fertilization.
5. Environmental and climatic influences, such as relative humidity, daylength, dry periods, hot or cold periods, etc., that bear on the development of the plant, synthesis and accumulation of starch, and incidence of pests and diseases.
6. Research of new internal and external markets for cassava derivatives.
7. Research on new and wide applications of cassava products.

Present state of research

In each state of Brazil there is one or more entity, state or federal, having a program on a small or large scale which is engaged in cassava studies: Agricultural Research and Experimentation Institutes, the Agronomic Institutes, and the Schools of Agronomy.

In addition, other Brazilian institutions study matters related to toxicity; nutritive value in general; the value of cassava as a component of dairy cattle, swine, and poultry rations; the area of vitamins; the technological aspects of starch; the industrial use of the roots; and the enrichment of cassava flours with protein and mineral salts.

At the Instituto Agronomico do Estado de São Paulo, at Campinas, cassava agronomic studies date back to 1937. In its Section of Roots and Tubers, research involves all the agronomic aspects, taking into consideration genetic improvement and all agricultural sectors.

At the same Institute, other sections collaborate with the cassava program in the fields of their speciality, such as botany, entomology, plant pathology, plant virology, genetics, cytology, physiology, foliar analysis, and statistics.

At the same agronomic Institute, a special work project has existed since 1969 in the area of cassava improvement, subsidized to a great extent by the National Bank of Economic Development (Banco Nacional de Desenvolvimiento Econômico, BNDE) through an agreement between these two entities.

The Food Technology Institute, also in Campinas, São Paulo, studies technical problems related to breadmaking and industrial processes.

At the São Paulo State Biological Institute, some scientists dedicate themselves to studying pests and diseases of cassava, its various plant pathology aspects, and plant protection.

The Animal Sciences Institute in São Paulo, through its animal nutrition division, carries out comparative trials on the value of cassava in relation to other sources of carbohydrates in animal rations.

I am willing to collaborate in cassava programs, principally in the area of plant breeding, which correspond to the activities I presently carry out in the Root and Tubers Section of the São Paulo State Agronomic Institute in Campinas, Brazil.

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CASSAVA PROGRAM REVIEW CONFERENCE

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1. Present status of cassava research at IPEAN

In 1969 the Amazonian area of Brazil was divided, for agricultural research purposes, into two regions: Western Amazonia and Eastern Amazonia. The Instituto de Pesquisas Agropecuarias do Norte (IPEAN) was given the responsibility for research activities in the Eastern Amazonia Region, which includes the State of Pará, the territory of Amapá and the Amazonic region of the State of Maranhao. Research activities in Western Amazonia were assigned to the new Institute (IPEAOC).

Cassava research at IPEAN has received reasonable attention, and solutions have been found to some of the most important problems of this crop.

At present the Amazonian region is going through an accelerated process of development, which is being brought about by the construction of two highways that will facilitate the integration of this vast area into the nation's economy. These roads are the Transamazonic highway and the Santarém - Cuibá road, and they are creating an increasing demand for cassava for industrial purposes. This has necessitated additional research on cassava in areas not previously considered, such as:

1. Management of cassava plantations for supplying industry.
2. Studies on the possible variations in starch quality due to regional climatic variations.
3. Mechanization of cassava production.
4. Research on cassava fermentation.
5. Genetic improvement of cassava.

2. <u>Present status of cassava production and utilization in Western Amazonia</u>

In the Brazilian Amazonia 85 percent of cassava is used in the form of table flour, which is produced solely from high HCN cultivars, since the sweet, low HCN types (Macaxeira) give the flour a somewhat acid flavor, which is not well accepted by consumers.

The following products are obtained from cassava:

a) Table flour

b) Tucupi

c) Tapioca flour

d) Macaxeira

e) Foliage

f) Chip flour

Starch is obtained only by decantation of tucupi. Most of the starch is used in the preparation of typical dishes in Pará, such as tacacá.

There are many other ways of using cassava, about which little commercial information is available.

The region is self-sufficient in production, having a small surplus for export mainly in the form of table flour.

3. <u>Limiting factors for production and utilization of cassava in Eastern Amazonia</u>

The following are limiting factors for cassava production:

a) The soil type in which cassava is produced.

b) The low cultural, social and economic levels in the rural sector.

The majority of cassava production is carried out in latosols (sandy clays), which are appropriate for the growth of arboreous species.

On the other hand the limited availability of agricultural inputs and the low level of education in the region do not allow the utilization of improved technology that would permit increased production. The same factors are responsible for not utilizing cassava in other ways and according to rational and technical systems.

The most important cassava product, from an economic point of view, is starch. Also, this product is basic for obtaining foreign currency. However, starch is used in a limited way in the preparation of a local dish, tacacá, and in home preparation of candies. Cassava is used mostly in the region to prepare table flour (85 percent), followed by tucupi and tapioca flour.

It is expected that the situation described above will change soon, as a result of the importance being given to education in the rural areas and by the great interest demonstrated by the specialized industry in establishing additional cassava processing plants. These actions will contribute to increased cassava production.

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CASSAVA IN EAST AFRICA

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Production and utilization

As a former member of the East African Agriculture and Forestry Research Organisation (E.A.A.F.R.O.), I am familiar with cassava problems in the East African territories of Kenya, Tanzania and Uganda. These three territories together grow about 900,000 hectares of cassava with an average yield of only 4.1 metric tons per hectare. This compares very unfavorably both with the world average of about 9 tons and with the average of 13 tons or more achieved by certain West African countries. Production is almost entirely on small peasant holdings and for home consumption, though there has lately been an increase in the export of dried roots to Europe.

Factors limiting production

Three causes of low production are: infection with viruses, inadequate rainfall, and poor husbandry.

