Annual Report

1969

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

Cables: CINATROP

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(December 31, 1969)

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Foreword

The mission of the Centro Internacional de Agricultura Tropical (CIAT) is to accelerate agricultural and economic development and to increase agricultural production and productivity in order to improve the diets and welfare of the people of the world. In addition, CIAT is concerned with increases in buying power of urban residents in the sense that they may be able to purchase more and thus benefit from the increased food supplies.

CIAT, a non-profit organization, works with governments, educational and research institutions, and private enterprise.

CIAT's basic operational philosophy is: a) to develop and demonstrate a pace-setting level of program excellence; b) to collaborate and cooperate with national agricultural institutions throughout the lowland tropics on research, educational and extension programs and to assist in the strengthening of these institutions; c) to be catalytic in the economic and agricultural development of the tropics; d) to maintain mutually complementary programs and relationships with other international and regional organizations, particularly the International Rice Research Institute (IRRI), the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), the International Institute of Tropical Agriculture (IITA), and the Instituto Interamericano de Ciencias Agrícolas (IICA); and e) to establish and maintain cooperative linkages with agricultural research and training institutions in the more developed countries.

Programs and Priorities

The Centro Internacional de Agricultura Tropical is directed toward the agricultural and economic development of the lowland tropics. It seeks to achieve these goals through problem-solving research, production-oriented training, and the development and stimulation of organizations and leadership. Initially, it concentrates its efforts and resources on six neglected agricultural products for lowland farming systems—corn, rice, tropical root crops, food legumes, beef, and swine.

CIAT's goal in working with these agricultural products is to develop, as quickly as possible, new, highly productive and profitable agricultural production systems for farmers of the lowland tropics, especially in the Western Hemisphere.

It is concerned initially with beef production systems for (a) the alluvial soils of the coastal plains and (b) for the vast expanses of latosol soils, such as those of the Campo Cerrado of Brazil and the Llanos of Venezuela and Colombia. Swine production systems receive less, but important, emphasis, with particular attention to management and use of indigenous and abundant low-cost and by-product feeds.

Among the cultivated crops, attention centers on rice, corn, and cassava, while the potential is explored for the improvement of other root crops and the food legumes. Crop sequences and rotations involving these and other crops also are investigated.

Work in agricultural economics and the other social aspects of agriculture relates not only to the profitability of production practices on the farm, but to matters of inter-commodity competition, of public policy as it affects development of the tropical areas, and of marketing problems. In cooperation with national agencies, research is undertaken to identify factors which are obstacles to rapid adoption of new agricultural technology and to demonstrate more efficient ways of bringing about change in rural areas.

The research program is closely integrated with training and communication activities which help mobilize, energize, and qualify the personnel and organizations in the lowland tropics necessary and instrumental to establishing the production systems developed and to realization of the productivity goals. Through these efforts, CIAT expects to reduce significantly the time lags which usually exist between the discovery of a new variety or agricultural practice and its widespread adoption by farmers.

The multi-commodity approach of CIAT is dictated by the diverse agricultural production systems and food customs of the countries and areas served. To make a significant impact it is essential to work with those products likely to be most instrumental in solving the complex problems of a multiple product agriculture. But it will not be efficient or possible to move forward simultaneously with the same degree of program activity with all commodities. Different degrees of program intensity and priority are determined on the basis of the following criteria:

1. *Area and number of people served.*
2. *Present level of development of production systems.*
3. *Nutritional importance, particularly with respect to proteins.*
4. *Significance for economic growth of country or area.*
5. *Income redistribution effects.*
6. *Expected time lag of program impact: short vs. long term dividends.*
7. *Activities of national agencies and other international or regional centers.*

Similarly, the CIAT staff selects approaches and methods of operation which maximize the involvement and development of relevant national institutions and enhance the multiplier and demonstrational aspects of its activities.

With the above principles and procedural policies as a guide, CIAT allocates resources among and within the various commodity programs.

As CIAT moves from the development of production systems for a single commodity to the kinds of multi-commodity systems most likely to be acceptable and viable in the lowland tropics, CIAT considers such additional issues as the following:

a. *Rotations or alternations between and among crops.*
b. *Multi-cropping and inter-tilling.*
c. *Complementary animal crop systems, such as*
   (1) Beef with Pastures and Forages
   (2) Swine with Cassava, Corn, Bananas, or Other Feed Crops
d. *Complementary and competitive aspects of various commodities:*
   (1) With respect to allocation of available land, labor, credit, machinery, power, water and other resources.
   (2) With respect to domestic and export markets, the local marketing and processing situations, and related matters.
   (3) With respect to the relative benefits to individuals and society.

Development and test of a commodity production system is no assurance that a significant number of operators will adopt it in a reasonable period of time. Many other factors must be considered, most of these being economic, social, infrastructural, and governmental, i.e., associated with public policy. At the same time, effective implementation frequently will depend on training a sufficient number of persons who will be responsible for teaching others and helping farmers learn how to use the new technology satisfactorily.

Thus, CIAT performs several inter-related roles:

a. *Research on commodity production systems, and additional studies of total agricultural systems.*
b. *Stimulation of concern about approaches to development in agriculture and related fields which take into account the total system involved. This goal can be pursued by disseminating information, through conferences and symposia, and by discussion with professional persons at all levels.*
c. *Training of professionals and sub-professionals.*

d. *Eventually, in cooperation with national agencies, the organization and conduct of intensive area development projects. These will not only help improve the economic and social welfare of the people involved, but also will serve as a demonstration and furnish a useful mechanism for research and training.*

To the extent that we recognize the major role of CIAT as an active and unique development agency, flexible in its organization, and staffed with a spectrum of inter-related competencies, we will be able to integrate our various activities into efficient, effective thrusts leading to the solution of significant development problems. Thus, research and training become means by and through which CIAT promotes, facilitates, and guides agricultural development in the lowland tropics.

The long range goal, then, is the strengthening of institutions through the development of individuals with the expectations that these institutions will not only be more effective in coping with the problems of today but also more competent to engage with the yet undefined problems of tomorrow.

CIAT headquarters near Palmira, Colombia

The Government of Colombia purchased and leased to CIAT at a nominal price a 520-hectare farm near the city of Palmira, Colombia, to be the main headquarters for CIAT programs. This farm is conveniently located near the Experiment Station of the Instituto Colombiano Agropecuario (ICA) and one of the Colleges of Agriculture of the Universidad Nacional. Also, the nearby Universidad del Valle, in Cali, offers many possibilities for cooperation in research projects as well as training programs.

However, because of the wide range of environmental conditions in the tropical lowlands, CIAT's research and training activities are located at several sites in Colombia and include cooperative projects in other countries. Consequently, during the period of training, a participant may be based at two or more sites, and in addition, may be on temporary duty at still others. Training locations frequently involved, besides the headquarters near Palmira, include the experiment stations of ICA, such as Turipana, on the Northern Coastal Plains (Monteria) and Carimagua, located in the Eastern Plains (Llanos Orientales).

Activities during 1969

The first annual report of CIAT is based on team reports of progress on the analysis of problems and their possible solutions through research and training as related to the six commodities, without particular reference to specific disciplines. However, certain work of a more general nature which may not be specifically related to the development of the six commodity production systems is reported under each discipline.

During the year covered by the present report, a major part of the activities have been directed towards laying the foundations for future programs. The farm land is being leveled, fenced, and an irrigation and drainage system is being installed. Temporary administrative quarters have been adapted using the old farm buildings and stables while the permanent buildings are being planned and built. This, however, was a necessary first step to insure a highly functional physical plant built specially to aid in meeting the objectives of the programs of CIAT.

Several accomplishments were achieved during the year, some of them in cooperation with certain institutions in Colombia and other Latin American countries.

Outstanding among these accomplishments are the following:

– The participation in the training of more than 50 young men who will contribute in the future to world food production.

– Collaboration with ICA in the production of corn strains adapted to the lowland tropics which have incorporated the opaque-2 genes thereby increasing considerably the nutritional value of this crop.

– The development of a survey procedure to determine marketing and other problems being encountered in the utilization of opaque-2 corn.

– Studies towards developing a highly productive beef and swine industry in the lowland tropics through breeding and selection of native stocks and utilization of indigenous sources of feed.

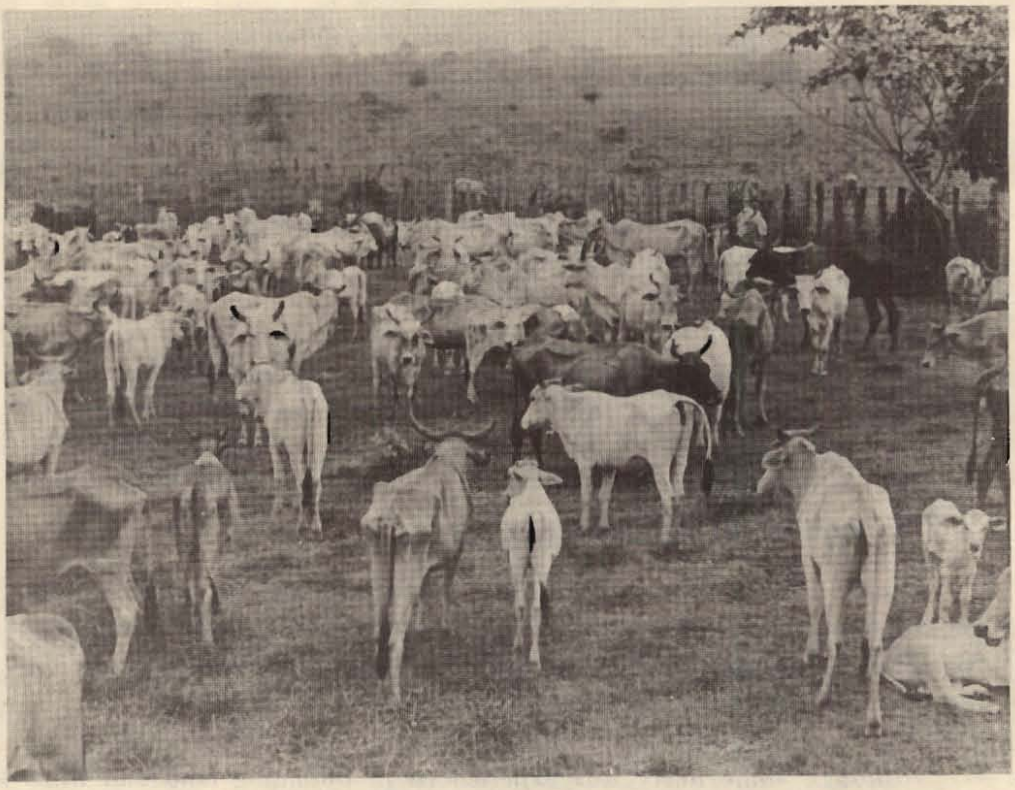
– The collection of more than 600 cultivars of cassava, a highly starchy staple food of the tropics, to be used for future breeding and selection towards improving quality and increasing the protein content. This collection is now being extended to other countries in Latin America and Asia.

Besides these accomplishments, other programs are in process, such as the development of new, improved, high yielding rice selections resistant to Sogata *insect damage and some diseases, and with the long grain and excellent cooking quality demanded by Latin American consumers.*

Although some delay was experienced in obtaining land and other necessary elements for the research and training programs, most CIAT programs are now under way and the organization looks forward to making rapid progress toward the major objective of producing more and better quality food for the world's burgeoning population.

A

B



A: Improved management of beef cattle. B: Prevailing management system in the tropical lowlands. These photos illustrate the differences in body condition between animals under improved and prevailing management systems.

Beef

The purpose of the Beef Cattle program of CIAT is to contribute to the development of efficient and economical systems of beef cattle production in tropical zones. This effort is directed towards production systems research and associated production training and is designed to complement and reinforce similar activities of national institutions in the development and implementation of their beef production programs, fulfilling both national and regional needs.

Status of the beef industry

The livestock industry in Latin America is large in numbers but not efficient in terms of productivity. There are approximately 220 million head of cattle in Latin America, i.e. about one beef animal per capita. This population produces about 5 million tons of carcass beef per year, or 23 kg/capita. Extraction rates (percentage of total population slaughtered annually) vary from 9 to 10 percent in Brazil to 29 percent in Argentina, with an overall average of 12 to 13 percent. This contrasts sharply with the United States where 100 million head of cattle annually produce twice as much beef, where the annual extraction rate is 35 percent and where slaughter animals are sold at considerably heavier weights than in Latin America. In summary, production per beef cattle unit is four times higher in the United States than in Latin America.

The two major factors contributing to low efficiency of production of the American beef cattle population are low net calf crops and low growth rates. A third factor is adult mortality. Effective calving rates as measured at weaning will average no more than 50 percent and are as low as 20 to 30 percent in certain low fertility, phosphorus-deficient soil areas. Growth rates are low; marketing steers on the average at 4 to 5 years of age weigh 400 to 500 kilograms. Furthermore, adult death losses, usually in excess of 5 percent, deserve major attention.

The current market for beef is firm. Deficit beef production, coupled with widespread consumer acceptance, would indicate continued strong internal and export demands for beef, a fact that aggravates the problem since there will be an increased stress on cattle population taking into consideration the slow rate of cattle reproduction and growth.

Strategy to increase beef production

The basic CIAT Beef Cattle program approach includes, first, the application of available knowledge to resolve or improve production obstacles, and second, appropriate research to extend production capability beyond the limits of existing technology and germ plasm.

Development of comprehensive beef cattle production systems and training program is based on an integrated multi-disciplinary effort embracing a soil, plant, animal and market inter-relationship. The program will concentrate on the two principal livestock producing areas in the Latin American tropics, namely, the alluvial soil grassland areas of the tropical countries in Central and South America, and secondly, the latosolic* grassland areas of Colombia, Venezuela, Brazil, Bolivia and Paraguay.

There is a heavy concentration of beef cattle in recent alluvium soil regions of the lowland tropics. However, animal productivity is low and pasture and forage resources are inefficiently used. These facts emphasize the prime necessity to concentrate on increasing productivity of these animal and pasture resources, through development, testing and application of improved production systems.

The extensive latosolic grassland areas of South America cover an area of at least 250 million hectares and are largely undeveloped.

*Latosols are loosely defined as highly weathered acid soils with low fertility.

Agriculture is essentially limited to extensive beef cattle production. It is estimated that available pasture lands would support 5 to 10 times the present population of 15 million. Although certain areas are marginally suited for crops, in the main they are adequate only for extensive livestock production. Consequently, the development of these vast under-utilized areas would produce a significant increase in beef production. Furthermore, this increased production would not be competitive with crops, thereby reducing somewhat the pressure on land resources that are more adapted to crop production.

Principal consideration in the development of CIAT beef cattle program are feed supply and adequate life-cycle nutrition, control of diseases and parasitism, germ plasm improvement and economics and marketing.

Feed supply and adequate nutrition

Year round feed supply and adequate life-cycle nutrition are probably the most critical factors affecting reproductive performance and growth rate, and also susceptibility to diseases and parasitism.

As grazing systems predominate in the tropics, we must first consider improved pastures and pasture management, maximizing net returns to capital investment and labor. Extensive grassland areas produce at only a fraction of their capacity. Inferior grass species, poor pasture management and under-utilization of pasture resources contribute to this low productivity. However, through the use of improved grasses, grass-legume mixtures, improved management and cultural practices, beef production in more developed rangelands could be doubled and probably increased four to five times in less developed grassland areas.

In addition, provision must be made to correct the nutrient deficiencies of grazed forages, using improved pasture management systems and supplemental feeding. Grasses grown on low fertility soils are generally deficient in certain minerals, particularly phosphorus, and often marginal in protein. Probably more important are the multiple deficiencies in protein, energy, minerals and vitamin A of dry season pasture forage.

In many tropical regions, the dry seasons are sufficiently severe to result in significant weight losses, markedly increasing the time required for animals to reach market weight. These weight losses can oftentimes be minimized or eliminated through planned pasture management systems using lower, wetter areas for dry season pastures, and employing grass and legume species that are more drought resistant and/or have superior nutritive value as mature dry season forage. Also, protein or protein-energy supplements can be provided for grazing animals to eliminate or minimize these losses.

Another dry season alternative is to place animals nearing market weight in feedlots on rations based on forages harvested during the rainy season. Additional nutrient source possibilities are by-products and other feedstuffs, such as urea, molasses, cottonseed hulls, cull bananas, freshly chopped sugar cane and cassava. Following this plan, animals can be finished and marketed during the dry season and sold at peak seasonal prices for slaughter.

Control and prevention of diseases and parasitism

It has been estimated that the beef production potential can be increased as much as 40 percent by good herd health programs because of the multiple effects of diseases and parasitism.

Diseases and parasitism contribute significantly to low net calving percentages. The reproductive diseases, brucellosis, vibriosis and trichomoniasis, directly affect reproduction, while such others as foot and mouth disease, vesicular stomatitis, anaplasmosis, and babesiosis have debilitating effects that delay breeding, increase calving interval and consequently reduce annual calving percentage.

