Cassava Program

Centro Internacion
de
Agricultura Tropi

INTRODUCTION

This document was prepared by members of the CIAT Cassava Production Systems Program with assistance from their advisory committee. Its purpose is to give a broad outline of the cassava program. More detailed information can be obtained upon request.

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CASSAVA

PRODUCTION SYSTEMS

PROGRAM

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Cassava, Manihot esculenta Crantz, is a starch-producing tropical root crop. Already a food for millions, it promises to be an efficient source of food and feed for alleviating expected shortages as world population increases and as food needs become more acute. CIAT has undertaken a comprehensive series of investigations of cassava designed to improve varieties and production practices and to disseminate material and "know how" to applicable regions.

PRESENT STATUS OF THE CROP

Cassava (manioc, mandioca, yuca) is a short-lived perennial species usually found in the cultivated state, but has numerous wild relatives. Although believed to originate within meso-America or northern South America, it is presently distributed between 30° north and 30° south latitudes at elevations from sea level to more than 2,000 meters. Cassava grows as a woody bush with variable branching habits, and sometimes grows to a height of four meters.

Some plant roots begin to enlarge two to four months after planting because of starch accumulation. The roots are harvested any time six or seven months following planting, sometimes being left in the ground for two years or more.

The roots contain a cyanogenic glucoside, linamarin, which when degraded by the enzyme linamarse, releases hydrocyanic acid. The peel, constituting 10-20 percent of the fresh weight, contains a higher concentration of the poisonous substance than do the starchy roots. Depending on the concentration of hydrocyanic acid released from the linamarin, the varieties are frequently classified as sweet or bitter. The level of hydrocyanic acid in the flesh varies from less than 10 to more than 150 parts per million.

Not all varieties of cassava flower freely. The small flowers are borne in racemes, and the female flowers mature before the males. Fertility is usually high, and seeds are easily produced through open or controlled pollination. However, for convenience, and in order to maintain varietal characteristics, cassava is usually propagated from stem cuttings.

The roots are used as a freshly boiled or fried vegetable, as a flour after drying and milling, or as a paste. The leaves are cooked as a green "spinach." The fresh, dried or partially fermented roots are used in animal feeds. Commercially, the starch is used in adhesives, sizing, and as a substrate for processing. Tapioca is a cassava product.

Because fermentation and putrefaction begin shortly after harvest, cassava can be stored for only a few days in its fresh state. But processing into durable forms by a variety of techniques is possible. It can be dried as chips and stored up to a year with little deterioration. These chips may be incorporated into complete diets for animals as a substitute for cereal grains. Flours are made by grinding the dried root either with or without prior fermentation treatment.

Cassava is an outstanding source of calories. The roots contain approximately 30 to 40 percent dry matter. This consists largely of carbohydrates, relatively small amounts of protein (usually 0.5 to 1.5 percent) and even less fats, vitamins and minerals. Preliminary amino acid analysis of cassava indicates a distribution rather similar to that of common corn with low levels of methionine. Threonine levels in the protein are twice as high as those found in corn protein. Analysis of the leaves shows high levels of protein, ranging from 3.7 to 10.7 percent on a fresh weight basis and 21 to 36 percent on a dry weight basis. Of the essential amino acids, only methionine is deficient; excellent levels of lysine (5.6 to 8 percent) are present.

The majority of the crop grows in small plantings and is consumed on the farm. Africa is the world's largest regional producer; Brazil harvests more cassava than any other single country. Compared with the world's average yield of 8.7 tons per hectare, several countries (Brazil, Bolivia, Paraguay, Thailand, Malaysia, Taiwan, Malawi, Mali, and French Polynesia) report national averages ranging from 14 to 22 tons per hectare. When cassava, grown as a plantation crop, is well-tended, yields of 25 tons per hectare are considered acceptable, although from 50 to 80 tons per hectare have been reported.

Several factors contribute to the increasing interest in cassava. First, the crop is widely grown and accepted, has a wide range of adaptability and seemingly has a great potential for improvements in yield and quality. The role of cassava in providing food for humans is expected to increase in importance. Second, to an increasing extent, dried cassava is used widely as a livestock feed. Cassava has been included successfully in diets for pigs, poultry and cattle and is used extensively in Europe where it supplies up to 40 percent of the ration for livestock feed.

