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Centro Internacional de Agricultura Tropical, CIAT
Apartado Aéreo 67-13. Cali, Colombia, S. A.
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Cassava Production Systems

The cassava program is directed toward an increase in the production and utilization of improved quality cassava (**Manihot esculenta**) in the lowland tropics. Activities include the development of:

1. Varieties with higher yield, with emphasis on the selection of varieties with higher nutritive value, i.e., increased protein content and/or quality, and higher starch content in the root, depending on the intended use.

2. Marketing, processing, storage and utilization systems which permit more constant supplies for human and livestock consumption and for processing plants.

3. Cropping practices and farming systems which will increase production and encourage food and feedstuff utilization on subsistence farms.

4. International regional testing programs to assist in the exchange of information and materials.

During 1970, work was conducted in the following areas:

I - Collection and evaluation of germ plasm material.

II - Cultural practices.

III - Plant quarantine and plant pathology studies.

IV - Agricultural economics.

V - Swine feeding.

I - Germ plasm collection

During 1970, additional material from Colombia and other Latin American countries was added to the collection of cassava cultivars started in 1969. This collection now includes 1884 cultivars from Colombia, 123 from Ecuador, 60 from Puerto Rico, 118 from Panama and 8 from Peru. An additional 330 cultivars collected in Venezuela are in quarantine in Bogotá. Upon certification of freedom from diseases this material will be transferred to CIAT headquarters. Another group of 70 cultivars was collected in Mexico and will be transferred to Colombia in the near future.

Classification and evaluation of the material in the collection was started both from an agronomic and nutritive quality standpoint. Root samples of approximately 600 Colombian cultivars were analyzed for nitrogen content by the Universidad del Valle Nutrition Laboratory. Although nitrogen levels ranged from 0.2 percent to about 0.5 percent, a few samples were found with slightly higher percentages. The variety Llanera is outstanding in this sense with a nitrogen content of about 0.9 percent.

The widely different environment conditions and the lack of uniformity as to the number of viable plants obtained from the original vegetative seed material collected made meaningful comparisons and classifications of plant and root characteristics impossible. For this reason 700 of the Colombian cultivars were planted in non-replicated three-row plots. This will provide uni-

TABLE 1. **Cassava response to fertilizer and plant spacing.**

Spacing cm	Plants/ha	Yield kg/ha [1]
120 x 80	10,416	35 550
120 x 100	8,333	36,480
120 x 120	6,944	33,790
120 x 140	5,952	35,910
120 x 160	5,000	34,090
Fertilizer treatment		
Check		32 660 A [2]
60-60-120		34,510 A
120-120-240		38,320 B

1. Spacing yield differences are not significant.
2. Means followed by the same letter are not significantly different at the .05 level.

form plant material for evaluation of plant characteristics as well as the first screening for yield potential. Harvests will be made at 9 and 14 months with the superior lines to be further tested in replicated yield trials. Additional plantings will be made to evaluate the balance of the collection.

II - Cultural practices

Cassava fertilization and plant population study

In a preliminary cassava fertilizer-plant population study, yield increases were obtained from a fertilizer application where plant populations did not influence yield.

An experiment was established in a clay loam soil with PH 7.0, a high phosphorus level, and a medium potash content. Potassium chlorate and a 14-14-14 fertilizer were mixed to give a 1-1-2 ratio and was broadcast and incorporated into the soil prior to forming ridges for planting the crop. Rate of fertilization was 0, 60 + 60 + 120, and 120 + 120 + 240 kg/ha of N, P_2O_5, and K_2O, respectively.

Llanera cassava was planted in rows spaced 120 cm apart and at varying distances within the row in order to test, at the same time, the possible effect of plant population on yields. The 20 cm seed stakes were planted at a 45 degree angle. Roots were harvested at 12 months maturity.

Differences between plant populations were not significant; however, the 5.6 and 3.8 ton per hectare increase in yield from the high fertilizer rate over the check and low fertilizer rate was significant (see Table 1).

Results of a Cassava Cropping system trial are reported in the Agricultural Systems section of this report.

From left to right: susceptible, intermediate and resistant cultivars of cassava to the bacterial disease of cassava, caused by **Pseudomonas** sp.