Herd beef production is directly influenced by mortality. Calf mortality tends to be high, often ranging from 10 to 15 percent particularly for calves born during the rainy season when diseases and environmental stresses are maximal. Bacterial, viral, and other agents contribute to calf mortality. Assessment of the importance and control of many of these agents is as yet undefined. In addition, adult mortality is often in excess of 5 percent.

Low growth rate is a consequence of many factors, including inadequate feed supply, diseases and parasitism, and genetically transmitted growth potential. Disease agents contribute to reduced growth rate through cessation of growth or weight losses during active infection, plus residual effects in lowering growth rate. Parasites play several roles, such as being vectors of disease transmission or blood parasites (hemoprotozoan diseases).

Unfortunately, available knowledge has been poorly applied in the definition and implementation of effective herd health programs. A large portion of the technology and inputs necessary for reasonably effective control and prevention of diseases and parasitism has already been developed. However, there are gaps which place definite limitations on production level, preventing animals from achieving their full production capability. Examples are effective control of foot and mouth disease, vesicular stomatitis, hemoprotozoan diseases, calf diarrhea syndrome and bovine enzootic hematuria.

The animal health program is geared to participate integrally in the development of comprehensive beef production systems. This includes definition and field testing of complete herd health programs through application of available knowledge and reinforced by specific animal health research in certain critical information gap areas. In consideration of available resources and probable contribution to the beef cattle industry, production-problem oriented research concentrates on 1) calfhood diseases, 2) diagnostic capability for identification of disease agents and 3) investigations of selected disease agents causing major beef cattle losses.

Germ plasm improvement

Genotype is the final limiting factor in determining an animal's beef production capability.

The beef cattle population of the tropics in Latin America was essentially Criollo until fairly recently, when importation of Zebu bulls began, mating these with Criollo which has excellent crossing ability and obtaining considerable hybrid vigor. On the basis of these initial promising results, backcrossing continued, using Zebu sires until a population of grade Zebu evolved. Unfortunately, in the course of this development process, little or no provision was made to preserve an adequate Criollo population to provide stock for use in future Zebu-Criollo crossbreeding programs. No effort was made to characterize the magnitude of hybrid vigor in crossing Zebu and Criollo stocks, nor to test continued rotational crossbreeding programs using sires of the two species on crossbred females. There is a need to conserve and build up desirable Criollo germ plasm as sire seed stock and to develop and test systematic two-breed rotational crossbreeding programs.

The animal breeding program emphasizes development of practical breeding systems using existing germ plasms. This includes selection of superior stocks within existing adapted breeds, particularly Zebu *(Bos indicus)* and Criollo *(Bos taurus)*, and crossbreeding between these and possibly other adapted breeds.

Economics and marketing

During recent years the market demand for Latin American beef has increased faster than production and has been accompanied by a general upward trend in beef prices. This increasing demand has been partly associated with somewhat higher incomes along with a high income elasticity for beef in the Latin American countries, and partly, by expanding demands outside the region.

As prospects are good for a continued demand expansion, accelerated rates of production increase will help to avoid unreasonable price increments. Increasing beef production along with improved technology to reduce the cost of production will keep the price at a reasonable level and encourage higher levels of beef consumption. Such an expansion would clearly be advantageous considering the shortage of high quality protein in the diets of the people in many Latin American countries. Another likely result of increasing beef production would be to enlarge export earnings to the Latin American countries.

The high rate of population growth in Latin America indicates that cropland acreage will have to be increased to fulfill food needs. However, although we can expect continuing shifting of better grazing lands to crop production, a large proportion of the land surface of the world (20 percent) and of Latin America (30 percent), presently in pasture, will continue as grazing lands as the most feasible and profitable system of exploiting these areas in consideration of environmental limitations and input-output relationships.

Another factor favoring an expansion of the beef cattle industry might be the development of non-conventional beef cattle feeding regimes

such as nutrient reconstitution-by-fermentation products using cellulosic materials and non-protein nitrogen as raw material.

Potential to increase beef production

Short term

Available field data from the Instituto Colombiano Agropecuario (ICA) and other sources indicate that beef production could be doubled or tripled through application of present knowledge to existing pasture and beef cattle resourses and with limited seeding of improved pastures. This indication is based on increasing calving percentage at weaning from the present level of 40 to 50 percent to 65 to 80 percent, marketing steers at about 3 years of age instead of currently at 4 to 5 years and reducing adult mortality from 6 to 10 percent down to less than 5 percent.

Long term

The present beef cattle population of tropical grassland areas of Latin America could probably be increased four to five times, and total marketable beef production increased up to ten-fold through application of available knowledge to existing pasture and animal resources, proper seeding of improved pasture, population with beef cattle of now idle grassland and development of improved breeding systems, particularly through selection and crossbreeding.

Research activities

The Beef Program of CIAT operates on a multi-institute, multi-national basis. The site of operations is the CIAT Center at Palmira, extending to other institutions in Latin America.

A collaborative project for research and training in beef cattle production has been established by CIAT and ICA. This project describes working relationships and project and sub-project areas of mutual interest. Specific work programs and experiments within these specified project areas will be developed bilaterally at the program level of the two institutions, conditioned upon being within the stated objectives and programs of the respective institutions and within their resources. This agreement facilitates cooperative work at ICA stations in Turipana on the North Coast, Carimagua in the Llanos, the Veterinary Medicine Laboratory (LIMV) in Bogota and Palmira, plus collaborative work at the CIAT Center.

CIAT has been invited to advise in the development of the national beef cattle program of the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Ecuador, based at its tropical station, Pichilingue. CIAT is collaborating with Texas A&M University in a hemoprotozoan disease research and graduate training project funded by The Rockefeller Foundation and USAID. A memorandum of understanding has been established with the University of Florida for certain Latin American graduate students enrolled in that institution to conduct thesis research in CIAT.

Preliminary exploration of the possibilities for collaborative research projects are underway in El Salvador, Bolivia, Peru and Paraguay.

Animal Husbandry

CIAT Center

Work was initiated in May 1969, directed towards developing and renovating existing pastures and handling facilities to operate grazing trials. These preparations were made to avoid interference with overall station development or with the livestock operation of the previous owner, who maintained a commercial dairy on the premises until the property was transferred to CIAT in October 1969. On this date, 310 commercial grade Zebu yearling steers and bulls were delivered to the farm and shortly thereafter placed on a grazing experiment to determine the effects of castration (steers and bulls), diethylstilbestrol implantation and vitamin A injections on growth performance. This trial will be terminated in late 1970.

Trials to be initiated in 1970 include: intensive maximum-yield grazing trial with Pangola grass; development of highly impervious low productivity soil areas as pasture, and forage evaluation and metabolism experiments.

Carimagua

In late November 1969, ICA purchased "Carimagua", an 18,000-hectare ranch located in the heart of the Colombian Llanos near Orocue in the high plains area south of the Meta river. CIAT was invited to collaborate in the development and operation of this station, emphasizing comprehensive beef cattle production systems with certain work in soils and crop production, particularly rice. This collaborative ICA-CIAT program emphasized development of efficient and profitable beef production systems in this extensive low-fertility

grassland area. Projects include: commercial cattle production systems using animals native to the area to which an improved management system is applied; establishment of improved pastures, particularly molasses grass *(Melinis minutiflora)*; growing-finishing systems using improved pastures; mineral and protein supplementation of grazing animals; selection and crossbreeding programs with Zebu and Criollo stocks; development of efficient herd health programs.

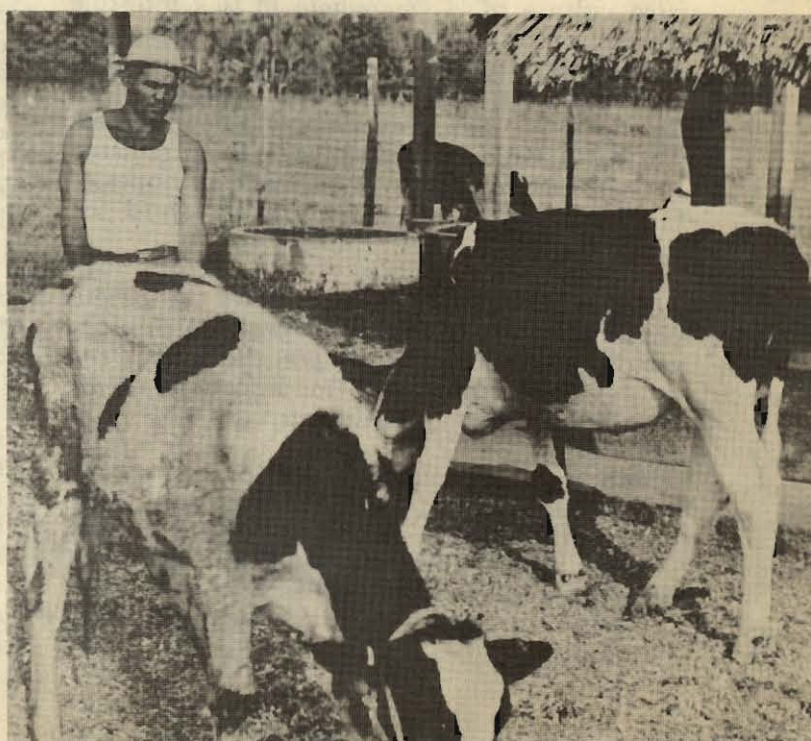
Animal health

Many factors contribute to the lack of effective animal health control and disease prevention programs in the tropics. The number of private practitioners working in lowland zones is insufficient; those existing either operate drug stores or are employees of official government agencies. Transportation is a problem. Animal health field and diagnostic services often cannot be effectively provided because of ranch inaccessibility. Biological products (vaccines, etc.) are either not used or are used on a limited scale. Adequate preservation of such products is a problem where refrigeration (electrical energy) is deficient. Diagnostic services are not as reliable or efficient as they should be. Persons responsible for the diagnostic centers do not have the transportation or time available to handle both diagnostic and preventive medicine programs. It has not been possible, physically or financially, to provide adequate numbers of trained field practitioners and diagnosticians.

It has been demonstrated in Colombia that effective animal programs can be developed when knowledge applied in the field is supported by reliable diagnostic services. This points to the urgent need for complete control and prevention programs consisting of active competent technical assistance directed at the producer level, backed by diagnostic services and a research arm capable of solving the defined limiting factors.

The animal health program embraces a two-pronged approach to provide more effective herd health programs for the producer. This includes production oriented research and training.

Production research focuses on certain technological gap areas which significantly limit beef cattle production capability, which are not receiving adequate attention elsewhere and which complement programs of existing institutions. Prime emphasis is being placed on: losses in young calves as a consequence of diseases and parasitism, and certain investigations of specific disease problems causing significant beef cattle losses. The programs in progress are concerned with: infectious and other agents specifically related to calf losses; the hemotropic diseases anaplasmosis, babesiosis and trypanosomiasis; biological control of internal and external parasites; bovine enzootic hematuria and certain vesicular diseases.



Field experiment conducted in Monteria to evaluate the various immunization products for anaplasmosis. The animal on the left (control) has become ill with anaplasmosis. The animal on the right is healthy.

Hemotropic diseases

The Texas A&M University group located in Colombia serves as CIAT's bovine hemotropic disease research and training unit. The program encompasses a multi-disciplinary approach to one of the major disease problems of the tropical livestock industry. It includes basic research and an active field program, to investigate the most practical means of controlling hemotropic diseases. Under the collaborative training program with Texas A&M reported above, three Texas A&M graduate students are in Colombia, one Colombian graduate student is at Texas A&M, and two Colombian graduate students are at the ICA graduate school.

Hemotropic diseases (anaplasmosis, babesiosis, trypanosomiasis) are extremely prevalent (up to 100 percent in some areas) in the lowland tropics. Anaplasmosis is being intensively studied from several standpoints. The possibility of simultaneous control of anaplasmosis and babesiosis in the field and the relation of chemotherapy using the Burroughs-Welcome 356C-61 and 4A65 products with coinfectious immunity (anaplasmosis, babesiosis) is being studied at various localities. Excellent protection has been obtained on a limited number of young animals in field trials. A detailed pathogenesis study of anaplasmosis in intact animals is underway.

Future anaplasmosis studies will include vector studies with *Anocentor nitens* as the incidence of this tick on cattle is high. Also, *in vitro* culture of *A. marginale* in tick intestine tissue culture system will be initiated. Pathogenesis studies using double *(A. marginale, B. bigemina)* and triple *(A. marginale, B. bigemina, T. vivax)* infections will be executed. An evaluation of the feasibility of an irradiated *A. marginale* vaccine will be made in hopes of finding a more efficient method of immunization.

All of the planned work involves the various phases of the *A. marginale* problem, i.e. the vector, effect of infection upon the animal, and studies concerning the modification of *A. marginale* for immunization purposes.

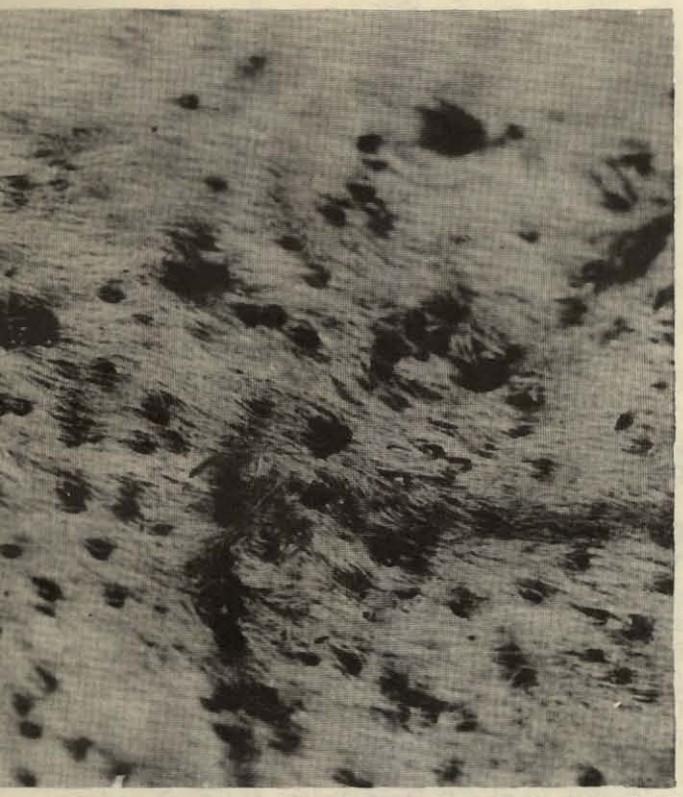
Babesiosis is common in the lowland tropics and is responsible for serious livestock losses, especially on cattle imported to the tropics. *Babesia bigemina* infection is more prevalent than *B. argentina.* Comprehensive studies are in progress, and several norms have been established.

Chemical prophylaxis against bovine babesiosis is a technique which may be incorporated into a control scheme. "Babesiacidation" of cattle was the basic chemotherapeutic prophylactic measure used. It consisted of the administration of a babesiacide (Burroughs-Welcome product 4A65) with a prolonged residual action into cattle in curative dosages shortly before exposure. Experimental and tickborne challenge of treated animals was used to evaluate the duration of the prophylactic period in the treated animals. Animals injected with 4A65 up to 46 days before challenge were highly resistant to blood-borne challenge with *Babesia spp.*

Attempts to produce immunity in cattle against *Babesia* infections have been undertaken by several investigators with varying success. Immunity persists as long as the animal remains a latent carrier of *Babesia* infection and through autosterilization or effective chemotheraphy the animal becomes fully susceptible. Animals premunized with blood collected from patent carriers of *Babesia bigemina* and *Babesia argentina* developed slight post-inoculation reactions which were manifested by parasitemia and anemia. After 3 weeks these animals recovered from anemia, and parasitenia was not detectable. When the animals were exposed to tick-borne challenge, *Boophilus microplus* naturally infected with *B. bigemina* and *B. argentina,* they were highly resistant to babesiosis; however, all animals became naturally infected with *A. marginale.* A control group of non-premunized intact animals was exposed at the same time to tick-borne challenge as the principal premunized group. These control animals became infected with babesiosis and anaplasmosis after 4 to 10 weeks of exposure and 25 percent of them died. It can be concluded that the ticks present were carriers of both *Babesia spp.* and *A. marginale* and that the effective control of tick-borne diseases at this location cannot be made unilateraly.

Cross immunity studies are in progress with *Babesia spp.* Preliminary studies suggest that there are strain differences; this observation is being tested.

Work is underway to collect and identify tick species that may be involved in the epizootiology of bovine babesiosis. To date *Boophilus microplus* was present in enzootic areas of babesiosis and anaplasmosis. *Anocentor nitens,* the tropical horse tick, was found on animals known to be infected with babesiosis and anaplasmosis. What is the role of this tick in the epizootiology of bovine babesiosis?