The CIAT Cassava Program

Intensive world-wide reviews of the literature, an international symposium in 1972 which brought together some 25 of the world's scientists concerned with cassava research, and a series of planning meetings with representatives of various countries assembled under the auspices of the International Development Research Centre of Canada and CIAT have stimulated the development of the current cassava program. Priorities were assigned and general policies developed. The program outlined here serves as a guideline for research activities, and as such, is conceived as a permanent but flexible framework.

OBJECTIVES

CIAT's main goal is to provide production packages which tolerate a wide climatic and edaphic variation, that are directly applicable to small scale units, but can be adapted readily to large scale production. The development of new varieties, the improvement of production practices, and the control of pests, diseases, and weeds that limit production are essential to this goal. These practices all aim to increase one fundamental characteristic - yield. Quality of the product will also be stressed. While maximizing yields, CIAT also emphasizes conservation of the crop through appropriate storage.

CIAT must move plant materials developed and information gained outside the farming community where its scope of direct influence is now limited. CIAT's approach is four-fold:

1. By establishing close links with government and other agencies in various countries.

2. By disseminating information among cassava researchers throughout the world to stimulate further research and to transfer information that ultimately will reach farmers.

3. By training people who would return to their native countries and expedite the spread of new technology, and

4. By promoting the use of improved varieties and production systems.

Yields

Adequate yields depend on superior varieties. The germ plasm collection is being screened for high yielding varieties, for resistance to diseases and pests and for other factors that influence yields; types with useful characters will be evaluated for quality. Both short-and long-term breeding objectives have been formulated and practical breeding activities initiated. Although it is believed that the same varieties will be useful for human food, animal feed, and industrial use, different varieties may be necessary for various ecological zones, climates, and soil types. Therefore, varietal tests in diverse locations are important.

It is recognized that data from many sources influence breeding goals. Thus CIAT's physiology group studies factors associated with yielding ability; the pathologists, disease resistance and simple cultural and sanitary pathogenic control methods; the entomologists, insect resistance and control systems, and the weed control group, weed control methods.

Cassava is grown under varied climatic and soil conditions both as a subsistence crop and on a commercial scale. No one production system perfectly suits these diverse conditions. First, when different ecozones are considered, different production methods are required. CIAT will develop production methods that tolerate a wide range of local conditions; these systems can then be modified for any particular locality, in many cases by scientists trained at CIAT, for that specific area.

The problems of increasing production on large and small scale units are basically similar;however, there are differences in the management and engineering functions, but not in biological processes. The same variety will produce similar yields and show parallel insect and disease resistance whether grown on one-tenth of a hectare or 1,000 hectares. The method and ease of chemical application, type of cultivation and population of parasitic organisms depend on the size of operations. The majority of techniques developed on small scale labor intensive plots in CIAT should be directly applicable to small scale farm units and readily adaptable to the larger scale units. Exceptions to this relate to mechanization and marketing.

CIAT has no immediate plans to develop mechanized planting and harvesting systems. Cassava harvesting can be both difficult and strenuous when soil conditions are poor and varieties have a poor root shape. Observations at CIAT suggest that by selecting for root shape and distribution, manual harvesting becomes a simple and rapid procedure. Nevertheless, in the future CIAT may, if necessary, move into mechanized harvesting. Mechanizing insecticide and fungicide applications is highly scale dependent; however, CIAT's approach to disease and pest control is through simple cultural and sanitary practices or through varietal resistance.

The discipline-oriented groups, including plant physiology, pathology, entomology and weed control expect to contribute to the agronomic program. Economic analysis will provide data useful in evaluating production systems and selecting optimum agronomic practices.

Quality

If consumption is high, the cyanogen in cassava can result in acute toxicity and chronic diseases such as goiter or ataxic neuropathy. Processing, or the use of low cyanide clones reduces the level of cyanide and its precursors, but does not eliminate them. If any cyanogen remains, there is danger of chronic poisoning. Therefore, CIAT is searching for and will develop, as necessary, low or zero cyanogen types.

Cassava contains little protein and even the high protein lines contain no more than six to seven percent crude protein (Nx 6.25) on a dry

Promising techniques and varieties are tested in farmers' fields

weight basis. Only about half of this nitrogen is true protein, and thus it appears unlikely that cassava can be an effective protein source. Nevertheless, the protein contents of new and selected varieties will be established.

Cassava is frequently eaten after fermentation, and it may prove possible to make a protein-enriched product that functions as an animal feed by using microbial fermentation and inorganic nitrogen. The possibility of an enriched fermentation product for human consumption will be considered.