(a) Virus diseases. Yield losses due to virus infection vary, but estimates as high as 95 percent have been obtained for cultivars grown in East Africa, whereas the highest estimate obtained in Central or West Africa is 43 percent. The high losses in East Africa are partly due to Brown Streak virus, whose distribution is limited to the east coast, and partly to the exceptionally high intensity of symptoms caused by mosaic viruses. I participated in a major program to breed varieties resistant to these viruses. In this program, resistance was transferred to cassava from several related species, and two of the hybrids produced were particularly successful and widely grown on the coast of Tanzania. However, reports of their health status ten years after release are conflicting. Some areas required a higher level of resistance and it was possible to build up resistance almost to immunity by further breeding, though the program was terminated before this enhanced resistance level could be combined with a high-yielding capacity. There is no doubt that the problem is capable of solution by breeding, possibly supported by further pathological work. The problem is so serious on the coast that progress in other directions is not likely to be achieved until it is solved, but it is less important for inland areas like Uganda.

(b) Inadequate rainfall. Some cassava is grown in areas where rainfall is low and a lot is grown in sandy coastal soil with low capacity to retain water. Varieties which produce roots quickly and establish themselves quickly are required. Certain hybrids derived from *Manihot glaziovii* have this characteristic, and further improvements by breeding may be possible, particularly if species adapted to semi-desert conditions are used. The problem is sometimes aggravated by scale insects which cause stems to dry out. This problem can also be solved by breeding.

(c) Poor husbandry. Production on small peasant holdings inevitably tends to be inefficient, with inadequate disease control, fertilizer usage and cultivations. If increasing urbanization increases trade in cassava products there will be a tendency towards larger units of production and more mechanization. This poses problems for the engineers, the agronomists and the breeders. Breeders will be required to select plants with a habit amenable to mechanical management and capable of responding to high fertility conditions. This will require studies to determine plant characters which provide high yield and programs designed to study ways of using the wide range of germ plasm available. Breeders should have ready access to germ plasm collections maintained on an adequate scale at germ plasm centers.

Factors limiting utilization

Nutritionists state that cassava utilization is limited by its HCN content and by its low content of protein. Thus though varieties with a high HCN content are prepared in western parts of Tanzania — because they are damaged less by wild animals — the production of varieties with a very low content should be the objective. It should also be possible to achieve a significant increase in protein content by breeding, because useful variation exists both among cultivars and among closely related *Manihot* species.

The present status of research

The breeding program with which I was associated was terminated in 1959. Present research is limited to variety trials and agronomic studies at Department of Agriculture Stations, and some work recently started at E.A.A.F.R.O., Nairobi, to characterize strains of mosaic virus.

I am not now engaged on a cassava project but am still interested in cassava problems. I would be happy to cooperate to ensure optimum use of East African breeding material.

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CASSAVA PROGRAM REVIEW CONFERENCE, GENERAL PROGRAM SCHEME

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For the purpose of indicating the areas of interest and the collaboration of the Ethnobotanical Section, Botany Branch, Graduate College, ENA, Chapingo, Mexico, I present the following scheme with regard to a general program with cassava.

I. Objectives

The use of cassava as an instrument for the optimum utilization of the resources of the hot humid ecosystems.

II. Goals

A. Expansion of production of cassava in the tropics.

B. Expansion of use of cassava products.

III. Methods

A. Botanical studies

1. Anatomical, morphological and reproductive information.
2. Present variability.*
3. Selective pressures by man: evolution of the cultigens.*
4. Plant exploration and germ plasm bank.*
5. Physiological and autoecological information.
6. Bromatological information.
7. Genetics.

B. Production factors

1. Phytogeographical information of cassava.
2. Present agricultural practices.*
3. Experimental research on:
    a. Introgression
    b. Heredity

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* Points in which collaboration may be established.

c. Production techniques:

1^1. unicultigen stands

2^1. associations

C. Forms of use of cassava plant products

1. Industrial processes.
2. Direct human consumption:
   a. Ethnological information.*
   b. Present day uses.*
   c. Possibilities of new future uses.
3. Direct animal consumption.

Plant exploration in Mexico conducted under the leadership of Victor M. Patino indicates that cassava production occurs in a large region of the hot humid tropics in three main patterns:

1. Small plantings in individual horticultural gardens.
2. Commercial stands in Morelos to supply the specialized market for human consumption in Mexico City; the total of these plantings is less than 200 hectares.
3. Commercial plantings restricted to the southeastern corner of Chiapas and totalling slightly over 1,000 hectares for production of raw material for industrial processes.

Historical information indicates that medium-small plantings have been established when a market has created a demand.

The principal factors limiting cassava production in Mexico for human consumption are primarily cultural. The related research needs are indicated in the outline above. For industrial purposes, it seems that research in processes may be needed and that both genetic improvement and betterment of agricultural practices may make a substantial contribution in production.

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* Points in which collaboration may be established.

At present the Ethnobotanical laboratory has devoted primary efforts in eco-biological and evolutionary studies of maize. I consider that the experience obtained to date places us in a position to extend our expertise to another autochthonous crop such as cassava.

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THE ROLE OF CIAT IN THE INTERNATIONAL IMPROVEMENT OF CASSAVA: THE AGRICULTURAL ECONOMICS INPUT[1/]

Per Pinstrup-Andersen
CIAT

Past economic analysis with respect to cassava is scarce. As a component of an international program on the improvement of cassava, research is needed on the economics of its production, marketing and consumption.

The suggested objectives of CIAT agricultural economics research activities on cassava are:

1. To help guide the allocation of research resources. Attempts will be made to estimate relative social pay-off from alternative research efforts.
2. To help improve the economic efficiency of cassava production and marketing.
3. To estimate the overall economic and social consequences of the adoption of improved technology in cassava production and marketing.
4. To help guide private and public investment and public policy with respect to cassava.