III - Plant disease and quarantine studies

Cassava diseases

Studies of cassava diseases revealed the presence of white leaf spot (**Cercospora caribaea**), brown leaf spot (**C. hennings**), powdery mildew (**Oidium manihotis**), stem and root rots (**Rhizoctonia** sp. and **Rosellinia** sp.), and a disease not previously reported in the literature caused by a species of **Phoma**.

However, the most important disease, economically, seems to be caused by a bacterium attacking the foliage, stem, and roots of the plant. Physiological and morphological studies identified the bacterium as a **Pseudomonas** sp. The disease spreads quite rapidly, which suggests a vector as the main agent of dissemination. Screening techniques to search for resistance were developed and, of 450 Colombian collections tested, five were resistant. A hot-water treatment of plant material at 52°C for 30 minutes effectively controlled the disease.

This project is being carried out in cooperation with ICA and the Department of Plant Pathology of the University of Wisconsin.

Quarantine treatment

Various methods are used in handling the seed material in the germ plasm collections made within Colombia which are planted directly in the fields at Palmira. Collections made in other countries are hot-water treated for control of diseases and pests and then planted in a greenhouse at ICA's Tibaitata Center. When certified free of disease, this material is brought to CIAT headquarters and planted in the field for the initial increase to provide additional planting material.

Studies were made of systems to prevent the introduction of potential plant pests. A hot-water treatment of 52°C for 30 minutes was found to be the most effective in controlling viruses, mycoplasma, and bacterial diseases as well as nematodes and insects.

Foliage symptoms produced in cassava by a bacterium of the genus **Pseudomonas.**

IV - Agricultural Economics

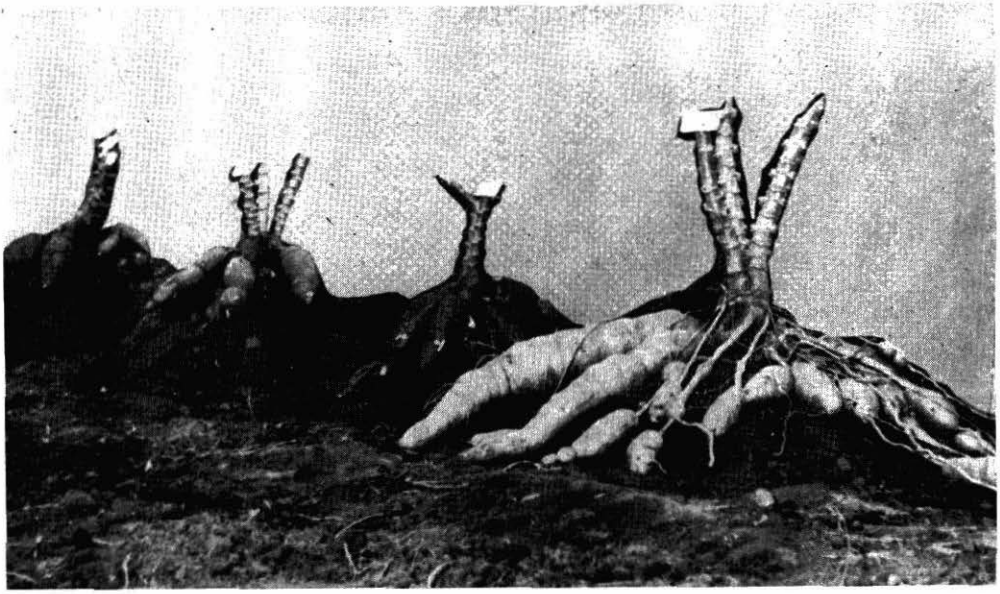
A compendium of world data on cassava production, yield, and cultivated area for all producing countries has been prepared at CIAT from secondary data, particularly FAO publications. Production per capita has also been calculated for each country for the last 10 years.

World production of cassava has been increasing in the last five years. South America and Africa each account for approximately 37 percent of world cassava production, Asia about 25 percent, and Central America and Oceania the remainder. On a per capita basis there has been a slight decrease in world cassava production.