Ticks concentrated on the skin of a Holstein animal raised in the tropics.

Trypanosomiasis due to *T. vivax*, a disease of questionable significance, is a newly identified problem in the lowland tropics. In most instances, *T. vivax* infections are being studied in calves to determine the possible significance of this organism.

In general, the studies realized to date have yielded vitally needed norms. During 1970 to 1971 a model field control program will be designed so that the problems inherent in such a project can be studied and, if needed, new research projects will be attempted to solve the problems presented.

Infectious diseases

In 1969 the virology section was in a state of transition from work under the auspices of the division of Medical and Natural Sciences of The Rockefeller Foundation (Arbovirology) to work in CIAT directly in the beef production program. To this end, initial surveys were made among the cattle, horses and wild vertebrates of various areas of Colombia to determine the extent to which vesicular stomatitis virus (VSV) was active.

There are three known serotypes of vesicular stomatitis virus: New Jersey (VSV—NJ), Indiana (VSV—Ind) and Cocal. VSV—NJ and VSV—Ind have produced outbreaks among cattle which are undistinguishable from foot and mouth disease. In Argentina, Cocal virus has caused at least one known outbreak of vesicular disease in horses.

In an effort to determine more precisely the extent of these vesicular diseases in Colombia, serological studies were carried out among cattle and horses from the states of Cordoba, Atlantico, Magdalena, Boyaca, Meta, Vichada and Tolima. These were done in collaboration with the Universidad del Valle, ICA, and the Middle America Research Unit (MARU) in Panama.

Extremely high levels of VSV—NJ activity were found among cattle and horses of the north coast states as well as those of the eastern foothills of Boyaca and Meta. Cocal virus had never been known to exist in Colombia, but an extremely high level of antibody prevalence was found among certain rodents (especially, the "spiny rat," Proechimys guayanensis) of the eastern foothills. There was also definite evidence of previous infection of domestic animals and humans by the same agent. There is evidence of widespread VSV—Ind activity throughout the country.

During the 45 years since its discovery, the virus of the New Jersey type vesicular stomatitis had never been isolated from an arthropod. While studying a severe outbreak of vesicular stomatitis among dairy herds in Antioquia, in collaboration with the Universidad del Valle, the virus was isolated from the black flies (buffalo gnats), *Simulium exiguum.* This finding deserves follow-up as the basic means of transmission of vesicular stomatitis viruses are, in fact, as enigmatic today as they were four decades ago.

Foot and mouth disease (FMD) is undoubtedly the most serious animal disease currently facing the livestock industry in South America. Large research efforts are expended in various countries to arrive at a better understanding and a more satisfactory control of this disease. While CIAT will not duplicate these efforts, it can provide additional information and evaluate preliminary results obtained elsewhere.

Major attention will be given to investigating microbiological and other agents that contribute to calf mortality between birth and weaning. These death losses are often as high as 10 to 15 percent.

Bovine enzootic hematuria

Enzootic hematuria, an around-the-world disease of cattle raised in the tropics above 1,000 meters, is characterized by a progressive anemia from hemorrhaging produced by various tumorous formations of the urinary bladder. In many areas where this disease is endemic, cattle must be disposed of at 4 to 6 years of age. Losses from this disease are serious, and until the etiologic factors are identified, control measures will not be possible. Studies in Turkey and Brazil indicate that Bracken fern is the host plant of this disease. However, it is sometimes difficult to demonstrate such a plant-animal association.

To date, 457 random samples have been collected, 75 of which had gross lesions. Although the study is just beginning, many samples had an early change of epithelial metaplasia on microscopic examination supporting an overall incidence of more or less 50 percent.

· This study is in collaboration with ICA at Manizales, the Universidad Nacional, and the Universidad del Valle where its electron microscope has been made available.

Economics of beef production

The upwards trends in beef prices and market demand, along with the low technical efficiency in cattle production in many Latin American countries, point out the need to identify methods to reduce production costs and expand beef production. Investigations are needed to determine the most efficient system of cattle production in the plains of the tropical countries. Furthermore, the relative cost of production in the various regions, both within individual countries and among countries, needs to be estimated.

Research in economics should not, however, be limited to production. More knowledge concerning the socio-economic problems associated with marketing and consumption of beef in Latin America is urgently needed. The export potential should be analyzed in some detail, whether the concern is beef trade among Latin American countries or export to countries outside the region.

CIAT studied, in collaboration with The Ford Foundation, the efficiency of alternative beef production systems for areas such as the Eastern Plains (Llanos) of Colombia. The study was intended to assist in making rational management decisions concerning the cattle production systems to be used in that area.

Total costs and returns were estimated for three selected beef cattle production systems:

1) An extensive, minimum input system typical of present conditions.
2) A medium intensive system, including controlled breeding involving some cross-breeding, an improved animal health program, and a limited amount of improved pasture.
3) An intensive system based on improved pastures and including intensive animal breeding and health programs.

The study showed that a medium intensive system would yield the highest net returns to invested capital. The gains obtained by changing from the present system to the medium intensive system were found to be large. However, an extensive substitution of improved pastures for native pastures was found not be profitable in the Eastern Plains (Llanos) under present market conditions. *

In the area of cattle and beef marketing, an attempt is being made to "take inventory" of the presently available research results. The objectives are to integrate these results and to produce a text about cattle and beef marketing for use in training programs.

Future research efforts will include investigations concerning the feasibility of beef exports from selected Latin American countries, studies of various aspects of cattle and beef marketing such as transportation price relationships and consumer behavior, and investigations to improve the economic efficiency in cattle production. The impact of an expanded production on such factors as price, income and income distribution, availability and suitability of marketing facilities, etc., will receive special attention in order to minimize potential "second generation problems".

Training

In October 1969, a two-year experimental project was launched to develop and test an intensive, learn-by-doing approach for preparing livestock production spcialists to work in the lowland tropics. The project provides for the development of a core staff as well as materials

* CIAT Special Report No. 1, 1969.

and guidelines for continuing such a program beyond the initial project by relevant national agencies if such action is indicated. Of the 12 persons enrolled, five came from the Instituto Colombiano Agropecuario, ICA, and one from the Universidad de Antioqùia. The other six were recruited by CIAT.

After completing the initial testing and basic training period at CIAT headquarters, the group will move to the north coast of Colombia where the training will be carried on simultaneously in cooperation with the ICA research center near Monteria and on cooperating ranches near Sincelejo.

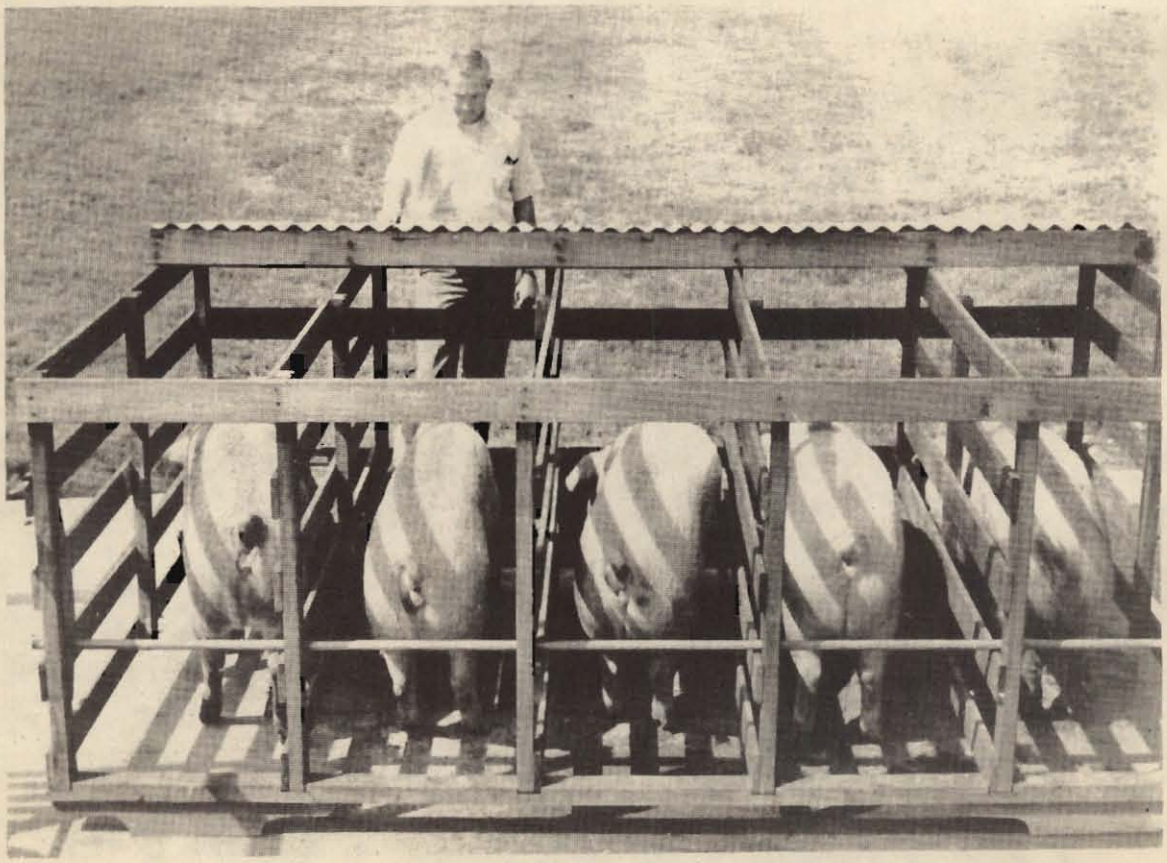
Phase one of the training project is a three-month period devoted to trainee evaluation and orientation, and provision of lectures, seminars and practical training utilizing CIAT or collaborator facilities to overcome deficiencies in basic preparation and current technological concepts in such areas as: animal disease, nutrition, feed production, breeding and improvement of farm animals. Also, trainees will obtain experience in ranch management, elements of agricultural engineering and communications, as well as aspects of the social sciences that have implication for livestock production.

During the latter phase of the program, a period of 12 to 18 months, each trainee will be assigned to one or more ranches, depending on ranch size, where, under the close guidance of the supervisor, he will undertake to implement a production improvement program which he has developed in agreement with the rancher and based on social, economic and production considerations. It is anticipated that trainees will live on the ranch or ranches assigned to them and will participate intimately in the daily routine in order to appreciate fully all aspects of the operation, to be able to pinpoint the less obvious problems, and to train ranch personnel.

After establishing the program the trainee will organize field days, meetings and/or short courses for the benefit of neighboring ranches. As his program becomes self-sustaining on a given ranch and he has time available, the trainee may assist neighboring ranches.

Each trainee will maintain complete and accurate records of the operation and operational changes on the ranch or ranches he serves as well as cost/benefit figures. In addition, he will be expected to provide data concerning production and disease problems in his area along with estimates of their economic significance.

Sows receiving individual daily rations of cassava diets during gestation.



Swine

The need to improve livestock production in the tropics, as a step toward better nutrition among the less fortunate, is now recognized. The ability of the pig to convert available feedstuffs into edible protein of high biological value, its rapid rate of growth and the prolificness of the species, justifies considering the pig as a possibility of high quality animal protein.

Status of swine industry

The swine population of tropical Latin America is substantial but not large when compared to the cattle population of the same area. The tropical regions of Latin America have a total swine population of approximately 99.3 million, but the annual production of pork is limited.

New breeds of swine are not needed for the tropics as the pig rapidly adapts to varying temperature, humidity, altitude and feed supply environments. The improved breeds of swine now available can be successfully grown in almost any environment if properly fed and managed and diseases and parasites controlled. Consequently, new breeds of swine are not needed. The ready availability of breeding stock will make it possible to move ahead rapidly in order to develop a viable swine industry.

The factors that limit the development of an efficient swine industry in tropical Latin America vary by country, but three of these factors are universal: management, nutrition, and disease and parasite control. Economic and efficient swine production systems are not used because of inadequate ability of personnel engaged in research, extension and production, failure to apply existing technical knowledge and lack of information about available feedstuffs, etc.

Swine production requires large amounts of energy feeds and moderate quantities of quality protein. In the leading pork producing areas of the world, this energy is provided by cereal grains available at reasonable prices. In other countries, the annual production of cereal grains is insufficient to satisfy human needs.

A variety of crops for both human and animal consumption could be abundantly and economically produced in the tropical lowlands of the world. If these already available or potentially available crops can be incorporated into efficient production systems, it would be possible to support a large and prosperous swine industry. These crops include tropical root crops, reject bananas, sugar cane by-products such as crude sugar and molasses, and certain grain legumes, but research data on the efficient utilization of these feeds are limited.

Generally, swine herd health practices are poorly understood by most producers and not employed effectively by those responsible for health programs on swine farms. A complete health scheme includes adequate sanitation as well as vaccination.

The disease patterns of swine depend somewhat upon the management system used and the sanitary precautions taken. The systems most commonly used are: (a) farrowing operation, (b) finishing operation where feeder pigs are purchased, and (c) a combination farrowing-finishing program. Disease control procedures in each system differ, as the animals in each vary in age, degree of susceptibility, degree of immunity and stress factors.

There is ample knowledge and pertinent information on several acute diseases, such as hog cholera and foot and mouth disease, but others, such as brucellosis, are more difficult to diagnose and require special techniques. A relationship should be established between the most important swine diseases and the management practices of the herd.

Strategy to increase swine production

The potentially important swine production areas in the tropics have not been identified. Feed represents 75 to 85 percent of the total cost of pork production; it is important to identify areas where feedstuffs are locally available and efficient production systems can be established.

Each area must necessarily be developed by national institutions, but CIAT can cooperate through training personnel, evaluating available feed products, developing efficient and economic production systems and disseminating information.

Swine operations will be selected to represent the various management systems, and an in-depth study will be made of nutritional and infectious disease problems. Once this information is available, research projects will be developed and priorities established. It appears that the most urgently needed investigation on swine diseases concerns the chronic, insidious diseases such as the pneumonias, abcesses and reproductive problems. Foot and mouth disease is always a threat as adequate immunization procedures do not exist.

Initially, the emphasis lies in the development and evaluation of feed ingredients and the incorporation of these ingredients into sound life-cycle feeding systems as well as in training.

Research in swine nutrition

In collaboration with research institutions in Colombia and Ecuador, CIAT has studied the nutritive value and potential of certain feedstuffs that have universal importance in the lowland tropics.

Use of tropical feedstuffs

Cassava

This plant, also known as manioc or yuca, has great potential value as a carbohydrate (energy) feed for swine. Its protein content is low. When freshly harvested, moisture ranges from 60 to 70 percent. It can be fed to swine in the high moisture form, or it can be dried and incorporated into complete diets.

The feeding of swine with cassava requires proper supplementation to the diet with vitamins, minerals and protein. Supplemental protein must be supplied through soybean meal, cottonseed meal, sesame meal, fish meal, meat meal and blood meal.

Gestating sows maintained in confinement have a normal daily requirement of 1.82 kilos of a complete feed containing 16 percent crude protein. This same level of intake can be reached by feeding 3.1 kilos of cassava and 0.62 kilos of a 40 percent protein supplement containing vitamins, minerals and proteins. If the sows are maintained on good pasture, they require 1 kilo of a complete 16 percent diet. A similar level of intake is achieved by feeding 1.7 kilos of fresh cassava and 0.4 kilos of a supplement containing 40 percent protein.

Studies conducted in collaboration with ICA to evaluate these cassava diets for sows in confinement and on pasture indicate that they were adequately maintained, gaining more total body weight during the gestation period than control sows.

The lactating sow is normally fed a diet containing 16 percent crude protein. She consumes daily 4 to 6 kilos of a typical grain-protein supplement diet. Research information indicates that the daily nutrient requirements of a lactating sow can be adequately supplied and high production maintained by either dry cassava incorporated into a properly supplemented 16 percent protein diet as a major source of energy or by fresh, chopped cassava fed in combination with a high protein supplement. The proper proportion of cassava to 40 percent protein supplement is 1 kilo of fresh cassava to 175 grams of protein supplement if the fresh cassava contains 2.54 percent protein.

Previous results reported by ICA indicate that fresh cassava is a satisfactory energy source for growing-finishing swine when either soybean meal alone or in combination with cottonseed meal was used as the supplemental protein source. Later studies (CIAT—ICA) have demonstrated that cassava can also be used as the major energy source in growing-finishing swine diets with wide variety of protein supplements, when these are combined with other sources to improve the amino acid balance of these supplements or to overcome unfavorable palatability or toxicity factors.

During the entire growing-finishing period from weaning to market weight at 90 kilos, each individual pig will consume approximately 4 kilos of fresh cassava and 0.8 to 0.9 kilos of a 40 percent protein supplement and gain approximately 700 grams of body weight a day. Cottonseed meal should not be fed as the only source of protein in the supplement because of its extreme deficiency of lysine and its toxicity resulting from the presence of gosypol, a pigment.