The specific areas of research needed include the following:

1. Research to identify the major bottlenecks in production, marketing and consumption of cassava; to estimate the relative economic importance of each one of these bottlenecks and to estimate the cost of reducing or eliminating them.
2. Research to estimate the cost of producing cassava under various management systems. This would include analyses on the relative cost of alternative means of disease, weed and insect control, optimum

1/ Discussion paper prepared for the International Cassava Program Review Conference, Cali, Colombia, January 10-12, 1972.

fertilizer use, plant spacing and other cost components. Furthermore, the relationship between cost of production and farm size should be analyzed.

3. Research to estimate economic losses during transportation and storage under various marketing systems. Furthermore, economic losses due to price fluctuations caused by seasonal variations in supply and demand or inefficient marketing systems should be analyzed.
4. Research to analyze present and future demand for cassava. Demands for fresh and processed cassava will be considered. The economic feasibility of utilizing increasing quantities of fresh cassava for animal feed and for industrial processing will be emphasized. This would include a study to determine the economic feasibility and the impact on consumer welfare of utilizing cassava to replace higher cost foods and feeds.
5. Research to analyze the implication of an expanded cassava production on employment, incomes, income distribution and foreign trade.

Given the research resources available to the Agricultural Economics Program of CIAT it is obvious that a considerable amount of outside collaboration will be needed to carry out the above mentioned research within a reasonable time span. Even with such collaboration it is doubtful whether all the projects involved could or should be carried out simultaneously, hence a time priority ranking must be established. It appears that research area number one, including closely related projects from the other four areas of research, is the most urgent.

*****

AGRONOMY PROGRAM IN CASSAVA

R. L. Thompson
CIAT

Objective: The general objectives of the Agronomy Program in Cassava are to

(1) Increase returns to the producer through increased production per unit cost.

(2) Increase and stabilize the total amount of cassava available for market or home use.

(3) Reduce prices to the consumer.

These should be achievable through development, testing and encouraging the adoption of production systems utilizing tested agronomic practices such as weed control, fertilization, cropping procedures and other practices which will tend to maximize returns from the efficient use of capital and labor inputs.

Project.

I Development of standards for efficient experimental procedures.

Sub-project:

A. Evaluation of sample size needed to secure valid experimental data.

B. Replacement of missing plants in experimental plots.

Many cultural practices influence germination and emergence of cassava plantings but often other factors enter into the emergence of plants which tend to confound the results obtained. In order to avoid this type of confounding it is desirable to have a perfect stand in experimental plots.

C. Suggested guide for cassava field trials.

II Outstation Research, National and International cooperative work.

Sub-project:

A. Standarized varietal testing procedure.

It would be desirable to identify several 'reference' varieties each adapted to an ecological zone. This would permit comparative testing programs enabling widely separated stations to evaluate their lines with the reference lines.

To implement this would require

(1) Some standarization of testing techniques.

(2) Delineation of ecological zones

(3) Evaluation, selection and distribution of the reference varieties.

B. Sub-project: Evaluation of Nutrient requirements and correlation of soil and plant tissue tests.

Accurate correlation data between soil tests, plant tissue tests and plant responses are essential if cassava yields are to be increased systematically through fertilization. These correlations will permit the establishment of base lines for

1. Making fertilizer recommendations from soil tests.
2. Diagnosis and correction of deficiency problems in growing plants.

Plant samples for tissue testing and soil samples taken from fertility or other experimental trials established on a widespread geographical basis could serve to start building a background of information concerning nutrient status of cassava plants. This will provide a simplified system of predicting fertilizer responses with a minimum of fertilizer experimental work.

Standarized procedures must be utilized for

1. Fertilizer correlation plots.
2. Plant and soil sampling
3. Plant and soil analysis

4. Evaluation of climatic or other factors seriously affecting yields other than fertility.

III Cassava Cropping Systems

Sub-projects:

A. Evaluation of effects of crop competition on cassava.

Cassava is widely grown in multiple cropping schemes. With variables of different crops, planting times and cultural practices the number of possible cropping systems prohibits testing all combinations. Evaluation of the competitive effect on cassava of crops with differing nutrient requirements, canopy arrangement, and time of maturity will result in establishing principles that can serve as a basis in planing multiple cropping systems.

B. Variety, plant population and time of harvest study in cassava.

Because of the variability of plant characteristics in cassava it is doubtful that uniform management practices will give equal results for all cassava lines. The evaluation of populations and time of harvest for a few varieties of cassava with distinctly different growth habit will establish guide lines for cultural practices for other varieties with similar agronomic characteristics.

CASSAVA PROGRAM REVIEW CONFERENCE

Nelson Estrada R.
Programa de Tuberosas
ICA
Apartado Aereo 7984
Bogotá, D.E., Colombia

1. Status of cassava production and utilization in Colombia

More than 90 percent of the cassava area in Colombia, approximately 300,000 acres, is cultivated under primitive systems, in plots not bigger than 10 acres, with very low if any modern inputs such as fertilizers, insecticides, fungicides or weedkillers. In addition, in many plots cassava is planted with corn, bananas, yams, etc., which makes mechanization very difficult if not impossible. Planting, weeding, digging, etc., is done by hand.

Cassava is used mostly as fresh food, in soups, and fried. In a few cases, small processing systems are established for starch extraction. As a result, yields are low: about 3.2 tons/acre.

2. Principal factors limiting cassava production and utilization and related research needs

Most of the factors mentioned in item No. 1 contribute to low yields. Additional factors limit the expansion and technical exploitation, e.g.: a) difficult and expensive transportation, b) growers' limited knowledge, c) extremely low conservation of the roots (3 days), d) lack of processing factories, e) lack of a minimum price for the product, f) limited amounts accepted by the local markets.

Favorable factors for cassava expansion in Colombia are: a) Good potential areas with good soil, temperature, water and hand labor conditions; b) few limiting diseases, and no virus disease problems have been found so far; c) the insects or spiders which attack cassava can be easily controlled; d) much of the processed cassava can be used in the country as starch for factories or as flour or chips for animal feeding; e) there are potentially good native varieties with high yields, high starch content and reasonably early maturation (8-10 months).