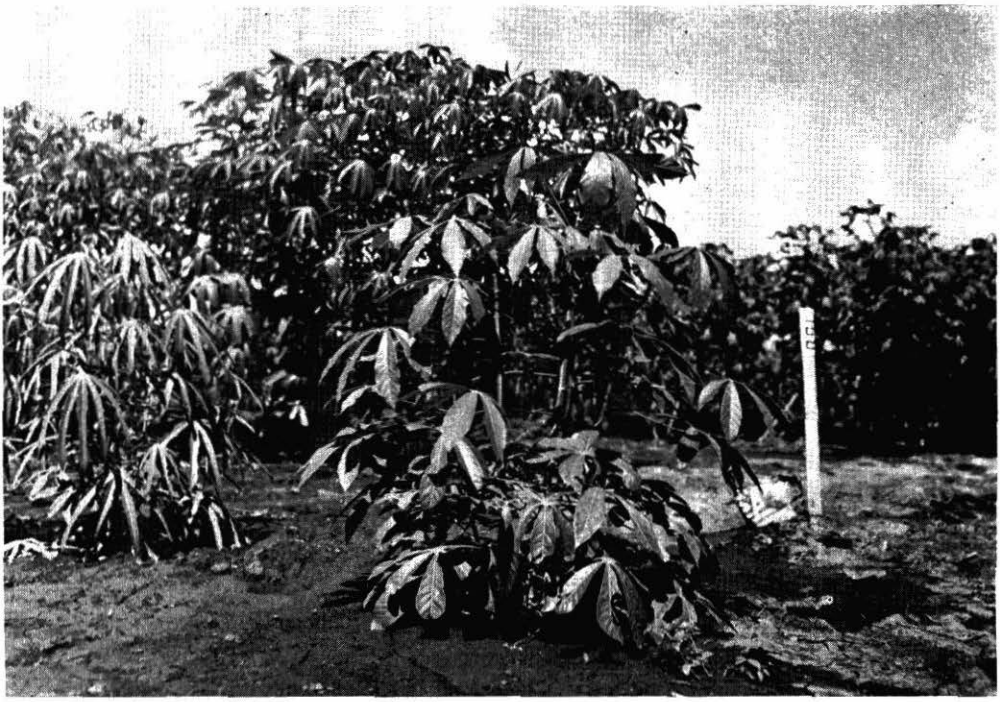
Other studies in progress include wholesale and retail cassava prices in 14 Colombian cities over the past 10 years, consumer demand for cassava, cassava flour and starch in the United States during the last 14 years; a description and analysis of cassava starch-producing facilities in Colombia; the marketing of cassava and cassava starch in Colombia; and an analysis of economic factors related to low yields in Colombia.

V - Cassava utilization through swine feeding

See the Cassava section of the Swine production systems part of this report.



A wide range of variability is observed in cassava, as shown by the root distribution of these four cultivars.



At CIAT's headquarters, a vast collection of cassava cultivars is being built up.

in protein quality may have been lost in the development of the double cross material.

Cassava

It has been demonstrated that cassava can be used as the major source of energy during the entire swine life-cycle. Production systems based on either fresh, chopped cassava or dried cassava meal have been developed.

When dried cassava meal, prepared from the variety Llanera, was used as the major source of energy for growing pigs, a small but significant growth rate depression occurred. This growth depression might be related to various factors such as digestibility and energy utilization, hydrocyanic acid toxicity, poor utilization of the protein fraction, amino acid deficiencies, and possibly to deficient or marginal levels of fatty acids present in diets containing high levels of cassava meal.

Research with growing pigs and chicks has been directed to the identification of the factor or factors responsible for this depression. Swine metabolism studies demonstrated that the dry matter and energy fraction of the cassava meal was digested at a level similar to that of commonly used feed ingredients such as maize and soybean meal. Despite this, however, growth depression occurred.

For swine growth studies, all diets were calculated to contain 16 percent crude protein, of which 8.8 percent came from cassava meal, and the balance of protein and energy from a combination of soybean meal and maize. These diets were supplemented with methionine, molasses, and beef fallow.

Data in this experiment indicate that, in the absence of beef tallow (fat), methionine supplementation increased gains, as did a 10 percent increase of fat alone to the diet. However, when both fat and methionine were present, a depression in gains was recorded. Consequently, when soybean meal is used to supplement diets containing cassava meal, methionine appears to be a limiting amino acid; thus, correction of this deficiency overcomes the growth depression. However, it is not yet known whether the same response when 10 percent fat is added to the diet is related to a change in the amino acid balance of the diet (as the amount of soybean meal is increased to maintain a 16 percent protein diet) or to an effect of fat **per se** (as fat supplies both concentrated energy and fatty acids).