Bananas

Studies similar to those reported for cassava are being conducted with reject bananas in collaboration with the Instituto Nacional de Investigaciones Agropecuarias (INIAP), of Ecuador. Bananas, which constitute a major portion of agricultural exports in this country, are available at a reasonable eost for livestock feeding. During the harvesting, processing and packaging of green bananas for export, approximately 25 percent of the total production from 180,000 hectares is discarded because it does not meet the rigid standards of size, color, soundness and shape for export. The research is directed toward developing a life-cycle production system based on these reject bananas as the major source of energy.

Bananas, because of their high moisture content (80 percent) and their low protein content (1 percent), must be supplemented with proteins as well as with some energy for optimal utilization.

Ripe bananas are more acceptable to the growing pig than green bananas and, when fed, produce faster and more economical gains. The young pig cannot consume adequate quantities of this high moisture feed to meet his entire energy requirements for maintenance and growth. Superior performance is obtained and greater economy of production is realized when limited quantities of energy in the form of grains and grain by-products are included in the ration. In practice, this is accomplished by diluting the 40 percent protein supplement with corn or other energy sources to a level of 20 or 30 percent protein. Under normal conditions of high grain prices, the 30 percent supplement generally supports more economical gains while the 20 percent supplement supports the highest rate of gain.

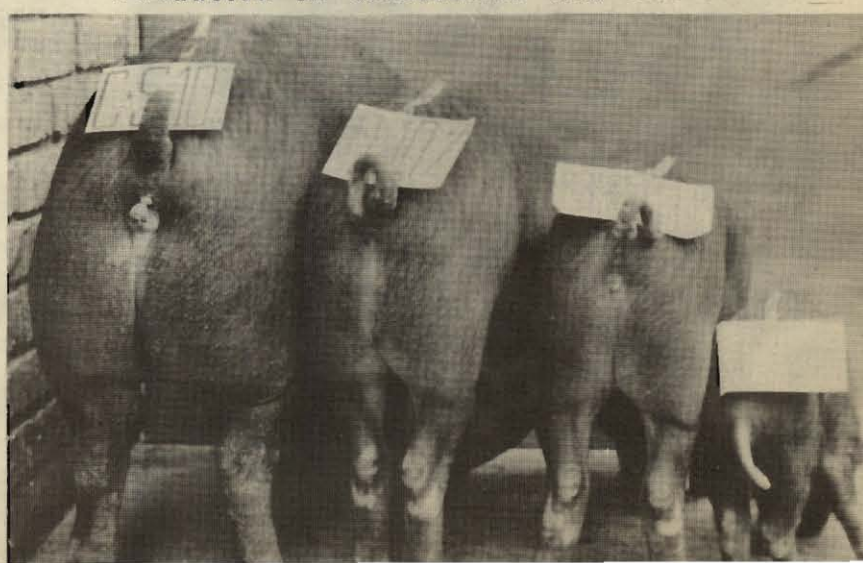
The gains and feed conversion of pigs fed with bananas and a protein supplement are slightly inferior to those obtained with a grain-supplement diet. However, pigs produced on banana-based diets are more economical to produce because of the high cost of grains in the tropical areas.

The essentialit_ of limit-feeding gestating sows to insure laige litters of pigs at birth facilitates the use of bananas as the major source of energy for this class of swine. The daily nutrient requirement of a gestating sow maintained in pasture on tropical grasses can be adequately met by feeding 600 grams of a 40 percent protein supplement and 4.5 kilos of ripe bananas during the first 75 days of pregnancy and 800 grams of the supplement and 6 kilos of ripe bananas for the remaining 39 days before farrowing.

The lactating sow, because of the high rate of feed consumption required to produce the large quantities of milk needed for a large, healthy litter of pigs, presents a nutritional picture directly opposed to that for the gestating sow. Because of her high energy and protein demands for sustained production, the lactating sow is unable to consume adequate quantities of the high moisture bananas to meet daily requirements of approximately 4 to 6 kilos of air-dry feed.

Corn

The development of corn hybrids into which the opaque-2 genes have been incorporated to modify the protein characteristics and improve the balance of essential amino acids, especially of lysine and tryptophane, has made other approaches available to the swine researcher and producer. Biological tests with swine have been conducted in collaboration with ICA to



Differences in growth of pigs fed a high quality diet of common corn and soybean meal (C+S), opaque–2 corn (O), common corn+lysine+triptophane (CLT) and common corn (C).

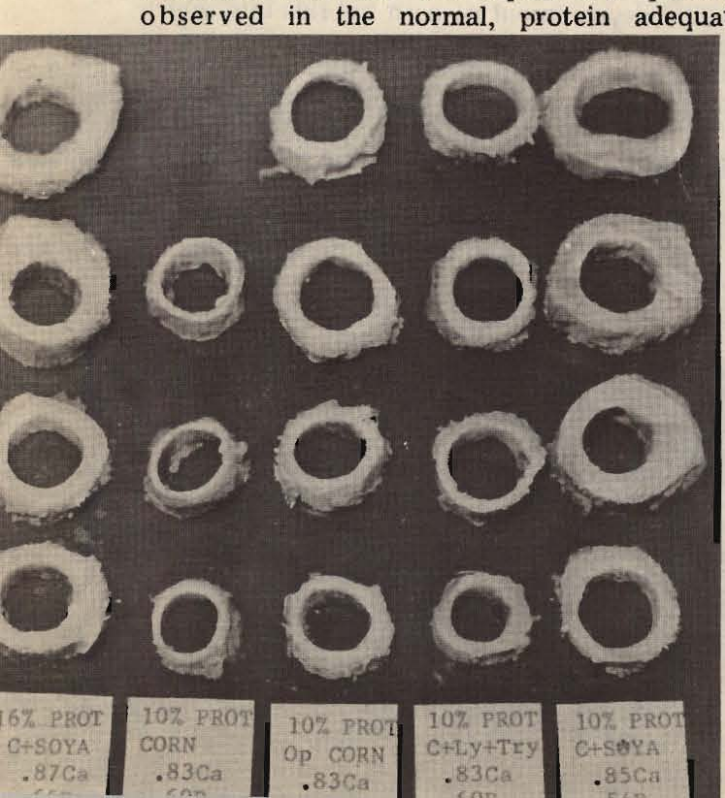
ascertain the biological value of this genetically improved corn and to compare it with diets of known nutritional value.

Young pigs fed common corn as the only source of protein, from 35 days to 165 days of age, grew poorly averaging only 21 grams gain per day. They showed the classical symptoms of protein deficiency and some died at the end of this period. In these deficient animals, changes of the stomach, duodenum and jejunum were characterized by growth arrest and atrophy of the lining epithelium and developmental arrest of essential organelle formation necessary for normal cellular function. These animals also exhibited a distinct cessation of skeletal system development.

In the protein deficient group (common corn), the livers of all pigs were fatty and friable, and microscopically, lobular fatty accumulations were observed. These histopathological changes are similar to those observed in kwashiorkor, the human protein deficiency disease.

Pigs of the same age were fed an opaque-2 corn diet under similar conditions as the common corn diets. The twelve-fold increase in average daily gain (256 grams per day) and the overall macroscopic soundness and general absence of protein deficiency symptoms amply demonstrated the superior nutritive value of this new corn. Histologically, the opaque-2 corn permitted the maintenance of the cellular organelle structures but the total epithelia structure still did not equal the quantity observed in the normal, protein adequate animals, nor did opaque-2 corn completely prevent the fatty changes of the liver. The corn fed as the only source of protein was able to maintain an architecturally normal, but somewhat reduced, skeletal system.

Comparison of development of pigs that received diets of common corn (C) and opaque–2 corn fed as only source of protein (O).



Bone development of pigs fed optimal and suboptimal levels of protein composed from corn and soybean meal and from opaque–2 and common corn.

However, the greatly improved gains and the nutritional adequacy of the opaque-2 corn were inferior to the responses obtained from a diet of corn plus soybean meal which contained an optimal level of protein and balance of amino acids.

The inability of opaque-2 corn to support optimal growth indicates that either the level of protein or balance of amino acids is improper to meet the daily amino acid requirement of the pig. Further tests have shown that lysine is still the first limiting amino acid of this so-called "high lysine corn" for the young, 8 to 10 kilo pig and that tryptophane and threonine are also limiting. When small supplemental quantities of these three amino acids were added to the opaque-2 corn or to the common corn diets, gains and efficiency of feed utilization were improved by approximately 85 percent with the opaque-2 diets and to a lesser extent with the common corn diets.

Mineral deficiencies

The differential features of a calcium deficiency and a phosphorus deficiency in growing pigs were studied in collaboration with the ICA Graduate School and with ICA. There appears to be a distinct difference in the gross, microscopic manifestation of the two deficiency diseases using the following levels of calcium and phosphorus: Control, 0.70 Ca; 0.55 P. Phosphorus deficiency, 0.70 Ca; 0.30 P. Calcium deficiency, 0.30 Ca; 0.55 P. Phosphorus deficiency involves endochondral bone formation in the young pig whereas calcium involves primarily membranous bone formation.

Economics of swine production

Little information is available about the economics of swine production and marketing in South America. Two such research projects, one to describe the production practices and one aimed at the marketing sector, have been started within the ICA Graduate School in collaboration with the Nebraska Mission and CIAT.

A number of cheap by-products, such as reject bananas, are available for swine feed in Latin America. More information is needed about the economics of using these products. A study is planned to evaluate least-cost rations for hogs with particular emphasis on by-products and available low cost feeds.

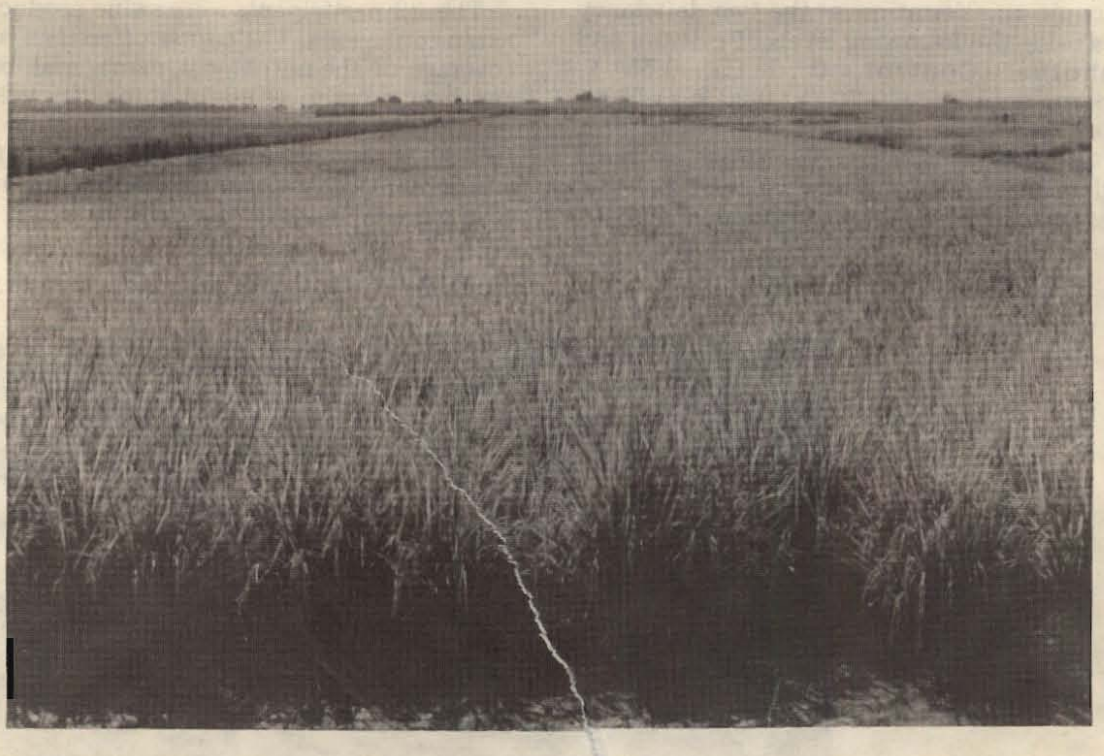
Training

A swine improvement short course was held at the Santa Catalina station of the Instituto Nacional de Investigaciones Agropecuarias (INIAP), in Ecuador. The two-week course was sponsored by the Swine Production Program of CIAT and the National Swine Program of INIAP with the collaboration of personnel from the National Swine Program of ICA and from the University of Nebraska Mission to ICA.

The 22 participants were swine producers and extension agents. The course offered an in-depth coverage of the nutritional, managerial, breeding and health practices essential for life-cycle swine production with emphasis being given to the feeding and management of swine in *tropical* and semi-tropical areas utilizing locally available feed ingredients.

Physical characteristics of phosphorus deficiency in pigs.

A promising dwarf selection of IR8 x IR12 adjacent to Tapuripa, a tall variety grown in several American countries.



A maturing increase plot of a high quality selection from the cross (Peta/3 x TNI) x TKM-6. This field yielded 7.6 ton/ha.

Rice

The Interamerican Rice Program started in 1967 following the transfer of its leader from the International Rice Research Institute, in the Philippines, to CIAT. As CIAT research facilities were not available at the initiation of the program, work commenced at the Palmira Experiment Station in close cooperation with the rice program of ICA. By the end of 1967 satisfactory research facilities had been cooperatively acquired and developed by CIAT and ICA, including a driven well and irrigation system, land preparation equipment, a screenhouse and offices, cold storage facilities, a quality laboratory, equipment and vehicles.

In 1969, existing field plots measuring about 300 M^2 were replaced by more convenient fields of 4,000 M^2 that are individually irrigated and drained. The formation of these fields separated by permanent levees was accomplished by leveling the land in water. The advantages derived from this work included: elimination of many levees and canals giving greater elimination of nutsedge or "coquito" *(Cyperus ssp)*, a weed impossible to control with herbicides, and percentage of land area for planting; reduction of: water percolation, labor for irrigation, and canal and levee maintenance.

The cooperative program features an informal pooling of personnel, facilities and budgetary resources of both organizations for purposes of research and training. A major factor in the progress realized has been the ample cooperation of CIAT and ICA, both at Palmira and the other rice research centers.

Status of the rice industry

Since the main objective of the rice program is to increase national yield averages throughout Latin America, extensive travel has been made to Mexico, Costa Rica, Panama, Guyana, Trinidad, Dominican Republic, Ecuador, Peru, Brazil and Argentina having two main purposes: identification of yield limiting factors, and identification of personnel and stations for international testing of improved lines and varieties.

Latin America has several regional advantages which should favor the rapid adoption of improved varieties and cultural practices. These include a highly mechanized, direct seeded culture on large farms, good communication and transportation, availability of farm inputs, relative absence of language barriers, a standard requirement for rice quality, and somewhat similar disease and insect problems.

Regional yields are moderately low and production costs are high. The major factors limiting yields, in order of importance, are: lack of high yielding varieties with acceptable grain quality and diseases resistance, inadequate cultural practices (land leveling and water control, seeding rates, fertilization rates and red rice control), and the lack of adequate numbers of trained research and extension personnel.

The rice revolution in tropical Asia had had little impact in Latin America. The IR8 variety, wherever adequately tested, has produced exceptionally high experimental and farm yields. Large farm yields of 6 to 8 ton/ha are common in the American tropics. However, its quality characters have limited its adoption to a few thousand hectares, principally in Ecuador, Colombia and Peru. Rough rice prices in Colombia for Bluebonnet 50 average one third higher than for IR8.

Strategy to increase rice production

In view of the above, CIAT's rice program has established the following priorities:

1. Development of superior varieties for irrigated, direct-seeded areas. Initially, the relatively small transplanted crops and the vast upland areas will not be emphasized.
2. Training of research and extension personnel.
3. Study of possible solutions to overcome limiting agronomic factors to insure maximum yielding ability of new varieties.

Research activities

Breeding program

Crosses made since 1967 reach a total of 420. Of the 92 crosses made in 1969, at least one parent had some IR8 parentage and nearly all

crosses were between advanced lines from IRRI. The principal objectives of these and earlier crosses are described in the following paragraphs.

Plant type

The IR8 plant type is ideal for tropical American conditions. But growth is greatly reduced and maturity is delayed when it is planted at higher elevations or in subtropical areas. IR8 in Palmira is about 30 cm shorter and 3 weeks later in maturity than when planted at lower elevations. Many other lines have normal vigor and growth over a range of elevations. Strong seeding vigor, moderately heavy tillering and dwarf stature are emphasized. Several IR930 (IR 8 x IR12) lines have drooping leaves until about 70 days, after which the leaves become erect. This may be desirable for direct seeding areas where water and weed control are inadequate.

Maturity

A range in maturity (seeding to harvest) of 90 to 135 days is desired for normal temperature regimes. Some selections from the cross of IR8 x Peta/5-Belle Patna mature in 85 to 90 days in the Tolima Valley. These lines and crosses with Bluebelle have been used as parents to combine earliness with high-tillering, thick-culmed materials. Early maturity is needed for irrigation areas chronically short of water, such as Tolima Valley in Colombia and Coastal Peru, and for double or triple cropping (Guyana). All material selected is photoperiod insensitive.