Important research needs are:

a) Selection or hybridization of varieties to get higher yields, earliness and high starch and high protein content; b) agronomic and physiologic studies on planting distances, water needs, planting and harvest time, plant nutrition, temperature needs; c) conservation studies to insure the post-harvest good condition of the root; d) disease (bacteria) and insect resistance studies; e) quality studies to define protein quality, starch content, etc., in large populations obtained under a well organized breeding or selection program.

3. Status of cassava research in ICA

ICA has been studying several of the limiting factors to improve the yields and the quality of cassava. Some good varieties, such as Llanera (CMC 9), CMC 40, have been selected for the Cauca Valley and other interior regions. Other varieties have been selected for the Caribbean Coast, such as CMC 99, CMC 12, CMC 15, CMC 40.

Several of the agronomic studies indicate which distances are better with some selected varieties.

Good insecticides are being tested and used for the control of several pests, and proper weed killers have been selected for the areas of the Cauca Valley and the Caribbean Coast (DNBP, Eptam, Vernam, Sutan).

Semi-commercial and commercial plots data indicate that yields of 16 tons/acre are easy to get in the Cauca Valley and yields of 12 tons/acre can be obtained in commercial plots in the Coast area. This will require an increase of inputs but with the 400 percent increase in yield it is more than justified.

CASSAVA PHYSIOLOGY PROGRAM REVIEW, 1972

James H. Cock
CIAT

Very little is known of the general physiology of cassava. Consequently the initial program is intended to give a basic understanding of the growth cycle of the plant and how this is affected by factors known to be of major importance in other crops.

Growth cycle of the plant

In most crops assimilation during the bulking period (the period when economic yield is formed) accounts for more than 80 percent of the yield. It has been repeatedly found in a variety of other crops that the primary factor influencing rate of assimilation is having sufficient leaf area to intercept more than 90 percent of the incoming light. In the Irish potato, yield is directly related to the integral of the leaf area index with time during the bulking period (when leaf area index is greater than 3 it is taken as 3). Hence a study of the pattern of leaf area index is essential to understanding the crop.

Formation of leaf area index is not, however, solely a varietal character; it can be markedly changed by varying nitrogen applications and spacing.

To study the growth cycle of the plants, the following experiment is planned:

Varieties:

a) Llanera; a heavy branching, fine leaved variety with maturity at about 10 months.

b) C. M. C. 76; a medium branching, broad leaved variety that has early maturity.

Spacing:

50	x	50	cm	(4 plants/m^2)
70	x	70	cm	(c2 plants/m^2)
100	x	100	cm	(1 plant/m^2)
140	x	140	cm	(c0.5 plants/m^2)

Fertilizer (kg/ha):

300 N split so as to be 100 at planting, 100 at 3 months and 100 at 6 months.

200 K_2O)

) at planting

200 P_2O_5)

Weed control:

By hand as necessary

Insect control:

Insecticides as necessary

Measurements

Harvests at 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 months after planting. At each harvest the following measurements will be made:

1. Leaf: Area, width, weight, angle, number, nitrogen content.
2. Petiole: Length, weight.
3. Stem: Node number, branching habit, sugar and starch content, dry weight.
4. Roots: Fresh weight, dry weight, sugar and starch, nitrogen content, number.
5. Light: L. T. R., total incident radiation, profile radiation.

Expected information

1. Dependence of growth rate on leaf area index and radiation: presence or absence of optimum L. A. I. for C. G. R.
2. Contribution of carbohydrate stored in the stems before tuber bulking to final yield.
3. Relationship between yield and growth rate after tuber formation.
4. Differences in growth associated with broad and fine leaves and their effect on light penetration.
5. Optimum time of harvest in terms of $kg/ha^{-1} day^{-1}$

Nitrogen response

There are several reports suggesting that there is little if any response to 'N' in cassava. As a crop physiologist I find this somewhat surprising. However, cassava is normally grown on light free-draining soils where nitrogen losses will be large. It seems possible that when 'N' is applied at planting most may have been leached from the soil by the bulking period, which must be highly important. Hence the following experiment is planned:

Variety: Llanera Spacing: 1.4 x 1.4 m

Time of nitrogen application:

kgN/ha

Total	At planting	At 3 months	At 6 months
0	0	0	0
150	0	150	0
150	0	0	150
150	150	0	0
150	50	50	50
300	300	0	0
300	0	300	0
300	0	0	300
300	150	150	0
300	150	0	150
300	0	150	150
300	100	100	100

Measurements

Yield, total dry matter, L. T. R. throughout crop growth period, nitrogen content of roots.

Expected information

1. Nitrogen response x time of application interaction.
2. Effects of time of application on nitrogen content of roots.

Mineral nutrition

On the CIAT farm there are many leaf symptoms which are not readily diagnosable. This is probably true of many areas in the world.

Experiment:

Grow yuca plants in sand culture with complete and deficient culture solutions and record (mainly photographically) symptoms associated with various deficiences at all possible growth stages.

Flowering

For a successful breeding project, time of flowering must be either predictable or controllable. Various chemicals, e.g., ethrel, will be tested to see if they induce flowering.

It is hoped that photoperiodic x temperature interactions can be studied in the ICA growth chambers in Tibaitata.

Date of planting

The response of yuca to climatic changes, particularly solar radiation, is not known. To gain preliminary information a series of monthly plantings using the best known available agronomic techniques will be grown in simple yield trials.

Clonal Propagation

At present the rate of multiplication of planting material is quite low in cassava, somewhere in the region of 10 times per annum. For a successful breeding and selection program a much faster rate of reproduction is required.

This problem will be approached in two ways:

1. An assessment of the feasibility of mist propagation as a means of rapid multiplication using single node cuttings. During this study hormonal and fertilizer treatments will be investigated.