Storage and Marketing

Because of the short storage life of cassava after harvest, the farmer has difficulty marketing his produce. The two approaches to this problem are:

1. Storage of fresh roots that can later be used for human or animal consumption, and

2. Drying of roots prior to storage.

For both types of storage, low cost processing systems that use local materials and skills are required.

Increased cassava production appears justifiable only if international and national demands remain strong. CIAT collects the basic marketing data necessary for decision-making. Staff members or outside experts or agencies collect such information when necessary, with emphasis on both food and feed markets.

Highlights of Progress

Although the cassava team is not yet complete, CIAT cassava scientists have made substantial progress in many areas in 1972 and to date in 1973. In addition, cooperative programs were undertaken with McGill University, the University of Guelph, and other institutions in Canada and Latin America.

Plant Physiology

Study of the growth pattern of cassava suggests that cassava grows continuously, producing additional starch with time. Since the number of roots remains constant, the increase in yield results from an increase in size.

Plants show remarkable response to planting density. Early yields increase with mounting density until a well-defined optimum is reached. While the optima differ with varieties, the three varieties tested on the

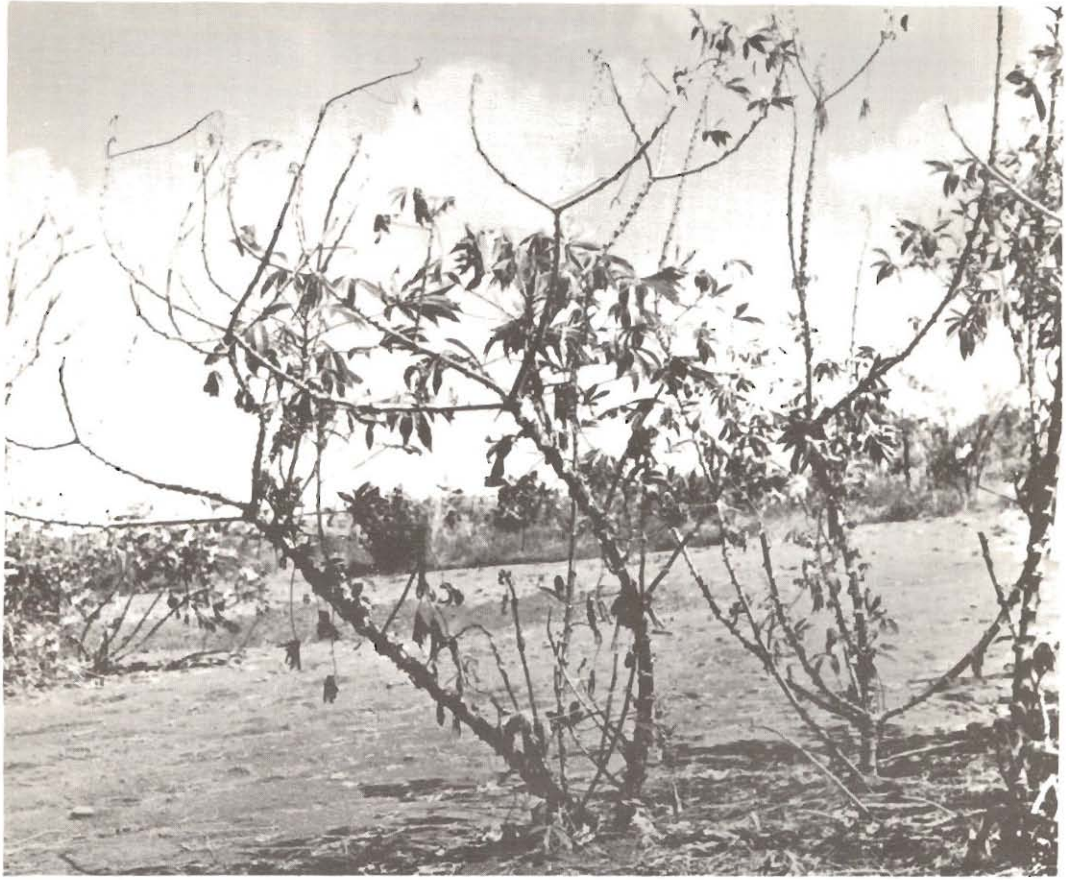
Experiments are in progress to establish the interactions between plant type and spacing

CIAT farm showed optimum populations for yield between 3,000 and 10,000 plants per hectare. The most favorable planting density for total dry matter production is greater than that for root production. This suggests that there is scope for yield increases by changing dry matter distribution at higher plant populations.