Blast resistance

Blast, caused by the fungus *Pyricularia oryzae* Cav., is the most serious disease of rice in Latin America. It is often epidemic and increased by the liberal use of nitrogen and semi-upland regimes. Few lines have remained resistant after cooperative testing in Costa Rica, Colombia and Peru. Although the program emphasizes general resistance to overcome variability (page 32) two crosses probably having specific resistance have maintained their resistance to date: IR 480-14 and IR 822. Selections of IR 822 (IR8/2 x Pankhard) have been used as parents in crosses with lines that do not show the extreme floret sterility of IR 822 at Palmira. All plant selections are tested for blast resistance through the cooperation of ICA plant pathologists at La Libertad Station. The four named varieties of IRRI, IR5, IR8, IR20, and IR22, are all highly susceptible in Colombia.

Resistance to Hoja Blanca virus and *Sogatodes oryzicola*

For several years, the hoja blanca virus has been a serious problem in northern Latin America. Its vector, *Sogatodes oryzicola* (Muir),

Table 1. Days until destruction of a 12-day old plant by nymphs, males and females

Variety	Average days until destruction of one plant			
	Nymphs (a)	Males (a)	Females (a)	Resistance (b)
Taichung (Native) 1	6,20	—(c)	10,40	S
IR 404	6,40	—	10,60	S
Bluebonnet 50	6,60	7,60	5,80	S
Belle Patna	7,20	—	7,50	S
Nilo 3A	7,20	—	9,00	S
Daen	7,20	—	11,60	S
ICA-3	7,40	—	11,00	S
Napal	9,40	—	10,00	S
ICA-10	10,00	—	6,80	S
TKM 6	10,80	—	12,20	MS
Tapuripa	14,40	—	—	MS
PI 215936	—	—	13,20	MS
IR 8	—	—	—	R
IR 5	—	—	—	R
Mudgo	—	—	—	R

(a) Ten insects per plant were used.
(b) 1 - 10 days = Susceptible (S)
11- 20 days = Moderately susceptible (MS)
... = It was not destroyed = Resistant (R)
(c) ... = The plant was not destroyed
Standard error = Nymphs 0,120; females 0,128

Cages for large-scale evaluation of breeding material for resistance to Sogatodes oryzicola.

causes even greater losses through direct feeding damage. A survey of several hundred varieties indicates that excellent resistance to insect damage exists in rice. Resistant varieties show little or no reaction as seedlings or adult plants while susceptible ones are killed by the insect. No japonica varieties tested were resistant. All sources of resistance found originated in southeast Asia. The varieties grown in Colombia, except IR 8, are susceptible.

A method was developed to evaluate 15-day old seedlings of individual plants selected from segregating lines. All plant selections are routinely evaluated for insect resistance. Resistance appears to be highly heritable and is easily combined with all other desired traits. It is not associated with tillering ability or plant pubescence.

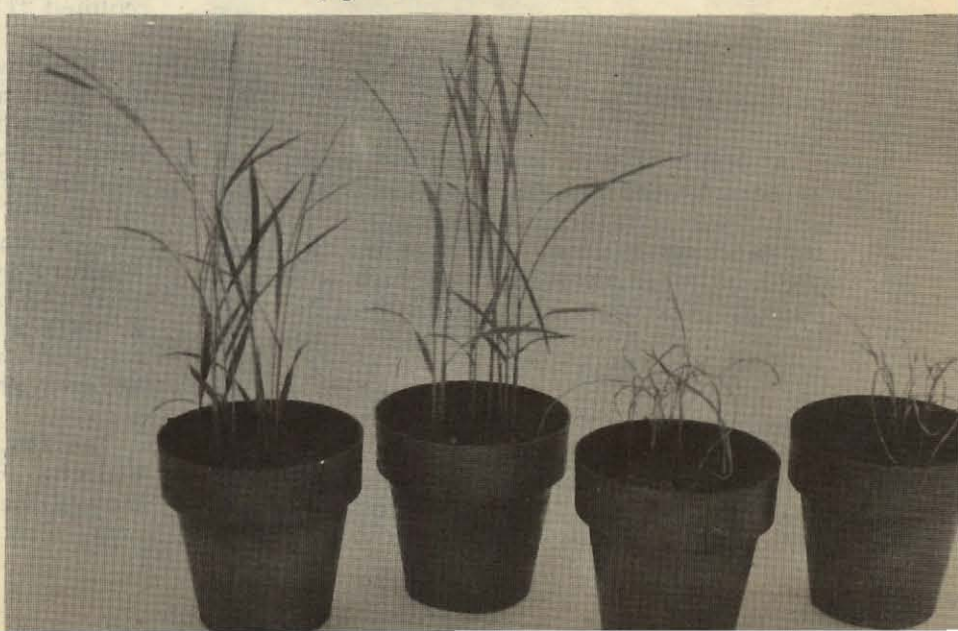
Resistance to the vector is independent of resistance to the hoja blanca virus. It appears that varieties resistant to the insect but susceptible to the virus, such as IR8, do not develop appreciable hoja blanca symptoms under field conditions. Resistance to the insect is being incorporated into all lines developed in the breeding program. It thus appears possible to eliminate or reduce costly insecticidal control programs. Studies with resistant and susceptible varieties indicated that plant resistance has a drastic effect on insect fitness. Insects lay more eggs, produce more nymphs, survive two to three times longer, and three to five times as many nymphs reach adulthood on susceptible in comparison with resistant varieties.

Grain characters

A long grain with clear endosperm, intermediate amylose content and intermediate or low gelatinization temperature is desired throughout Latin America. Many sources of superior quality are available, and all crosses made have primary emphasis on the recombination of cooking and milling quality with dwarf plant types.

Several comparisons of brown rice with milled rice for determination of gelatinization temperature showed that good results can be obtained with brown rice by slightly increasing the concentration of the KOH used in the analysis. However, as some intermediate reactions were difficult to distinguish from high gelatinizing rices, the program in 1969 built a test-tube miller by modifying the basic design used by the cooperative Thailand Rice Department - Rockefeller Foundation program.

Gelatinization temperature, white belly and grain length are determined for all single plant selections. Facilities are not available for amylose determinations. Strict selection for long slender grain types is made in the field beginning in the F_7 generation.



Resistance in rice, to Sogatodes oryzicola. **The variety Mudgo (left) is free of damage; Bluebonnet 50 (right) is dead, following seven days infestation.**

Other diseases

Sheath blight and a physiological disease associated with reduced soils tentatively called "anaranjamiento" are diseases of local importance. Sheath blight increased dramatically in Colombia in 1969 and the leading variety, Tapuripa, is severely affected. IR8 and other program selections appear to be tolerant or resistant under natural conditions of infection. Disease ratings of preliminary yield trial entries are made at the ICA station in Cerete.

"Anaranjamiento" is locally severe on acid latosols and may be widespread in the great plains area of Brazil, Colombia and Venezuela. Recent observations indicate that several yield trial lines are apparently undamaged while others are nearly totally destroyed. If this suggestion of resistance is confirmed, selection will be made within breeding material at the ICA La Libertad station.

Nurseries

Five plantings were made during 1969 (March, April, September, October and November) in order to spread work loads. During the year, 10,741 pedigree rows were grown. The most advanced material from the initial 1967 crosses was in F_5 generation. All pedigree rows were evaluated for resistance to blast, *Sogatodes* and to hoja blanca, seedling vigor, earliness and quality.

One hundred and three F_2 bulks of about 4,000 plants each and 172 F_2 families (of variety x F_1 crosses) of 200 to 400 plants each were planted. Strict selection for plant type, maturity and grain traits is begun with F_2 plants.

Yield experiments

Observational yield trial

A total of 326 varieties and lines were grown in unreplicated observational yield trials. All lines were rated for diseases and insect resistance, grain traits, plant type and vigor, and yield. Although yields have been high with many lines yielding from 6,000 to 8,000 kg/ha, most lines have been discarded because of unsatisfactory grain traits.

Advanced tests

A total of 231 lines and varieties were grown in replicated plots at Palmira and other research centers in Colombia. Many lines yielded from 6,000 to 9,000 kg/ha compared with yields of 3,000 to 6,000 kg/ha for commercial varieties included in the tests as checks.

Since 1967, the majority of the lines tested in observational advanced traits have been discarded, despite exceptionally high yields, because of unsatisfactory grain traits. Some lines, however, received from IRRI and others selected from bulk populations provided by that Institute combine superior plant type with acceptable grain appearance and quality. In September, 133 of these were planted in five locations in Colombia. Excellent evaluations were made for blast, hoja blanca, *Sogatodes*, anaranjamiento and sheath blight resistance. About 20 of these will be selected for multiplication and advanced agronomic trials in 1970. The most promising materials include: IR8 x (CPSLO x Leuang Yai 34), IR8 x (Peta/5 x Belle Patna), IR8/2 x Pankhari 203, (Peta/3 x TNI) x Khao Dawk Mali, IR8 x IR12, IR8 x (Sigadis x CPSLO), (Peta/3 x TNI) x TKM6, IR8 x Tadukan, and Nahng Mon S-4/2 x TNI.

Cooperative variety testing

During 1969, 1,757 seed packets of fixed lines and segregating material were sent to Argentina, Brazil, Peru, Ecuador, Dominican Republic, Trinidad, El Salvador, Panama and Uruguay.

Yields obtained in Peru and Ecuador in 1969 with seed provided by CIAT in 1968 were exceptionally high. The National Rice Program in Lambayeque, Peru, reported a yield range from transplanted plots of 3.8 to 16 ton/ha with 44 dwarf lines yielding more than 9 ton/ha. Growth duration of these lines ranged from 142 to 171 while the local check variety, Mochica, required 213 days.

The Universidad Nacional Agraria del Norte, also in Lambayeque, compared CIAT—provided material with local varieties. In a direct seeded test, 11 lines yielded more than Minibir 2, which produced 7.2 ton/ha. The highest yield of 9.4 ton/ha was produced by a selection of Sigadis x TNI. In transplanted tests, 25 lines outyielded Minibir 2's yield of 7.2 ton/ha with the top yield of 10 ton/ha produced by a selection of (Peta/3 x TNI) x TKM6. In both trials the dwarfs provided by CIAT averaged about 45 days earlier in growth duration than the local variety.

The first experimental planting made at the Boliche Station, Guayaquil, Ecuador, also showed the high yielding ability of dwarf types under direct seeding. Many plots yielded more

than 6 ton/ha. IR8 produced 9.1 and a selection of (Peta/3 x TNI) x TKM6, now in multiplication at CIAT, yielded 7.9 ton/ha.

Rice pathology

Two major diseases of rice are important in the Americas: hoja blanca and blast. The first is transmitted by a plant-hopper borne virus and the second is caused by the fungus *P. oryzae.*

Hoja blanca

Viruses have to be identified and characterized fully by direct means determining their size and shape and their physico-chemical characteristics to avoid misidentification by other ways such as transmission, symptomatology, etc.

Purification and electron microscopy of the virus. To determine the characteristics of the particle itself, the virus has to be isolated from the cells. A method of purification was developed for the hoja blanca virus.

Electron microscope studies made with the collaboration of the Hokkaido University in Japan suggest that the particles of the hoja blanca virus have an exceptional shape and size compared with those known for other leaf-- or plant-hopper--borne viruses. The virus particle has a long and thin threadlike shape.

The isolation of the virus leads to the determination of its physico-chemical properties and the production of an antiserum. The specific antibodies will be used internationally to test for the possible presence of different strains of the virus in the various rice producing countries of the Americas.

Varietal resistance to the virus and its vector. Varietal resistance is the best method of controlling virus diseases. In the case of plant-hopper-borne viruses, varietal resistance to the vector is being explored as a method of controlling both the virus and the direct insect damage.

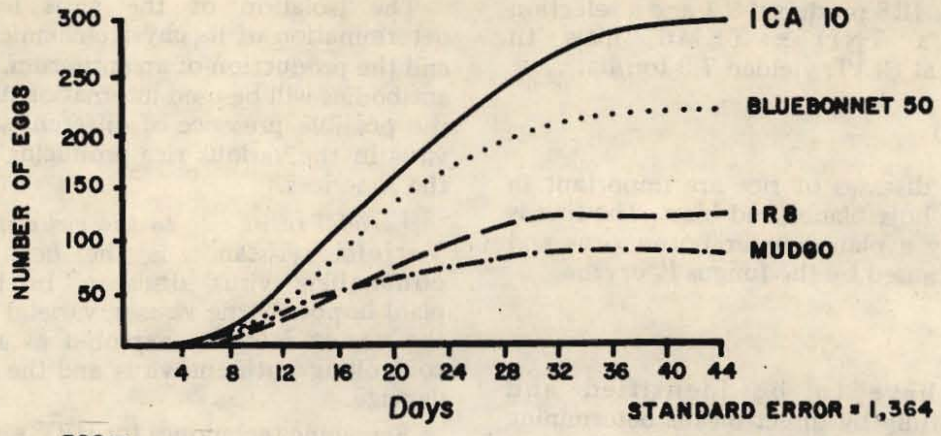
Screening techniques for HBV were developed using a highly-active colony of the vector *Sogatodes oryzicola* (Muir) that permit the testing of a large number of lines in a short time. A non-active colony of the vector was developed to be used to screen lines for resistance to the insect. Resistance to the virus was estimated as a percentage of affected plants and resistance to the insect in number of days of life span of the plant and the insect, number of eggs and progeny, and weight gains of the insect. Although the number of varieties used was small, it served to test the efficiency of screening methods for both the virus and the insect.

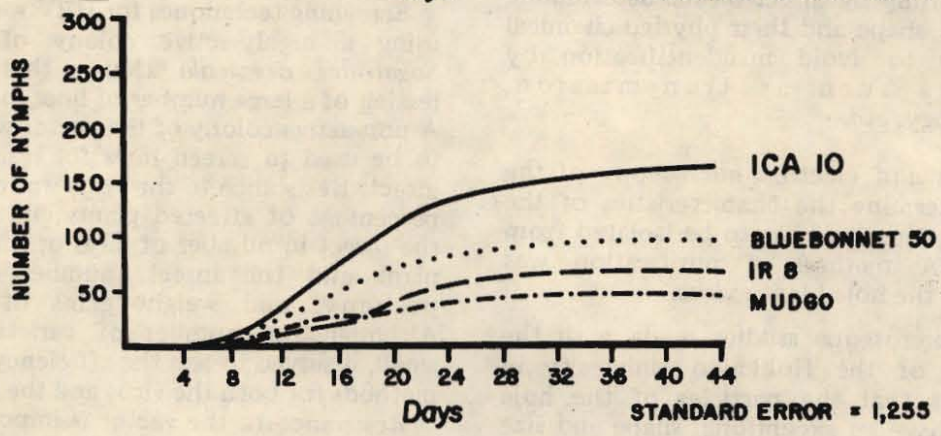
Resistance to the vector is important in such cases where virus susceptible varieties escape infection probably just because of low numbers of vectors to spread the virus in the field.

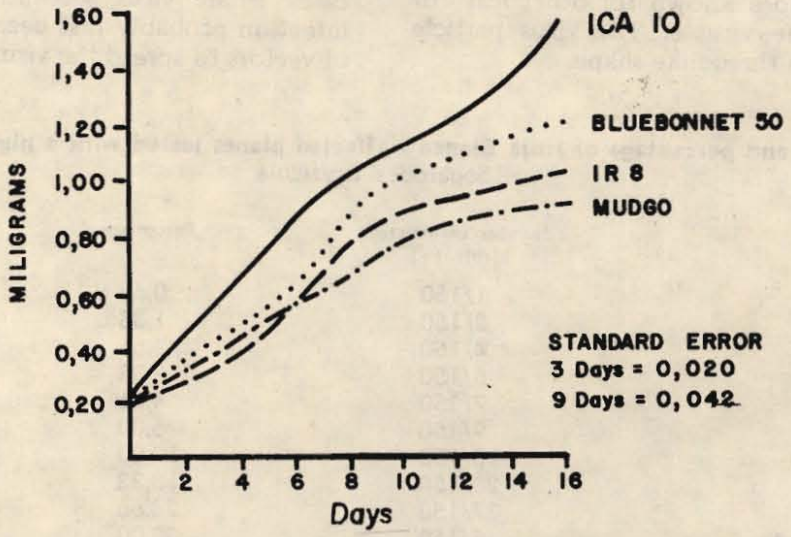
Table 2. Number and percentage of Hoja Blanca - affected plants tested with a highly - active colony of Sogatodes oryzicola

Variety	Number of affected plants (a)	Percentage	Resistance (b)
ICA-10	1/150	0,66	R
ICA-3	2/150	1,33	R
Niio 3A	4/150	2,66	R
Mudgo	5/150	3,33	R
IR 5	7/150	4,66	R
Napal	9/150	6,00	R
PI 215836	18/150	12,00	MR
Tapuripa	20/150	13,33	MR
TK M 6	37/150	24,66	S
Taichung (Native) 1	45/150	30,00	S
IR 8	51/150	34,00	S
Dawn	56/150	37,33	S
Belle patna	59/150	39,33	S
IR 404	72/150	48,00	S
Bluebonnet 50	89/150	59,33	S

(a) Numerator: Number of plants showing symptoms
Denominator: Number of tested plants
(b) 0 - 10% = resistant (R)
11 - 20% = moderately resistant (MR)
21 -100% = susceptible (S)
Standard error = 2,268







Number of eggs, progeny and weight of insects in different varieties of rice.