2. Investigation of rapid methods of propagation in the field.

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NOTI-CIAT

Centro Internacional de Agricultura Tropical

Nos. 2 and 3
July - August 1971
September-October 1971

Two International Rice Seminars at CIAT

Advances leading to the increased and improved production of rice will have a major impact on the economic and social development of Latin America.

In connection with the release of two new high-yielding rice varieties, CICA 4 and IR22, in April, 1971, CIAT planned and sponsored a seminar on "Rice Policies in Latin America," in order to communicate to scientists and policy makers recent developments in rice research and the probable consequences of this research on the agricultural and related sectors of the Latin American economy.

The seminar took place October 10-14, 1971 in Cali, Colombia and provided the opportunity for decision and policy makers of national agricultural planning organizations to learn more about the potential of the new high-yielding rice varieties. The delegates were able: to consider the economic and social consequences of increasing rice production, to identify and discuss solutions for the specific problems associated with increased rice production, to discuss ways of increasing rice production within countries so as to improve the diets of people and expand domestic markets, and to formulate new or revised policies and programs, stressing those factors particularly relevant to the country.

Some of the 180 international delegates at CIAT's October 'Rice Policies in Latin America' seminar

A regional and country group; delegates discussed their respective country's rice policies

More than 180 delegates from 23 countries attended the sessions. Speakers from the International Rice Research Institute (IRRI), the Philippines, the Instituto de Nutricion de Centro America y Panama (INCAP), Guatemala, the Ford Foundation, Louisiana State University, the Programa Nacional de Arroz de Peru, and CIAT presented papers.

Following these presentations, delegates worked together for one and one-half days in country and regional groups; they discussed norms, objectives and policies pertinent to future rice planning in their respective countries. On the last day of the seminar, each group presented its conclusions and recommendations for discussion.

In another seminar which preceded and overlapped the rice policy session, 16 scientists, representing research institutions in Japan, the Philippines, Brazil, Peru, Ecuador, Nigeria, the U. S., and CIAT, reported to nearly 100 delegates on the blast disease of rice. Blast, caused by the fungus Pyricularia oryzae Cav., is one of the major factors limiting rice production in Latin America.

NOTI-CIAT is published bimonthly by the Centro Internacional de Agricultura Tropical, CIAT. It contains information about the activities of this institution and news of interest for the development of agriculture and livestock production in the tropics. Address correspondence about "Noti-CIAT" to: Section of Publications, Training and Communication, CIAT, Apartado Aéreo 67-13, Cali, Colombia.

TO: Persons Receiving Preliminary Draft

This document has been prepared to provide basic reference material for use in the Cassava Program Review Conference and, in a final form to be published following this event, for circulation to a wider audience.

Consequently, we would appreciate your giving some attention to this draft and returning this sheet to the Conference Secretariat, with appropriate comments, before you leave Cali.

1. If you have noted specific errors, what are they?

2. What additional data would make this report more useful to you or others?

3. What changes, if any, in organization of the data or format of the report would make the report more convenient to use?

(continued overleaf)

TO: Persons Receiving Preliminary Draft

4. What other sources of data do you suggest we explore before putting the report in final form?

5. To what categories of persons or institutions do you suggest the revised report be sent?

6. What other comments do you have about this report?

(use reverse side, as necessary)

Preliminary Draft
Not for Publication

SUGGESTED GUIDE
FOR
CASSAVA FIELD TRIALS

by

R. L. Thompson and D. W. Wholey

January 1972

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL

CALI - COLOMBIA

STANDARD PLAN AND REPORT SHEET FOR CASSAVA FIELD TRIALS

Introduction

Each year there is a considerable expenditure for research work on different aspects of cassava. Many of these trials are well conducted and provide useful information. Many could be improved through relatively minor changes in plot size, border areas, or evaluation techniques.

Most experiments would also provide additional information about cassava culture on a much wider area basis if the experimental work was:

1. More clearly defined, including more complete ecological and climatic descriptions.
2. Conducted under more uniform, standarized designs and evaluation systems.
3. Summarized and the results distributed more widely.

Reports of experimental work which do not achieve the desired purpose due to experimental design, etc., may be valuable in preventing others from making the same errors. These results are often not publishable but may be included in an informal newsletter to cooperators.

The following uniform plan and report form for cassava trials is intended to provide a check list for design of experimental work. It is intended only as a guide and each research worker will require additional plans, details and information, but the use of the guide may assist in obtaining a more complete record of experimental conditions. Through the cooperative effort of various institutions, more rapid advancements in cassava improvement should be possible. This cooperative work should in no way restrict independent and original work but should enable the adoption of superior techniques and research systems, thus reducing unnecessary duplication and loss of time and money.

The following are some of the items which should be given consideration in setting up experimental work.

Experimental Considerations

Plot size

Present indications are that a minimum of between 16 to 32 sample plants are needed to give a reliable estimate of yield for particular treatments.

Where the stands are very uniform — without missing plants — the minimum number may be sufficient. Where plants are missing or stands are lacking in uniformity a larger number of plants must be available so that plants with normal competition can be harvested for yield purposes.

Missing plants

The loss of plants in many experiments masks the treatment effect which is being evaluated. For this reason it is advisable to plant extra stakes when the original planting is made. These can be transplanted to replace missing plants. For some experimental work the reduction in emergence because of a particular treatment, i.e., stake size, age, planting systems, etc., is the most important factor and can be measured simply by a plant count. The yield, which is of course of ultimate importance, is subjected to so many factors that the yield results may lead to erroneous conclusions. As an illustration, in a comparison of size of seed pieces the small cuttings germinated only 75 percent, but because of moisture shortage the reduced population produced a higher yield per unit land area. The conclusion might be that small seed pieces are better than the large, whereas in fact the experiment more correctly showed the evaluation of populations. Normally, perfect stands are needed to get unconfounded results.