Supporting studies with chicks provided additional evidence that when cassava meal replaces maize in a diet supplemented with soybean meal, sesame meal and fish meal, methionine becomes a limiting amino acid. As with the above studies, the addition of fat along with methionine into the diet results in a growth depression.

In studies with pigs and chicks, addition of molasses similarly failed to improve gains as when fat was added, thus supporting the theory that fat **per se** supplies some factor (energy or fatty acids) deficient in cassava diets.

Chemical analysis of the nitrogen fraction of cassava pulp indicates that approximately 50 percent of the nitrogen is not true protein but is present as non-protein nitrogen. Although the total nitrogen level of the peeling is higher than that of the pulp, approximately 70 percent of the nitrogen is non-protein nitrogen and therefore of little if any value to monogastric animals. Preliminary data from chick growth studies in progress support the indications that the biological value of the nitrogen fraction available in cassava is poor.

Bananas and Plantains

In many areas of Central and South America, large quantities of bananas and plantains unfit for local or export market consumption are available for

TABLE 1. **Lysine and tryptophane analyses of selected grains of the opaque-2 hybrids H-208 and H-255** [1].

	Sample	Protein (%)	(Grams/100 g Protein) Lysine A.A.	Lysine Pyr.	Tryptophane
Whole Kernel	H-208 Opaque	11.1	4.69	4.32	1.04
	H-208 Crystalline	12.0	4.19	4.07	0.87
	H-255 Opaque	10.6	4.31	4.23	1.08
	H-255 Semi-Crystalline	12.3	3.80	3.90	0.90
	H-255 Crystalline	12.3	2.69	2.52	0.57
Endosperm	H-208 Opaque	8.9	4.00	4.08	0.87
	H-208 Crystalline	9.6	3.66	3.66	0.76
	H-255 Opaque	10.3	4.07	4.14	0.93
	H-255 Semi-Crystalline	12.0	3.21	3.00	0.69
	H-255 Crystalline	11.0	1.76	2.18	0.48

1. Courtesy of Dr. Edwin T. Mertz, Purdue University.

protein supplements are more than twice the price of maize, use of opaque-2 maize would be more economical.

The system developed for swine may have greater significance for human nutrition. If opaque-2 maize could be successfully introduced, the added protein requirements of pregnant and nursing mothers could be totally supplied by opaque-2 maize. Infant protein malnutrition could also be substantially lessened by introducing opaque-2 maize into infant diets.

Despite the nutritional advantages of opaque-2 maize, its acceptance has been hampered by its soft, floury endosperm (See Maize Production Systems). Samples from a commercial harvest of two Colombian opaque-2 hybrids, ICA H-208 and ICA H-255, were observed to be still segregating with some crystalline kernels appearing among the predominantly soft, opaque grains. These crystalline kernels and completely opaque kernels were selected and analyzed for protein, lysine, and tryptophane content. Results are presented in Table 1.

The crystalline samples tended to have higher levels of protein than the opaque kernels. The lysine and tryptophane levels of the opaque and crystalline H-208 samples were similar to those of the opaque H-255 samples, although the crystalline H-255 contained significantly lower levels of both amino acids.

Rat growth studies to evaluate biologically the various selections of opaque, semi-crystalline and crystalline kernels demonstrated that the nutritive values of the opaque H-208, crystalline H-208, and opaque H-255 were similar. The crystalline H-255, although superior to normal maize, was inferior to the others in biological value.

Semi-crystalline H-255 kernels tested followed the amino acid analysis in supporting growth and protein efficiency ratios approximately mid-way between the opaque and crystalline H-255 extremes.

Floury-2 maize

Samples of double cross hybrids containing floury-2 genes and produced by ICA's maize program have been used in nutritional studies with swine, rats, and poultry. In all trials to date, floury-2 maize has not equalled locally available opaque-2 varieties in growth support or efficiency of protein utilization. The amino acids lysine, tryptophane, isoleucine, and threonine have been limiting in these floury samples. There are indications that some of the floury-2 genes associated with the modification