Rice blast

The rice blast disease has been extensively studied throughout the world but no effective control measures have been developed for the tropics. The great variability of the fungus has made impractical the use of resistant varieties having major genes for resistance. The success in the control of late blight of potatoes by varieties having horizontal resistance has encouraged the undertaking of a similar project. Varieties with horizontal resistance must have a relative resistance to all the races present and those that might develop in the future. This cooperative project with ICA and IRRI is being planted in Los Llanos, Colombia, where the disease is endemic and frequently presents epiphitotic characteristics.

The tested varieties or lines were planted in nurseries according to the method developed in IRRI. The ratings were from 0 to 7, and any material having 5 or more was discarded. Those that were resistant in Colombia but susceptible in the Philippines were also eliminated. Two-hundred and sixteen varieties or lines have kept their resistance through four plantings in 1969, i.e., about 20 percent of the original resistant material.

These lines will be further tested for at least 10 more plantings, and then they will be collected in an International Blast Nursery for horizontal resistance. Assays will be carried out cooperatively in different countries of the tropical and temperate regions of the world, searching thoroughly for this kind of resistance.

The combined use of resistant varieties and systemic fungicides may provide the only method for controlling this disease in the tropics.

Rice soils

Some highly weathered soils of the tropics present special fertility problems when flooded for rice production. Although there is no evidence to date, these problems are apparently associated with excessively high iron concentrations in the soil solution shortly after flooding and decreased phosphorus availability with prolonged flooding. Also, excessive nitrogen losses frequently occur, and other factors may be equally important.

Concentrated attention to these problems is justified because of the large reserve of such soils in the tropics and their potential importance for rice production. Flooded rice does not normally need lime, even on extremely acid soils, a great advantage in areas where lime is expensive and a necessity for most upland crops.

Consequently, some specific problems for research are:

- Management of flooded soils
- Water and fertilizer management to increase efficiency of phosphorus fertilizer and native soil phosphorus
- Use of slow release or delayed release nitrogen fertilizers to increase nitrogen fertilizer efficiency

Problems associated with flooded rice production on highly weathered soils are being studied in a series of screenhouse and greenhouse experiments conducted at CIAT. Anaranjamiento ("orange leaf" or what might be called "bronzing") symptoms have been widely observed in the piedmont region of the Llanos, near Villavicencio, for several years. The symptoms are apparently associated with nutritional disorders on extremely acid soils which are very low in available phosphorus. Per-plant flooding for 20 days and phosphorus applications reduce markedly the symptoms and improve plant vigor. Longer periods of pre-plant flooding are of no benefit and frequently quite deleterious. Phosphorus availability probably increases initially under flooded conditions, but sometime after 20 days, decreases, apparently quite markedly. Iron concentrations in the soil solution would be expected to initially increase rapidly perhaps reaching toxic levels for at least a short time before falling to sub-toxic levels.

It has not been possible to grow in pot experiments what might be called "normal" plants on these problem soils of the Llanos, regardless of pre-plant flooding, phosphorus levels and lime applications. Further investigation is needed to define limiting factors.

Economics of rice production

A study is in progress to estimate the supply response of existing rice varieties. The study is carried out in cooperation with the Department of Economics of the Universidad del Valle. The study attempts to estimate production functions on the basis of data obtained from rice producers in the Cauca Valley.

Training

At year's end, five men--from the Dominican Republic, Colombia, Ecuador, and Peru--were appointed to the first rice production training program at CIAT. This program will emphasize, in the early stages, land preparation, land leveling, levee buildings and soil puddling preparatory to installation of the first CIAT rice plots at the headquarters site. Following this, the trainees will transplant and tend until harvest a number of promising new rice strains being multiplied for more extensive field trials.

In addition, four post-graduate interns (three from Ecuador and one from Costa Rica) completed training periods from six to ten months. One more post-graduate intern from Argentina will begin a nine month training period in January 1970.

Child • enjoying a hospital meal before returning to his "barrio" home. He and his little brother regained his health through diets using opaque – 2 corn as the protein source.

A geneticist from Purdue University, Lafayette, Indiana, who conducted research on the opaque–2 gene of corn, observes a child that regained his health at the Hospital of the Universidad del Valle through diets using opaque–2 corn as the protein source.

Corn

The main objective of the Corn program of CIAT is to increase present levels of production and productivity of this crop throughout the tropical region of the world. Corn is a basic staple food for millions.

Corn has been historically a paramount source of food in Latin America. In areas of Central America, it provides 60 percent of the total caloric intake and up to 50 percent of the daily protein supply. In Colombia, the Instituto Nacional de Nutricion has estimated that 30 percent of the national calorie intake comes from corn. This figure is higher for persons living in rural areas and increases in an inverse relationship with the percent of the family budget available for the purchase of food.

In the tropics, as in other areas of the world, there is a high rate of rural urban migration which, combined with a high population increase, makes severe protein-caloric malnutrition an ever present threat. More and higher quality food must become available if stable nutrition patterns, necessary for the overall progress of the region, are to be achieved.

The development of more productive and efficient varieties with an increased nutritional value, coupled with the most appropriate production systems to achieve economic production and greater corn yields, are specific goals of the Corn program.

Strategy to increase maize production

Improvement of nutritional value

In the higher elevations of the tropical region of Latin America, floury types of corn with low lysine and tryptophane content are used for human consumption and relatively small amounts are used for animal feed. At least, 25 percent of the crop is used as green corn. Also, at low elevations, a considerable amount of corn is used directly for human consumption which makes relevant the need to produce high lysine and tryptophane corn.

In addition, perhaps up to 50 percent of the crop is used as feed, without any protein supplement because of the high cost of the latter. Consequently, the development of high lysine-high protein corn will also benefit the economy of feed production and utilization in the region.

CIAT's corn breeding program will undertake projects aimed at:

1. Improving the nutritional value of corn, including the biological value of the protein and the modification of its content.

2. Increasing total protein levels from 10 to 15 percent with presently available germ plasm, keeping in mind, however, the relationship between protein content and yield.

3. Improving grain quality in the high protein-high lysine types. Also, in the higher lysine types, studies leading to increasing protein levels and to a greater accumulation of flinty endosperm, will be continued.

4. Providing technical assistance to regional corn breeding programs to aid in the development, maintenance and utilization of high protein-high lysine hybrid varieties and populations.

These programs will also try to identify and develop systems for utilizing broader-gene basic genetic stocks that contain genes for improved content of other important amino acids.

Genetic improvement

Numerous plant breeding procedures are presently under study at CIMMYT and could effectively orient the corn breeding program of CIAT and related institutions. These studies will produce both plant breeding information as well as improved populations which will be used cooperatively as basic stocks as soon as they become available.

A number of agronomic factors, in addition to yield per se, require considerable attention. Plant height and ear length, rate of drying, area of adaptation and vegetative efficiency must be studied in large testing nurseries to provide the necessary information for selection procedures. Plant physiology will supply important information background for these studies.

Specific research projects in this area will include:

1. Adaptation studies to evaluate the effect of temperature, elevation, daylength, diseases, light quality, etc.
2. Definition of the most efficient plant structure, including the possibility of an increased number of ears per plant as an important factor in increasing yield.
3. Relative efficiency of dry matter accumulation. This has become an important area of plant breeding, particularly in the tropics where, under a short day system, inefficient plants may dominate in a population because of early seasonal advantages, as in the case of rice.
4. Rate of dry matter accumulation and rate of drying of the mature grain. Presently available hybrids and varieties dry slowly after maturity, at least in part because of long shanks; this character seems to be associated with insect resistance. The importance of these factors must be assessed to orient research towards the development of corn types adapted to mechanical harvesting in areas where this operation is or is to be practiced.
5. In some areas of low soils fertility, special attention must be given to the relative value of corn and sorghum production. The Eastern Plains (Llanos) of Colombia and the Campo Cerrado in Brazil are critical areas for these projected studies.

Regional Collaboration

There is no uniform formula that can be applied to regional activities. Up to now, these have been based on cooperative projects in which part of the activity was carried at a central location in cooperation with a regional organization.

Frequently, corn breeding programs lack facilities for seed production and promotion. Whenever possible, this matter will be discussed with local program administrators and government leaders to emphasize the role of private industry and official institutions in this phase of development.

The Corn program of CIAT will work in close cooperation with CIMMYT in the following areas:

1. Methods of breeding
2. Production systems
3. Disease and insect resistance
4. Collection, storage and use of regional germ plasm collections
5. Economic marketing and price studies.

CIAT has initiated contacts with CIMMYT to define areas of mutual activity and has already a strong cooperative program with ICA in Colombia which will also benefit from the contribution of CIMMYT.

Research

In order to evaluate the introduction of opaque-2 corn among Colombian farmers, a project was started in the second semester of 1969, in collaboration with ICA. Package programs with a simple design were prepared, to be applied by about 60 farmers in six widely diverse corn growing areas of Colombia. The project was designed to compare the production of opaque-2, some local varieties and the best adapted hybrids under the technology used by local farmers, with production levels that can be obtained when using the full technological package (spacing, fertilizer, herbicides, insecticides, etc.).

In addition, a socio-economic analysis of the main obstacles to a successful introduction of opaque-2 corn in Colombia is being carried out. The objectives of this study are to identify the main social and economic obstacles to a successful expansion of the production, marketing and consumption of opaque-2 corn, and to suggest ways by which these obstacles may be overcome. Basic data are being obtained by means of interviews with producers, marketing agencies and consumers. The study is expected to terminate in the summer of 1970.

With respect to the farmer, the study is attempting to determine: a) their reaction to and acceptance of opaque-2; b) the yields that farmers expect and are capable of obtaining; c) modifications in protein content and quality that may result when opaque-2 is grown under farmer conditions; d) their level of understanding, in regard to nutrition and protein; e) their marketing problems; f) the degree of rapport that a young college graduate can establish with farmers with low levels of education; g) the type of working relationship needed among these college graduates and other professionals and agencies for the success of a program of this nature.

Training

Production specialists

Six young men began work in August as corn production trainees in the above mentioned research project with opaque-2 corn, in six geographical areas of Colombia. Their work

included gathering data--agronomic, sociological and economic--as well as helping the cooperating farmers with the research plots.

Conferences and symposia

CIAT launched its conference and symposia program in April 1969, with a scientific meeting attended by more than 100 national leaders from nine countries in medicine and public health, agricultural research and policy, and industrial research and processing. This international Seminar on the Utilization of High Lysine Corn (Opaque-2) was held at the Universidad del Valle, Cali. Participants reviewed the promising results of nutrition studies in which locally produced high lysine corn was used to feed swine and to treat children suffering from serious protein deficiencies.

Scientists and officials discussed the great potentiality of the new corn, had first-hand observations of a community nutrition project and compared the physical condition shown in "before" photographs of under-nourished children with the robust "after" live performance of the recovered youngsters.

Organizations cooperating with CIAT in sponsoring the seminar included the Asociacion Colombiana de Facultades de Medicina, the Federacion Panamericana de Asociaciones de Facultades de Medicina, the Universidad del Valle and ICA.

Results of the meeting were quickly manifested in the formulation of action programs in some countries, enthusiastic commitment of several major industries to carry out large scale processing and marketing activities, and widespread recognition and appreciation of the multi-disciplinary research (agricultural-medical-industrial) which made possible this rapid progress with opaque-2 corn. The most pervasive concerns of the conferees were the need to accelerate the research in more areas and to seek ways to facilitate and expedite the widespread production and consumption of this new corn.

Post conference activities were widespread and almost immediate. Corn processing industrialists in the United States held a seminar in Iowa; a conference, similar to the Cali meeting, was held in Venezuela with the participation of several members of the CIAT staff; and, one Cali processing firm, within 4 months, had two products in test markets. One of these is a baby food and the other is a prepared mix for making "arepas" one of the traditional corn-based foods of Colombia.

Food legumes

Proteins as a food source are deficiently represented in human diets in the lowland tropics. The problem is acute and it is urgent that it be remedied. To meet the demand for food legumes that will be present by the year 2000, production of grain legumes, the most important and efficient plant protein producer, must at least be doubled in relation to actual levels of production.

About 20 species of edible grain legumes are produced for food purposes. The most important species grown commercially in the hot, humid lowlands are: soybean *(Glycine max);* pigeon pea *(Cajanus cajan);* cowpeas *(Vigna sinensis);* horse gram *(Dolichos uniflorus);* dry beans *(Phaseolus vulgaris);* lima beans *(Phaseolus lunatus)* and peanuts *(Arachis hipogaea).* High temperatures, high humidity and the alternating dry and humid periods present in the tropics have traditionally limited commercial production of these grain legumes.

As a group of plants, food legumes have a high protein content, with levels ranging between 17 and 25 percent in the dry seeds. By contrast, in the cereals, the levels of protein content vary between 6 and 14 percent.

Except in a few cases, little research has been done so far in the tropics to improve food legume varieties and productivity. It is believed that, with adequate supply of technical inputs and good management, three crops of short season legumes could be produced annually in the lowland tropics. Before this situation can become a reality, research must define input levels for economic production and management techniques. At present, only one crop is grown annually and, in the absence of proper storage facilities and industrial utilization, greater consumption of these high protein foods probably occurs after harvest and becomes much lower at other times of the year. Any production system for food legumes in the tropics must also be concerned with preparation after harvest, storage and utilization.

Dry edible legumes supply as many calories per unit weight as cereals. When compared in this respect with energy food sources most commonly consumed in the tropics (cassava, plantains, yams, etc.), the comparison favors the leguminous plants. Most legumes commonly used for food contain some fat and are fairly good sources of vitamins and some minerals. About 80 percent of the proteins and 97 percent of the carbohydrates in food legumes are absorbed. The digestion of food legumes and the absorption of their nutrients is practically as complete and about as effective as with cereals.

Legume proteins are chiefly globulins; albumins are also present in a few species. The high protein content of food legumes is highly significant but the quality represented by the amino acid composition, which are the units necessary for growth and maintenance, is also important for nutrition. In general, legume proteins are poor sources of the sulphur-containing amino acids methionine and cystine and some are relatively deficient in tryptophane. But food legume protein is richer in lysine than protein of cereals, in which this essential amino acid is relatively deficient. As cassava protein is also deficient in methionine and cystine, as well as in lysine, present food legume varieties are, therefore, poor food supplements to cassava. This points to the importance of a breeding program aimed at eliminating this specific deficiency in grain legumes as well as in cassava.

Strategy to increase production

Food legume research will focus on the following areas:

1. Determination of the productivity of the potentially most important food legumes, particularly soybeans, cowpeas and pigeon peas, in specific lowland environments with emphasis on their nutritive composition and variation in response to environmental and cultural conditions.

2. Development, if so required, of new food legume varieties having the following characteristics: adaptation, high yielding ability per unit area and unit time, insensitivity to daylength, acceptable degree of maturity, resistance to diseases and insects, tolerance to alternating dry-wet conditions, ability to respond to fertilizer applications and high

photosynthesis efficiency in specific tropical lowland conditions.

3. Implementation and demonstration of cropping practices and production systems designed to maximize yields and economic returns while lowering production costs in the tropics.

4. Active participation in a program designed to survey, assemble, evaluate, maintain, distribute and exchange valuable food legumes germ plasm.

5. Training of personnel in production and in the disciplines related to crop improvement in an effort to provide and support trained leadership for national plant protein improvement teams. Also, to provide information and materials for cooperating national food legume improvement and production programs.

6. Cooperation with the ICA food legume program and, at the international level, with programs established for the improvement and utilization of these crops at national research institutions.

At present, the Food Legume Program is being organized. Qualified staff members are being sought and it is expected that by mid-1970 a program leader will be identified. A Colombian agronomist is being trained in certain aspects of legume diseases. CIAT is cooperating with ICA in the introduction and exchange of food legume germ plasm.

Research activities

Beans

These plants are an important protein source in many American countries. However, in most of them, viruses cause heavy losses. Since few studies have been made in these countries on virus characterization, CIAT has initiated a project to identify and characterize the bean viruses.

Common bean mosaic

The virus was isolated from different varieties of beans in the ICA experimental farm near Palmira and tried in a systemic host, the variety Diacol Andino. Local lesions were obtained in the varieties Kentucky Wonder Brown and Kentucky Wonder White, the former being the best for bioassay. The virus is transmitted through seed, mechanical means and aphids.