Border rows

Most experiments will require border rows around each plot in order that edge effects and unequal competition between varieties of different growth habit are eliminated. Fertilizer applications are often difficult to distribute uniformly and accurately to an exact line, especially when incorporated by machinery. Roots amy also cross over into adjacent plots where border rows are not used.

The number of border rows required will vary with the type of experiment, experimental plan, row spacing and other factors. Normally, at least two border rows are desirable around the outside of an experimental area. Within the experimental block, one row around the plants to be sampled is the minimum. Additional rows will be required where close row spacing, widely contrasting plant types or other experimental conditions call for them. Where evaluations are to be made before there is competition for light, moisture, or other factors (e.g. germination studies) plants may be left unbordered but care must be exercised when such decisions are made. Border plants can be valuable for developing sampling systems for evaluation in the experimental plot proper, providing destruction is avoided until a day or so before the experimental plot proper is harvested.

Experimental design

No experimental plan or design will compensate for carelessness in experimental work. The use of replications and proper experimental design may help in the determination of better cultural practices, varieties, or management systems but statistical calculations will never correct errors made in field plot technique. Because of the variability observed in cassava it appears that four replications in simple experimental designs is the minimum. Experimental projects often fail to provide results because of over-complex plans involving too many treatments instead of sufficiently replicated simple experiments. The objectives of the experiment must be clearly in mind before the plot layout or design can be made.

Recording of data

Simple systems which require a number or letter to denote a characteristic are desirable, providing an accurate evaluation for comparative purposes which is easily analized. Photographs can be very helpful for recording overall impressions.

Notes are best taken directly in field books to avoid having to transfer data more than necessary. (A somewhat soiled field book is more reliable than an immaculate typewritten sheet where errors have been made in the transfer of data.)

The use of more than three significant figures in reporting yield data from small sample plots often is at times confusing.

The careful choice of units for recording data can help to avoid errors during transfer and calculation. Plot yields in pounds can mean wasted time and possible errors when converting to kgs. per hectare.

The plot area for yield determination should be easily converted to an universally acceptable large unit, eg. hectares. It is suggested that 100 m^2 (one are) be used as a reference unit which can be further subdivided into two or four smaller areas which can be mentally converted to the final unit. This often prevents obvious errors which can occur with complex conversion factors.

Numbering the days in the year beginning with No. 1 January 1st and running through 365 on December 31 provides a simple system which is useful in reporting the age of plants at various growth stages, observations and treatment periods. If both the date and day number are entered, record keeping is facilitated. A table is presented as Appendix I.

Reporting of results

Results should be reported initially in terms that will be most meaningful to the individuals using the results. This normally will be the farmer or producer where local units of measurement are used. To avoid confusing collaborators in other countries it is also helpful to convert the results into standarized terms which are easily comparable from one area to another,eg. kg/ha.

If this is not done a conversion factor is essential.

Because of the wide variation in the growth period of cassava, yields are more easily compared if they are reported in kilograms of dry matter per hectare per day (kg/ha/da) instead of unit weight per unit land areas (kg/ha); with changing cultural practices the time between planting and harvest becomes more important and consideration must be given to alternative land uses in areas where possibilities exist for continuous cropping programs.

Accurate descriptions of the methods used in various experiments will permit the more rapid standarization of experimental procedures, which in turn should permit greater advancement in cassava work.

The following sheets may be used as guides for the planning and information collecting phases of experimental work. Most experiments will also require data sheets which will have specific data to be collected in addition to the general information needed.

DATA SHEETS

BACKGROUND INFORMATION:

Person responsible: Name, address and organization ______________________________

____

Cooperating individuals or groups ______________________________

____

Location of experiment: ______________________________

Latitude ______________________________

Altitude ______________________________

Brief description of climate ______________________________

____

____

Slope - class & direction: ______________________________

Soils Information: Fill in as complete as posssible for all items where information is available

Soil type: (Sand, silt, clay, etc.) ______________________________

Top soil ____________ Subsoil ____________

Soil depth - Topsoil ______________________________

Soil classification (nomenclature) ______________________________

Drainage poor_____ Med. _____ good _____ other ____________

Water holding capacity: High _________ Medium _________ Low _________

Is irrigation available if needed? ______________________________

Laboratory soil test:

Name and address of laboratory: ______________________________

Type of test used: ______________

Results:

Organic matter ____________ Phosphorus ____________ Potassium ____________

pH____________ Other ______________________________

____

Previous cropping history:

Previous crop ______________ Yield ______________

Fertilizer or amendments added: kind and amount ______________________________

____

Deficiency symptoms? ______________________________

Weed problems? ______________________________

Control measures used ______________________________

____

Insect Problems ______________________________

____

Control Measures ______________________________

EXPERIMENTAL DETAILS:

Type of Experiment:

1. Varietal evaluation
2. Cultural Practices
   a. Land preparation
   b. Spacing or plant population
   c. Weed control - chemical
      - mechanical
      - effect of weeds
   d. System of planting
   e. Composition studies
   f. Other. Specify ______________________________
3. Fertility study
4. Time of planting
5. Water control (irrigation)
6. Quality evaluation
7. Physiological studies
8. Planting material study
9. Other. Specify ______________________________

Title of experimental work: ______________________________

____

____

Objective or objectives: ______________________________

____

Experimental design: SPLIT PLOT IN RANDOMIZED BLOCKS

EXAMPLE

Treatment	A VARIETY	B NITROGEN LEVEL	
Code in	(V_1) LIANERA	(N_1) 30 Kg/ha	______
Brackets	(V_2) TEMPRANITA	(N_2) 60 Kg/ha	______
	(V_3) FAT FOWL	______	______

Total Treatments ______________________________ 3X2 = 6

No. of Replications (Minimum 4) ______________________________ 4

Total No. of plots (Total Treatments x Reps) ______________________________ 24

Summary of treatments:

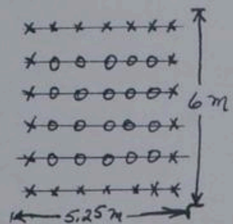
EXAMPLE

Treatment (use code)	Plot number I	II	III	IV
1. V_1 N_1	1	10	15	22
2. V_1 N_2	2	7	13	19
3. V_2 N_1	3	12	17	21
4. V_2 N_2	4	9	16	24
5. V_3 N_1	5	11	18	20
6. V_3 N_2	6	8	14	23

EXPERIMENTAL LAYOUT

EXAMPLE

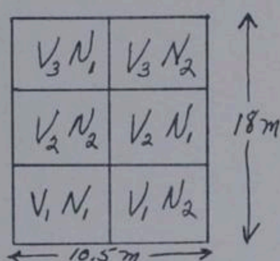
Diagram of Individual Plot.