Breeding programs are frequently delayed because sufficient quantities of planting material are not available. A rapid method of clonal multiplication for cassava was developed with mist propagators. For instance, six mature stem cuttings (total of 60 nodes) produced more than 180 shoots in 42 days, a three-fold increase over single-node propagation methods.

Plant Pathology

A system of young shoot propagation eliminated bacteria from the germ plasm bank of more than 2,000 collections. As experiments with bacteria on the farm are terminated, the CIAT farm will be completely



Cassava blight bacterium causes severe defoliation and reduces yields; however, control methods have been developed and varietal resistance found

cleaned. The system of eliminating bacteria is being tested on a commercial farm to assess its effectiveness. If successful, then certified bacteria-free planting material can be made available.

A new disease, which results in superelongation of the internodes of young stems, was identified. This disease appears serious, but high levels of varietal resistance have already been found.

Entomology

Striking differences in susceptibility of varieties to thrips were observed. This pest seems highly important under dry conditions.

Striking differences in varietal resistance to thrips, a serious pest in South America, have been found

The horn worm can be effectively controlled using insecticides; however, the economics of control cannot be established until the effects of attack on yield are determined.

Weed Control

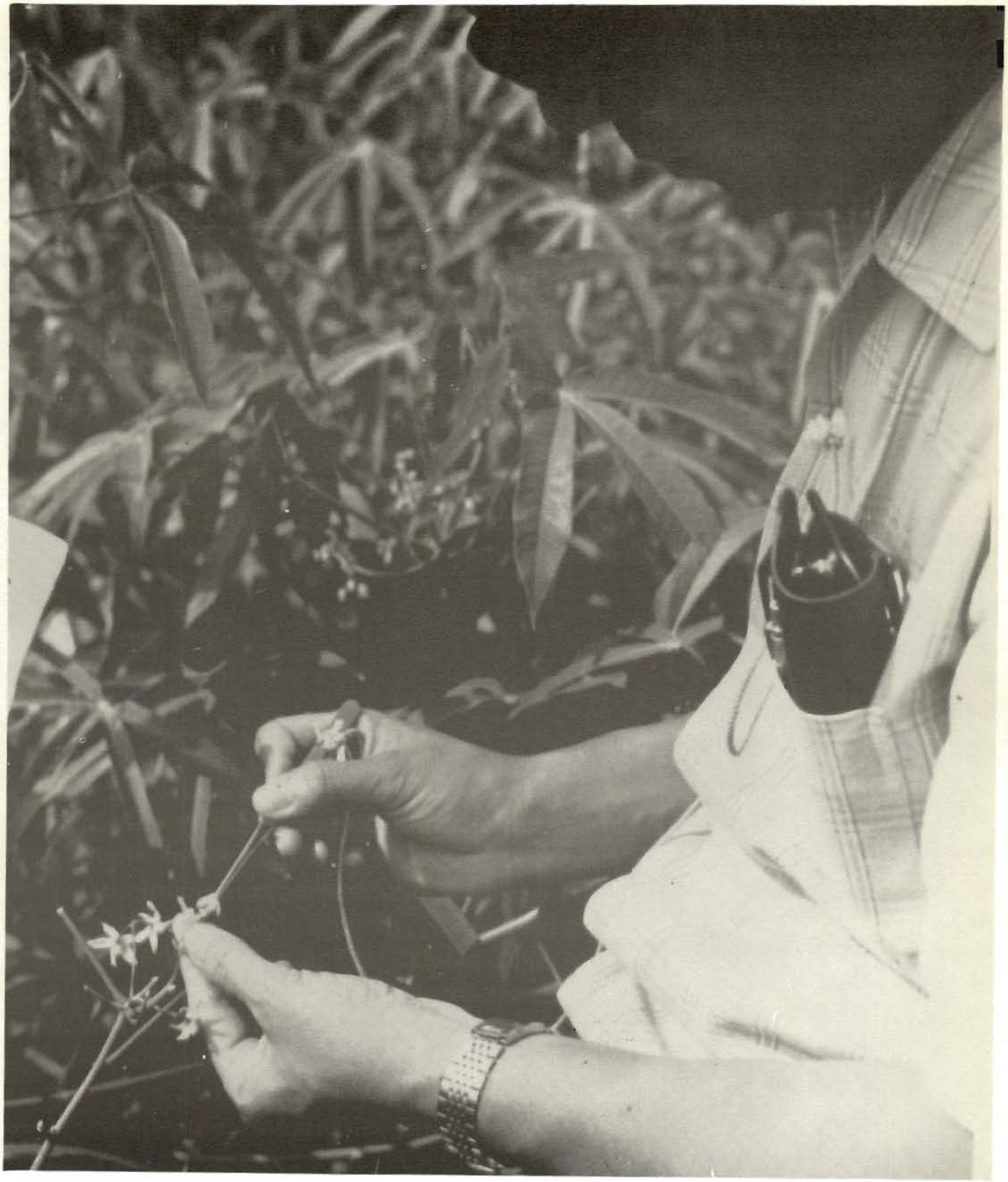
Several potentially useful herbicides and weeding schemes for cassava were identified in tests involving 27 chemicals and four methods of management. These schemes could lead to lower production costs, especially in the early stages of establishing a stand when competition from weeds is severe.