Southern bean mosaic virus

This virus is being studied in the laboratory comparing biological assays and analytical density-gradient centrifugation as the means for determining physico-chemical characteristics.

Soybeans

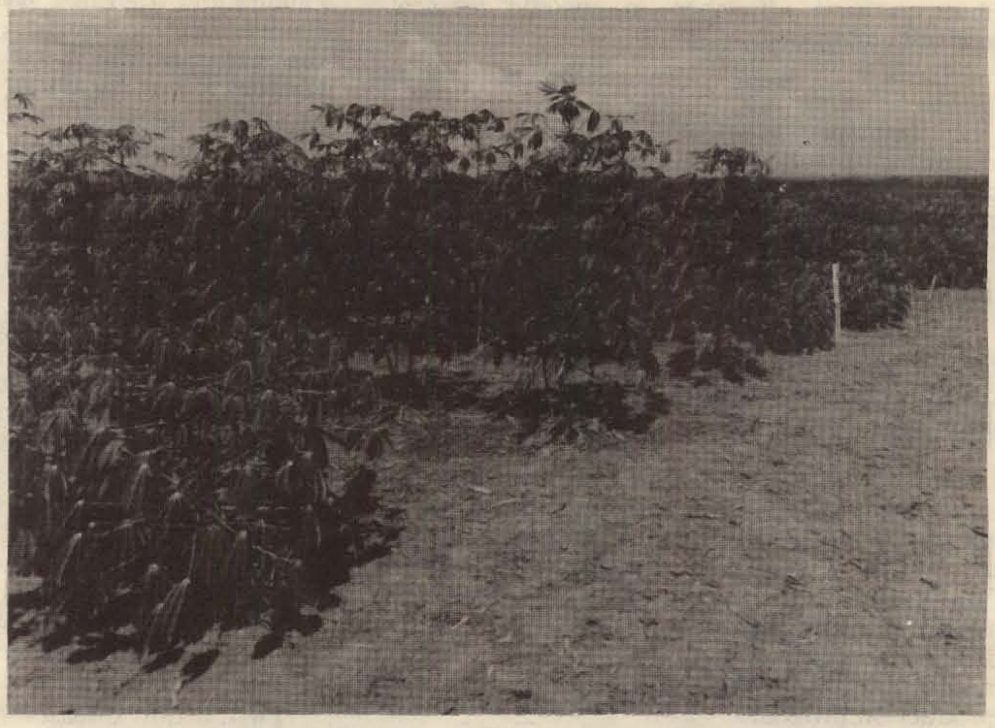
Soybeans host more than 30 viruses. Many of them, as well as several from beans, are seed transmitted, an important fact to be considered.

Two major diseases are being studied, one that shows apparent virus symptoms and the other, a bacterial disease. The virus-like disease has been mechanically transmitted and it shows symptoms that do not resemble any of the reported virus diseases. It shows lesions that resemble bacterial pustules in the inoculated and in the first systemic-affected leaves. Then, the newest leaves turn chlorotic and finally a curling and distortion of the leaves is observed. In several trials, bacteria isolated from the spots have not been pathogenic.

The pathogenicity of the bacterium isolated from the other disease has been demonstrated and it is now being identified.

Economics of plant protein production

A study is in progress to estimate return to scale and least-cost resource combination for producing red beans in the Cauca Valley. The technique used is to estimate a statistically determined production function based on data derived from a stratified random sample of sorghum producers. The production function will then be used to estimate not only return to size of operation but also the production response of the producers to relative changes in prices. This study is carried out in cooperation with the Department of Economics of the Universidad del Valle.



e collection of Cassava varieties at
AT includes promising material for
ınt improvement purposes and
servation of desirable agronomic
ıracters.

A cultivar of Cassava, known as Llanera, collected in the Eastern Plains (Llanos) of Colombia, has yielded more than 100 ton/ha in a 10 –month period. It is well accepted by farmers and by the consumers of this important source of energy.

Tropical root crops

Several plant species are important major food sources for the inhabitants of the tropical lowlands. Of these, the root and tuber producing species are the major source of energy in the form of carbohydrates. In this group of species the most important are: cassava *(Manihot esculenta* Crantz); sweet potato *(Ipomoea batatas* (L) Poir); yams (several species of *Dioscorea*); taro *(Colocasia esculenta* L. Schott); tania (several species of *Xanthosoma);* arracacha *(Arracacia xanthorhiza* Bank) and arrow-root (*Maranta arundinacea* L.). There are at least 28 botanical families, with species that produce roots, tubers, rhizomes or corms that are used for food or feed in the tropics. Cassava is probably the most widely cultivated starch-producing species in the lowland tropics of the world.

Research to improve these species and to develop efficient production systems has been extremely limited and has mostly been focused on the description of the origin, history and geographical distribution, with minor attention to botany, agronomic practices, plant protection, genetic improvement and utilization.

The Tropical Root Crops program of CIAT will study in depth the problems that limit production in the most important starch-producing species and will focus research on cassava, sweet potatoes, yams and probably taro with the idea of understanding their limitations and potentials, and to try to develop improved varieties with higher nutritive value and the efficient agronomic practices required to raise yields subtantially.

CIAT's initial efforts concentrate on cassava and, as the program develops and more facilities become available, work will be started with other starch species.

Cassava

This plant, also known as manioc, mandioca, guacamote and yuca, is one of the major sources of carbohydrates for the inhabitants of the lowland tropics in the Western Hemisphere and Africa. Its present day distribution is worldwide in frost free latitudes, between 30° North and 30° South, at elevations ranging from sea level to 1,800 meters.

Cassava production

Production statistics are inaccurate as a large portion of the crop is consumed locally and does not enter the market. In Colombia, during 1967, cassava was produced on 150,000 hectares with a total production of 885,000 metric tons giving an average of 5.9 tons per hectare. Data available from FAO indicates that 83.2 million tons of roots were produced on 9 million hectares in 1964 giving an average of 9.2 ton/ha. Africa is the world's largest regional producer, while, individually Brazil produces more cassava than any other country.

Cassava is often described as a back-yard crop. Large acreages are seldom grown on a farm. In general, small plots are planted for the support of the family. However, there are areas in Brazil and Thailand, where the crop is grown to provide both for local requirements and as a cash-crop export to the temperate zones. It is cultivated in pure stands or in multiple cropping schemes with corn, bananas, yams and sweet potatoes.

Yields and nutritional value

As an unprocessed food, cassava roots are boiled or fried, or consumed as crude flour. Commercial products that can be derived from cassava include starch for paper sizing, laundry starch, adhesives and tapioca. Fresh or dried roots are used as animal feed.

Cassava is considered a prodigious producer. Although the world average is 9.2 ton/ha, some producing countries such as Brazil, Thailand, Cambodia and Bolivia, have national averages ranging from 14 to 18 ton/ha.

Where cassava is well tended as a plantation crop for commercial use, average yields of 24 ton/ha are common and yields of 50 to 100 ton/ha have been reported from individual plantings. One cultivar, Llanera, collected in the Eastern Plains (Llanos) of Colombia by ICA, has yielded more than 100 ton/ha in rich black soils in a 10-month period.

Cassava is a long-term crop, taking from 10 to 18 months or longer from planting to harvest. It contains 30 to 40 percent dry matter. Roots contain a relatively small amount of protein (usually, 0.5 to 1.5 percent) and minimal percentages of fat, vitamins and minerals. Analyses of 87 cultivars have shown the possibility of finding clones with a higher protein level. One of the collected cultivars contained 7.25 percent protein, (based on N^2 x 6.25 calculations, with zero percent moisture content). However, a portion of the total nitrogen present in cassava may be non-protein nitrogen of low nutritive value for single stomach animals. Amino acid content is similar to that of corn, methionine being low and threonine twice as high as in corn.

Cassava leaves are rich in protein. One survey of varieties showed a range of 3.7 to 10.7 percent protein on a fresh weight basis and of 21 to 36 percent on a dry weight basis. Essential amino acids are well represented, having a deficiency only in methionine. Lysine content of 5.6 to 8 percent is acceptable.

There are toxic and non-toxic cassava varieties. Toxicity results from the presence of hydrocyanic acid (HCN) which is derived from linamarin, a glucoside. Another glucoside, lotaustralin, can be present also in minute amounts. Sweet or non-toxic varieties have a content of less than 50 mg of HCN per kilogram of fresh roots, while bitter, toxic types have well over 100 mg per kilogram of fresh roots.

Varietal improvement

Cassava has been largely overlooked by research workers in temperate climate countries. No tropical country, where the crop is grown in large quantities, has organized and maintained an improvement program of satisfactory scope and duration to produce significant results.

The genus *Manihot* has probably some 150 to 200 species, all native to the new world. Although, it is likely that the majority of these so-called species would be cultivars rather than distinct species. Several experiment stations have collected and do maintain varieties of the cultivated species, *M. esculenta*. At present, fairly large collections are located in Brazil, Malagasy Republic, Uganda, Congo, Colombia and India. However, it appears that most workers have not gone beyond the evaluation of their collections and multiplied and distributed their better materials.

Hybridizations within the cultivated species and inter-specific crosses have been rarely attempted. For example, during the period 1932-1942, efforts were made in Java to increase root protein content through intra-specific crosses between *M. esculenta* and *M. saxicola*. Some resulting clones initially contained more than 2 percent protein but these were reported to regress to normal levels (0.8 to 1.5 percent) after continued propagation. It was concluded that there was little chance to increase protein content through selection following hybridization. In view of the considerably higher protein content observed in cassava collected in the Colombian Llanos, it would seem worthwhile to repeat this work. Moreover, former yuca research workers report that individual protein analyses have reached 9 percent or more in related *Manihot* species.

A more succesful breeding project has been reported from the Malagasy Republic where workers sought resistance to mosaic, a serious virus disease. Numerous partially controlled pollinizations resulted in 15,000 to 20,000 seedlings per year. These were screened for mosaic resistance and starch content. The resulting varieties were claimed to be resistant to mosaic, to show increased adaptability to low fertility soils and to have increased yields from 12 to 30 ton/ha.

Agronomic practices

Actually, very little is known about the value of improved cultural practices in relation to varietal types. Cassava supposedly responds in yield to applications of P_2O_5 and K_2O, but there is a possibility that this is more closely related to native soil fertility than to a fertilizer-variety interaction.

Nearly all reports stress the fact that applications of nitrogen fertilizers do not increase cassava root yields. All workers agree that stem and leaf weight show a positive response to nitrogen. Furthermore, limited spacing studies indicate that optimum spacing, on low fertility soils, is closer than that on soils with normal fertility. This fact combined with the general unresponsiveness in root production to applied nitrogen would suggest that the fertilizer response is impeded by mutual shading resulting from excessive vegetative development.

Cassava diseases

The lack of attention to cassava diseases is illustrated by the observation that, in 1966, *The Review of Applied Mycology* published two references to cassava diseases, 17 to carnation diseases and 234 references to research on tobacco diseases.

In general, the literature implies that diseases and pests are not important on cassava, although sound information on disease and pest losses is scarce. Mosaic, one the three of four known virus diseases of cassava, was estimated in 1956 to have caused an 11 percent loss in the British African colonies. Fields with 100 percent mosaic infection yielded one ton or less per hectare.

Strategy to improve cassava production

Cassava has a great potential as a major food and feed source and as raw material for industry in the tropical lowlands. The development of this potential merits a strong research effort.

CIAT has established the following goals in order to develop economic production systems for increasing food production in the tropics. These goals are:

a) To explore and collect cultivars and related wild species of *Manihot* in the countries where variability is present, with emphasis in the primary centers of origin (Northern South America and Middle America), in order to establish a germ plasm bank representative of the world's variability.

b) To classify and evaluate the genetic variability of the collected material as a basis for future work. The germ plasm bank will constitute a reservoir of breeding material available to researchers throughout the world for the improvement of this important tropical crop.

c) To identify superior cultivars that can raise present yield substantially.

d) To find production systems that maximize the efficiency of planting methods; control of pests, diseases and weeds; adequate fertilizer application and harvesting procedures.

e) To develop more practical and efficient systems of drying and using cassava as human food, animal feed and for industrial use, with emphasis in economic mechanization schemes that can be used by small or large growers.

f) To obtain superior varieties through plant breeding with higher yield capacity, increased starch and protein content and nutritional quality of the roots; with resistance to diseases (particularly, mosaic) and adapted to cultivation in heavy soils, and with levels of HCN content in accordance with the final use of the roots (food, feed or industry).

g) To provide practical training in varietal collection, evaluation, improvement and testing as well as in crop production methodology and in plant protection, to young scientists from major cassava producing areas.

h) To exchange information, materials and scientists with other national and international institutions concerned with the improvement of cassava throughout the world.

Research activities

Collection of cassava material

In May 1969, CIAT started a systematic collection of genetically diverse cassava materials present in Colombia. CIAT obtained the cooperation of the Secretaria de Desarrollo y Fomento del Valle, this organization appointing the Director of the Cauca Valley Botanical Garden to work with CIAT in the collection procedure.

A general collection plan was prepared and a special form designed for this purpose. One CIAT trainee and a botanist of ICA were trained in collection techniques. Through the efforts of the collection team, a total of 611 cultivars of cassava were collected in 20 Departments of Colombia. All materials collected were planted at CIAT's farm and an intensive program of observation and data gathering has been underway since. Information is being obtained on sprouting, branching, growth patterns, foliar characteristics and other morphological characters to be used later for classification purposes. The collection of cassava cultivars will be actively continued during 1970 and initiated in other tropical countries in Latin America, in cooperation with national programs and organizations.

Plant Protection

Aware of the importance and dangers represented by pests and diseases, particularly those caused by virus, when conducting plant introduction schemes, CIAT initiated a cooperative project with the plant pathologists of ICA.

The Plant Protection program was designed to develop an efficient plant quarantine scheme that will insure the prevention of introducing contaminated materials into Colombia. It has been agreed that introductions from foreign countries will be quarantined by ICA, in an insect free and especially adapted greenhouse at the Tibaitata station. CIAT, in cooperation with ICA, is training a young agronomist in the techniques of plant quarantine.

The success of an initial breeding program is based upon the genetic variation available to the breeder. The first step, therefore, should be the establishment of a germ plasm bank. The introduction of genetic material of cassava, which is vegetatively propagated, brings the danger of the importation of pests and diseases, particularly of viruses not present in the host country. To prevent this possibility, several experiments were designed to find a suitable way to inactivate viruses without severely damaging the buds of the cuttings.

Hot-air and hot-water treatments were applied to cuttings 20 cm long. The hot-air temperatures included from 50 to 56°C, at 2°C intervals, for 8 hours. Thirty percent of the cuttings germinated at 50°C but not at temperatures beyond 52°C.

It was concluded that cuttings could be treated safely at 52°C for 20 min, as well as at 50°C for 60 min, with hot water. Although virus or virusses, mycoplasma-like organisms and bacteria may be inactivated by this treatment, it will be necessary to repeat it to insure a complete virus-free stock. After the treatment the cuttings must be protected with a fungicide to avoid root-rots and stem-rots during germination.

The introduction and storage of large quantities of cuttings may bring about a problem of germination and decay. To gain some experience on this matter, studies are underway to determine the best conditions for long storage periods which include different temperatures, chemical treatments and wax protection.

Attempts are being made to identify and characterize a bacterial disease of cassava present in the northern part of Colombia.

Multiple cropping

A multiple cropping experiment with cassava was started in November 1969. The purpose of this program is to evaluate the possibility of growing a relatively short season crop, like soybeans or corn, during the initial establishment phase of the cassava plants. Soybeans or corn were planted between the cassava rows. Both crops were planted at the same time. To allow comparison, cassava was also interplanted between and within soybean rows which had been planted about 45 days earlier.

Agricultural economics

Efforts to accelerate economic growth in the lowland tropics of Latin America must be based on changes in technical, social and economic factors within production, distribution and consumption systems. Neither the immediate CIAT objective of expanding food production nor the ultimate one of improving the welfare of people can be successfully fulfilled strictly by introducing improved techniques of production.

Optimum allocation of available resources among alternative production possibilities is determined by economic as well as technical relationships. Furthermore, economic analyses play an important role in determining the impact of these alternatives on general economic progress and welfare of the people. Hence, the Agricultural Economics program is an integrated part of the overall CIAT program.

The agricultural economists seek information on three related types of economic problems. The most fundamental of these is the evaluation of the economic considerations involved in determining research, training and action program priorities. But, to deal in a satisfactory manner with this problem, two others must be considered. The first of these factors has to do with the nature of economic barriers to the widespread adoption of the technical advance being considered. These barriers include, on the production side, analysis of factor and product prices, physical input-output relationships, availability of essential inputs, including not only materials but also technical assistance and credit.