No. of Sample plants (O) 20
No. of Guard plants (X) 22
Total No. of plants (A) 42
Width between rows 1 m
Distance between plants .75 m
Area per plant .75 m^2
Plants per hectare (10,000/Area/plant) 13,333 plants

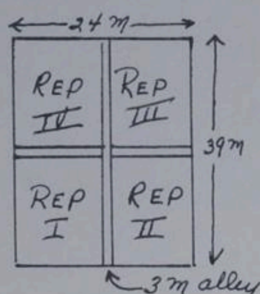
X 0 0 0 X indicates Row Direction
0 = Sample plants
X = Border Plants

Diagram of Replicate I



Number of plots per block (B) 6
Number of plants per block (AxB) 6 x 42 = 252

Diagram of Experiment



Number of Blocks (C) 4
Total No. of plants (AxBxC) 4x252 = 904

1 BORDER AROUND ENTIRE EXPERIMENT 128 PLANTS
TOTAL PLANTS 1032

Area under alleys 178 m^2

Net experimental area 758 m^2
Gross experimental area 936 m^2

PRODUCTION SYSTEM:

Land preparation and distribution of crop residues ______________________

____

Plowing or hand tillage ______________________________

____

Disking or secondary tillage ______________________________

____

Other ______________________________________

____

Fertilization:

Kind and amount applied ______________________________

____

System of application ______________________________

____

Time of application: Day No. ______________________

Day No. ______________________

Day No. ______________________

Day No. ______________________

Planting:

Time of Planting: Day No. ______________________

Planting system used:

Flat bed ______________________

Ridged ______________________

Other ______________________

Length of stake __________ cm

Origin of stake: Apical __________ Basal __________ Mixed __________

Stake position: Horizontal ____________ Depth ________________

Vertical ____________

Inclined ____________ Approx. ________°angle

depth to bottom of vertical or inclined stake _____ cm

Location of top of vertical or inclined stake:

a) Below the surface _______ cm

b) Above the surface _______ cm

Germination and transplanting

Date of emergence(approx. 50% of plants emerged) Day No. ___________

Percentage of germination (approx. 30 days after planting) __________

Transplanting completed or excess plants removed. Date _________ Day No.________

Results of transplanting: good ________ fair __________ poor ____________

Weed control

Chemical applied ____

Rate of application ____

Results ____

Cultivation or hand weed control_________________________________

Type of weeds present and percent ground covered by weeds ___________

____

____

Insect control:

Problem encountered ____

Control used ____

Material ____

Rate ____

Results ____

Economic evaluation: Agricultural wages U.S.$ _____ per day

Mechanization: Availability ______________________________

____

____

____

Cost ______________________________

Costs of experiment U.S.$ ______________________________

Breakdown

Land Preparation and planting ______________________________

Maintenance ______________________________

Harvesting ______________________________

Analysis ______________________________

Other ______________________________

Total ______________________________

Additional data recorded will vary according to the objective of the experiment. The following is a partial listing of items which may be considered. Appendix II is a sample data sheet for use as a guide.

Percent ground cover in 60, 120 and 180 days.

Plant height, top of canopy.

Height to first branches.

Stem diameter.

Differential leaf drop under moisture stress or excess canopy.

Days to floral initiation

Harvest data.

Time of harvest (age in days)

Conditions of soil at harvest; dry, wet, hard mellow, etc.

Harvest system used: hand dug, soil loosened by tractor, mechanized, etc.

Rate of harvest (plants/day/man)

Fresh weight: marketable roots, non-marketable roots, above ground parts.

Percent moisture: in roots and above ground parts.

Dry matter production per hectare per day.

Number of marketable roots per plant.

Number of plants harvested per plot.

Number of missing plants per plot.

Number of plants with poorly developed roots.

Climatic data:

Daily precipitation records and temperature (max. and min.) should be maintained as a minimum for climatological data. If temperature, relative humidity, open pan evaporation and solar radiation data are available, they should be reported. Any abnormal weather conditions which cause a stress on plants should be noted. Appendix III is sample data sheet for climatic information.