Breeding

The breeding program was initiated in January, 1973, and already has produced successful hybridizations. The plant breeder is trying to develop high yielding disease and pest resistant types that are easily harvested and low in cyanide.

As little knowledge exists on the genetic variability of cassava, a variable hybridization program will attempt to obtain improved types

Chemical weed control shows great promise in cassava (testigo absoluto = without treatment)



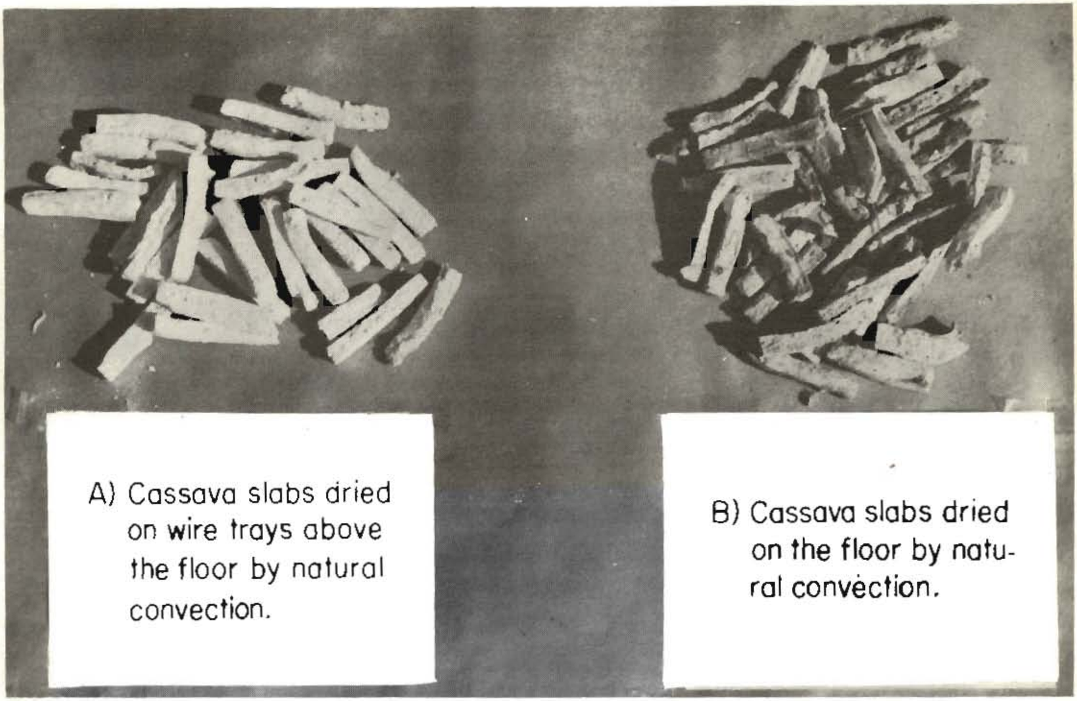
Cassava has separate male and female flowers and can readily be hybridized while at the same time gain scientific information on specific genetic characteristics.

Storage and Processing

Research on the storage problem of cassava included testing of a simple and inexpensive on-the-farm method of storing cassava roots in soil-covered piles similar to those used for storing potatoes. This system needs further experimentation but the promising results obtained, plus the important implications the storage problem has for marketing cassava, lead to the continuation of this research in 1974.