CONVERSION TABLE FROM CALENDAR DATE TO DAY NUMBER

CALENDAR DATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	CALENDAR DATE
1	1	32	60	91	121	152	182	213	244	274	305	335	1
2	2	33	61	92	122	153	183	214	245	275	306	336	2
3	3	34	62	93	123	154	184	215	246	276	307	337	3
4	4	35	63	94	124	155	185	216	247	277	308	338	4
5	5	36	64	95	125	156	186	217	248	278	309	339	5
6	6	37	65	96	126	157	187	218	249	279	310	340	6
7	7	38	66	97	127	158	188	219	250	280	311	341	7
8	8	39	67	98	128	159	189	220	251	281	312	342	8
9	9	40	68	99	129	160	190	221	252	282	313	343	9
10	10	41	69	100	130	161	191	222	253	283	314	344	10
11	11	42	70	101	131	162	192	223	254	284	315	345	11
12	12	43	71	102	132	163	193	224	255	285	316	346	12
13	13	44	72	103	133	164	194	225	256	286	317	347	13
14	14	45	73	104	134	165	195	226	257	287	318	348	14
15	15	46	74	105	135	166	196	227	258	288	319	349	15
16	16	47	75	106	136	167	197	228	259	289	320	350	16
17	17	48	76	107	137	168	198	229	260	290	321	351	17
18	18	49	77	108	138	169	199	230	261	291	322	352	18
19	19	50	78	109	139	170	200	231	262	292	323	353	19
20	20	51	79	110	140	171	201	232	263	293	324	354	20
21	21	52	80	111	141	172	202	233	264	294	325	355	21
22	22	53	81	112	142	173	203	234	265	295	326	356	22
23	23	54	82	113	143	174	204	235	266	296	327	357	23
24	24	55	83	114	144	175	205	236	267	297	328	358	24
25	25	56	84	115	145	176	206	237	268	298	329	359	25
26	26	57	85	116	146	177	207	238	269	299	330	360	26
27	27	58	86	117	147	178	208	239	270	300	331	361	27
28	28	59	87	118	148	179	209	240	271	301	332	362	28
29	29	--	88	119	149	180	210	241	272	302	333	363	29
30	30	--	89	120	150	181	211	242	273	303	334	364	30
31	31	--	90	--	151	--	212	243	--	304	--	365	31

Appendix II

SAMPLE PLANT DATA SHEET

Planting system experiment

3 treatments Horizontal, Vertical, Inclined 45°
2 varieties
5 replications

Planting date ________________ Day No. ______ Harvest date ___________ Day No. _______ Total growing period ______ days

Plot No.	Ground covered %		Stem number per seed piece	Stem diameter (mean of ...plants)	Number of plants harvested per plot	Roots Number			Fresh field weight				D.M determination			Other data
	60 day	120 day				Total	Market-able	Average market-able per plant	Average size	Roots Total	Market-able	Stems and Leaves	Wet wt	Dry wt	% DM	Root dry matter per/ha per/da

Appendix III

Climatic Data sheet - Year

Precipitation

Date	Month	Month	Month	Month	Month	Month
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

Total

Longtime average

SUMMARY OF PARTICIPANT STATEMENTS

Jan. 10, 1972

1. The most important Cassava Research undertaking which participants see:

	Frequency of Mention
Increase productivity	4
Increase production	1
Increase net income per worker	3
Improve quality (Protein, HCN content; consumer acceptability, etc.)	7
Improve cultural practices	5
Reduce time to maturity	2
Increase knowledge of the plant, physiology, production potential, problems limiting production, etc.	6
Utilization	
Increase consumption	1
Identify alternate uses	2
Improve storage	1
Determine present consumer uses	1
Disease resistance (Mosaic virus)	1
Maintain cassava's present advantages as a crop	2

2. The most difficult obstacles to improved cassava production which participants see:

Adoption of research results by farmers	
Working into rotations which require fertilizers	1
Large number of small producers	2
Back yard cultivation	1
Low educational level of growers	1
Lack of adequate socio-economic structure	1
Farmers may prefer to invest in other crops	1
Amount of labor required	1
Technical problems	
Lack of efficient cultivars	1
Length of growth cycle	1
Virus diseases	1
Asexual propagation limits agronomic trials	1
Institutional problems	
Little interest by government agencies	1
Lack of communication among workers	1
Attitudes of European/North American scientists	1
Getting research workers to respond to consumers' needs	1
Lack of knowledge of production/marketing problems	1
Defining different levels of cassava production: subsistence, commercial, etc.	1

Other problems:	Frequency of Mention
Difficulties in mechanical harvesting	4
Need for mechanical processing	1
Storage and utilization	1
Low social status of cassava	1
Human ignorance	1

3. <u>The most serious economic issues which participants see as being associated with increased cassava production:</u>

<u>Production</u>	
Limited capital and credit	5
High costs w/present cultivars in large scale production	1
Reducing production costs to make cassava more accessible to low income people	1
Increasing costs of hand labor	1
Marginal crop - not apparent farmer can make fair standard of living	1
Justification of large scale production	1
Costs and mechanization	1
Determining efficient use of inputs	2
<u>Marketing</u>	
Defining alternate uses for products	2
Limited commercial production	1
Low elasticity of demand	1
Rapid spoilage	1
Lack of alternate markets in short term over-supply situation	1
Low price	1
Low status as food	1
Uncertainty of future markets	1
<u>Processing</u>	
Cost of removing water to produce starch/flour	1
Processing and storage	1
<u>Policy</u>	
Not important as export crop; hence low government priority	1
Possible artificial support of food grains	2

4. <u>The things which participants hope this conference would accomplish:</u>

<u>Exchange and flow of information</u>	
What is known, who is doing what	2
Regular series of conferences, and other channels of communication	2

	Frequency of Mention
<u>Coordination and cooperation</u>	
Coordination of activities on global scale	3
<u>Toward an International long-term program</u>	
Work out a program	5
Define priorities	6
Seek means of financing both applied and basic research	1
Decide whether programs should be research-oriented or poduction problem - solving oriented	1
To show that production depends upon production research and socio-economic factors	1
<u>CIAT cassava program</u>	
To provide information from cassava experts	2
To define objectives, goals, and priorities	2
To define how CIAT can provide technical assistance to other programs	1

5. <u>Things which participants fear may happen as a result of this Conference:</u>

Failure to clarify priorities and objectives	3
Failure to cooperate, to follow through; inactivity, or short-lined activity	5
The program designed may not be executed fully at required levels	2
Certain governments may decide to reduce support for cassava research because of CIAT's program	3
Nothing	3
Recognize there are post-harvest as well as production problems	1
Failure to recognize wide diversity of ecological conditions	1
Neglect to attend to cassava's role in present food production systems because of a concern for use of cassava in more sophisticated systems	1
Disregard of experience with similar poorly known cultivars	1
Overlook the grower	1
Becoming too involved in technical aspects of cassava problems and neglecting specific problems	1
Failure to resolve the socio-economic problems involved.	1