The basic physical parameters that control the drying of cassava chips were investigated under natural ambient conditions. Results are being used to design low-cost, simple methods of on-the-farm drying that employ solar energy.

Roots can be stored using simple on-the-farm methods



The drying rate and quality of cassava chips can be improved by placing them on wire trays above the floor (A), instead of on a concrete floor (B)

Agricultural Economics

A survey of more than 300 cassava producers in various regions of Colombia described present production systems and provided data on estimated costs of production and labor. This work is being extended to other cassava-producing countries.

The University of Guelph, Canada, and CIAT are jointly analyzing the potential demands for cassava for direct human consumption, industrial starch and animal feed. The animal feed market looks particularly promising.

Tentative results from an analysis of the economic feasibility of partially substituting wheat with cassava in bread in Colombia suggest that such substitution is not economically sound at present. CIAT is studying the economic feasibility of using cassava as an energy source for swine.

On the basis of secondary data an analysis of the world cassava production and yield trends during the period 1960-68 was conducted. The analysis suggests an increasing production trend of about two million tons annually during this period, because of an increase in cassava acreage of about 200,000 hectares each year.

Research is being initiated on the implications of expanded production on employment, farm returns, income distribution, and international trade.

Library and Documentation

Cassava literature is estimated at about 3,500 articles in the world. The CIAT Library has located and ordered more than 3,000 of these documents and approximately 1,200 have arrived to date. The Library uses a mechanized system of information retrieval whereby cards containing the literature citation, the main topics (keywords), and an abstract of each article are produced and distributed to cassava scientists. This system allows for retrospective searches to be made in terms of specific keywords or combinations of keywords.

A comprehensive bibliography based on these abstract cards is being produced in book-form and will be distributed internationally in 1974.

CIAT is an autonomous non-profit, international, research and educational organization which operates worldwide and initially concentrates on selected areas of the lowland tropics of Latin America and the Caribbean. Presently, CIAT works with six major commodities: Beef, cassava, swine, beans, rice and maize. Research and training in each commodity is carried out by a multidisciplinary team of scientists and specialists. Each team concentrates on identifying and seeking solutions for the problems most limiting production. In addition, another research team studies farm units as agricultural systems.

More than $6,000,000 US was donated by three philanthropic organizations: The Rockefeller Foundation, The W. K. Kellogg Foundation and the Kresge Foundation, for constructing and equipping the center.

Funds for the operation of CIAT are provided by donors represented in the Consultative Group for International Agricultural Research. The cassava and swine programs receive additional financial support (for special projects) from the International Development Research Centre (IDRC) of the Canadian International Development Agency (CIDA).

CIAT wants to express its appreciation to CIDA and IDRC for their help and financial participation in sponsoring jointly the cassava program review conference that provided valuable ideas and information to our Cassava Production Systems Program, and for their contribution to the core support of CIAT research and training programs.

August, 1973

SPECIFIC RESEARCH PROJECTS IN 1974

Much of the work started in 1972-73 will be continued in 1974. Among the specific research projects to be completed or initiated in 1974 at CIAT are the following:

1. To determine the effects of variation in plant type on plant spacing requirements.
2. To develop a system for rapid propagation from vegetative materials.
3. To produce stake storage systems.
4. To determine whether the production of carbohydrates <u>per se</u> or the roots' ability to accept carbohydrates limits yield.
5. To find the interactions between plant spacing and different weed control methods with respect to yield.
6. To produce successful integrated weed control methods.
7. To develop and demonstrate methods for eliminating bacteria from heavily infected farms.
8. To evaluate yield losses associated with shoot fly attack.
9. To assess the seriousness of horn worm attacks at different growth stages.
10. To screen the germ plasm bank for sources of resistance to thrips.

Among the activities being undertaken by other institutions as part of the CIAT program are the following:

1. To develop a simple, low-cost method of on-the-farm storage of fresh roots (Tropical Products Institute/CIAT).
2. To produce and describe mineral deficiency symptoms (University of Guelph).
3. To describe factors affecting variability among cassava varieties with respect to photosynthesis (University of Guelph).
4. To devise methods of producing disease-free planting material by using physical inactivation methods (Instituto Agronómico de Campinas, Brazil).
5. To characterize African cassava mosaic virus and to help define control methods. (McGill University).
6. To define methods of tissue culture that can produce virus-free plantlets (National Research Council, Canada).