Once the economic barriers have been determined and analyzed, there still remains the second problem of the economic consequences of the wide-spread application of the technical change. With regard to this matter, questions that arise include the following:

1. What is the effect on total agricultural income of various levels of increase in agricultural production for individual commodities? This requires knowledge of both domestic and foreign demand for the product in question, as well as a clear understanding of price control mechanisms used and/or available to the various regions considered. In addition, detailed information is required on transportation, storage and credit facilities.

2. What are the likely income distribution effects of increased production not only between agriculture and the rest of the economy, but also within agriculture? A closely related matter is the effect of the new technique on employment within agriculture and elsewhere in the economy. New techniques may be labor intensive or extensive.

3. How will production increases affect the region's balance of trade? This involves knowledge of the potential export markets for the product in question not only in terms of size and special restrictions but also in terms of quality of product that is acceptable.

Economic analysis of the type indicated is essential to the long term success of CIAT programs. For example, failure to take into account market conditions before launching a campaign to increase the production of one product may well result in strong price reduction of the product, which in turn may produce a more serious adjustment problem than the original one.

The general approach of the agricultural economics group may be separated into research, training and advisory services to the general administration of CIAT as well as to individual CIAT scientists on economic matters.

Research and training is carried out in two distinct but related programs. One program includes cooperative research with plant, animal and social scientists, other than economists, in the commodity teams integrated within CIAT.

In this program, an agricultural economist works as a member of the team designated to study an individual crop or livestock production system. The economist helps to select the areas of research and participates in the design and execution of the research program of the individual teams. On the basis of team research the agricultural economics group is responsible for economic research related to corn, rice, food legumes, tropical root crops, beef cattle and swine.

Since neither an individual crop nor an animal is produced in isolation, knowledge about the economics of competing crops and livestock is essential. Without this information, it is difficult, if not impossible, to suggest reasonable ways to increase the quality and quantity of food available in the regions being served by CIAT. Consequently, in addition to participating in the commodity teams, the agricultural economists also investigate some crop and livestock activities for which no teams have been established. Studies of demand, marketing, international trade and agricultural policy also will be carried out independently of production teams.

Two areas of investigation considered to be particularly important and relevant are: the economic adjustment within the existing state of technology and the adjustment possibilities using new production techniques.

The adjustment problems as related to farm size will receive special attention. While development and introduction of new technologies may benefit large commercial farmers, the adverse effects on small farmers may be of such a magnitude that the net effect of the technology is negative for the farm sector as a whole and even for the total economy.

The adjustment problems in the agricultural sector are determined not only by internal agricultural factors but by a variety of relationships in all sectors of the economy. Such problems, among small farmers, for example, may be largely determined by employment possibilities outside the agricultural sector. Hence, research cannot be limited to the adjustment within the agricultural sector.

The interactions between the agricultural and non-agricultural sectors will be analyzed to determine the impact of alternative changes in the agricultural sector on such key factors in national economics as employment, income distribution and general economic growth.

Major emphasis will be placed on research to predict product prices, income distribution and expected "bottlenecks" in marketing under certain assumed expansions in the production of the commodities in the CIAT program. Through this type of research it is hoped that the so-called "second generation problems" may be foreseen and corrective measures suggested to reduce or eliminate the adverse effect of such problems.

Studies completed or in progress

The majority of the economic studies completed or in progress relate to the various commodities. Hence, these projects are reported in the respective commodity sections.

A study that relates to all the commodities for which teams are established is presently being planned. The objective is to estimate the impact of increased levels of production of the various food commodities on such key factors as prices, levels of income and income distribution both within the agricultural sector and in the total economy. The first phase of this study will be an estimate of the price elasticity of demand at the consumer level.

Cooperation and collaboration with other agencies

Aside from collaboration with other departments of CIAT, the Department of Agricultural Economics has formed close links of cooperative research with the Department of Economics of the Universidad del Valle, ICA and the Ford Foundation agricultural advisers in Latin America.

Training activities

An apparently successful part of the training program has been the participation of plant science trainees in socio-economic farm surveys. After a short introduction to interviewing techniques the trainees are sent to the field to interview a number of farmers. It is apparent that the trainees' ability to communicate with farmers improves greatly during the period of interviewing.

In cooperation with the Corn program of CIAT a survey was made in six different corn producing areas of Colombia in order to obtain some socio-economic information regarding the introduction of opaque-2 corn.

Soils

Millions of hectares of generally smooth, well-drained tropical soils constitute the world's principal reserve of undeveloped, potentially productive crop and pasture land.

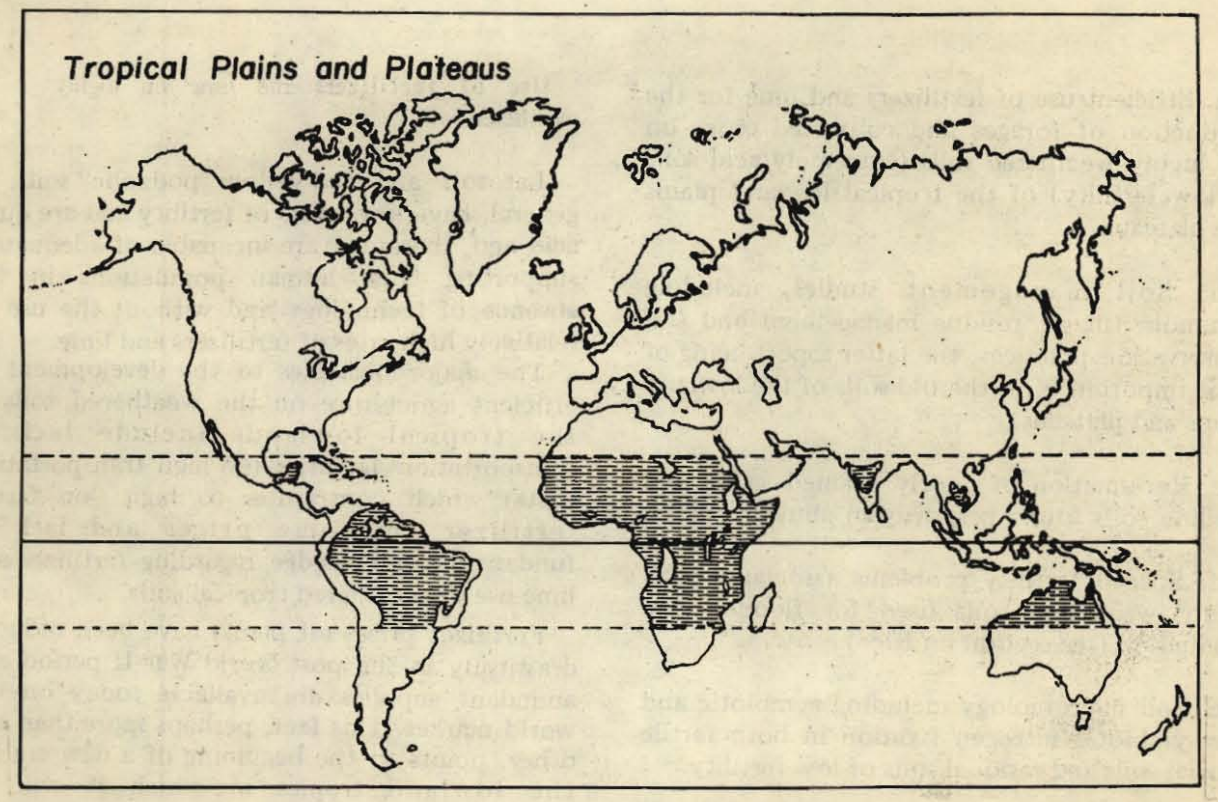
In Latin America, the majority of tropical lowlands are essentially uninhabited. Paradoxically, many of these regions are better suited, from the standpoint of topography, drainage and soil physical conditions, to the development of efficient, highly productive agricultural systems than traditional agricultural zones of the tropics, especially the steep mountain regions and foot hills. Geologic erosion on these sloping soils continually exposes fresh parent material as a natural source of plant nutrients thus providing a base for agriculture at low levels of management.

Status of soils research

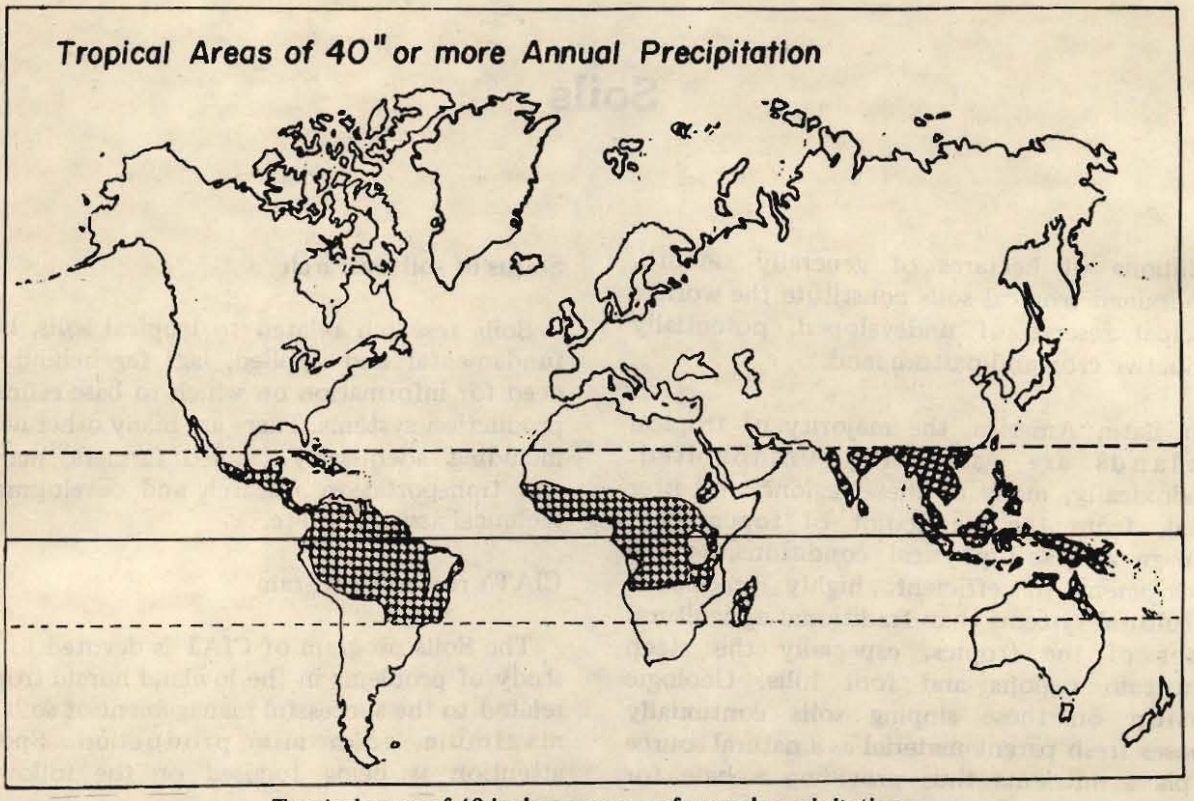
Soils research related to tropical soils, both fundamental and applied, lags far behind the need for information on which to base efficient production systems. There are many other needs including adequately trained farmers, market and transportation research and development, technical assistance, etc.

CIAT's research program

The Soils program of CIAT is devoted to the study of problems in the lowland humid tropics related to the successful management of soils for maximum economic production. Special attention is being focused on the following areas:



Approximate distribution of tropical plains and plateaus.



Tropical areas of 40 inches or more of annual precipitation.

a. Efficient use of fertilizers and lime for the production of forages and cultivated crops on the highly weathered soils (extremely acid soils of low fertility) of the tropical lowland plains and plateaus.

b. Soil management studies, including minimum tillage, residue management and soil conservation practices, the latter aspect being of great importance on the old soils of the lowland plains and plateaus.

c. Reclamation of poorly drained saline and alkaline soils found primarily in alluvial valleys.

d. Special fertility problems associated with highly weathered soils used for flooded rice production (see section on Rice).

e. Soil microbiology including symbiotic and non-symbiotic nitrogen fixation in both fertile alluvial soils and residual soils of low fertility.

f. Soil studies at the CIAT site and other research centers.

Use of fertilizers and lime on highly weathered soils

Latosols and red-yellow podzolic soils, in general, have low levels of fertility and are quite acid and, therefore, are incapable of adequately supporting large human populations in the absence of technology and without the use of relatively high rates of fertilizers and lime.

The major obstacles to the development of efficient agriculture on the weathered soils in the tropical lowlands include lack of transportation facilities (or high transportation costs) which contributes to high "on farm" fertilizer and lime prices and lack of fundamental knowledge regarding fertilizer and lime use on weathered tropical soils.

Fertilizer prices (at plant) have been reduced drastically in the post World War II period and abundant supplies are available today on the world market. This fact, perhaps more than any other, points to the beginning of a new era for the lowland tropics in which it will be economically feasible to produce crops on many soils formerly not utilized.

Specific studies

-Nutrient cycling and leaching losses. Well drained tropical soils are highly permeable and therefore subject to excessive leaching losses of N, K, Ca and Mg, when traditional fertilizers and management systems are used.

-Phosphorus fixation. This is especially serious in high-aluminum, high-iron soils.

-Micro-nutrient and secondary nutrient deficiencies (B, Zn, Cu, Mb, S, Mg). These are very frequent, especially on low organic matter, coarse-textured soils.

Soil management

Little is known about managing highly weathered tropical soils for efficient production and adequate soil conservation. Historically, such soils have been exploited almost exclusively using primitive tools and cropping systems. The results have usually been low levels of production and rapid destruction of soils.

Latosols are in general friable and should lend themselves well to minimum tillage systems. At the same time, they are found in regions of moderate to high rainfall and are susceptible to erosion, even on moderate slopes and will, undoubtedly, require vigorous application of conservation methods to prevent soil destruction. These two considerations, plus the availability of new chemical and mechanical methods for controlling weeds, point to the need for devising and testing new systems of soil management for the lowland tropics.

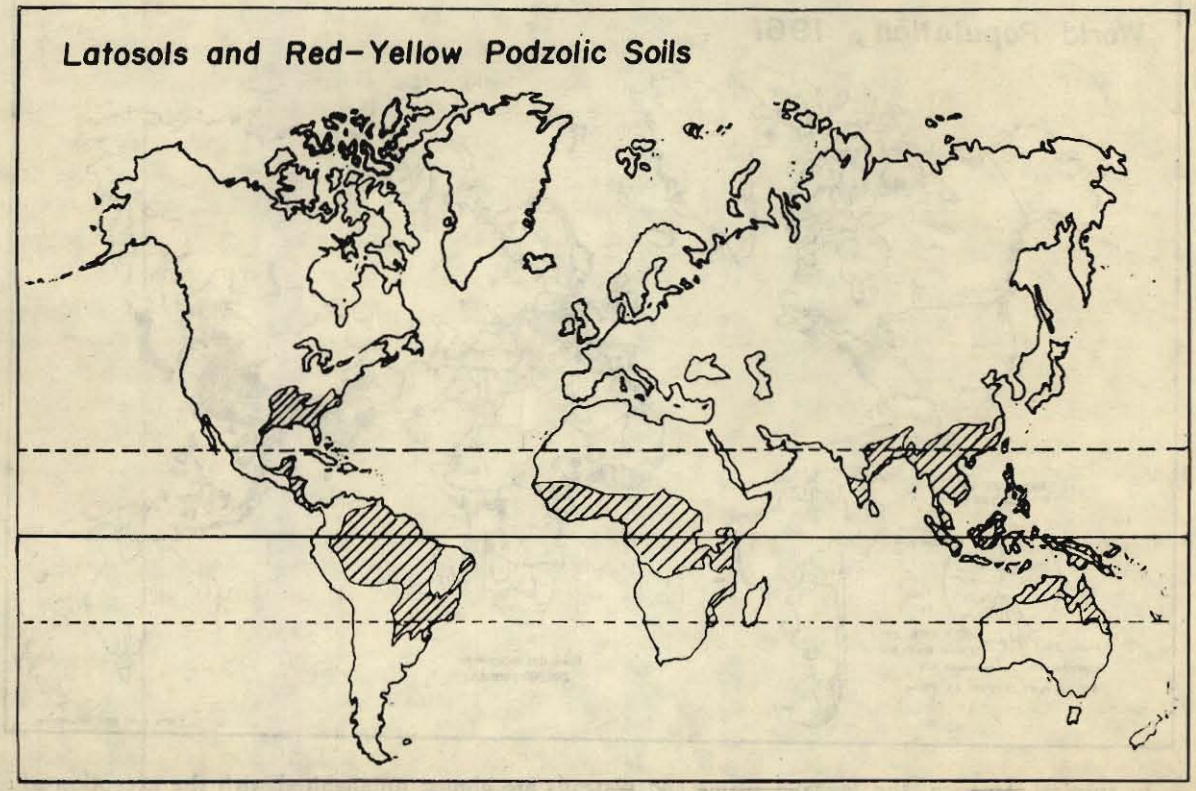
Specific studies

-Minimum or no-tillage planting systems where soil physical conditions permit.

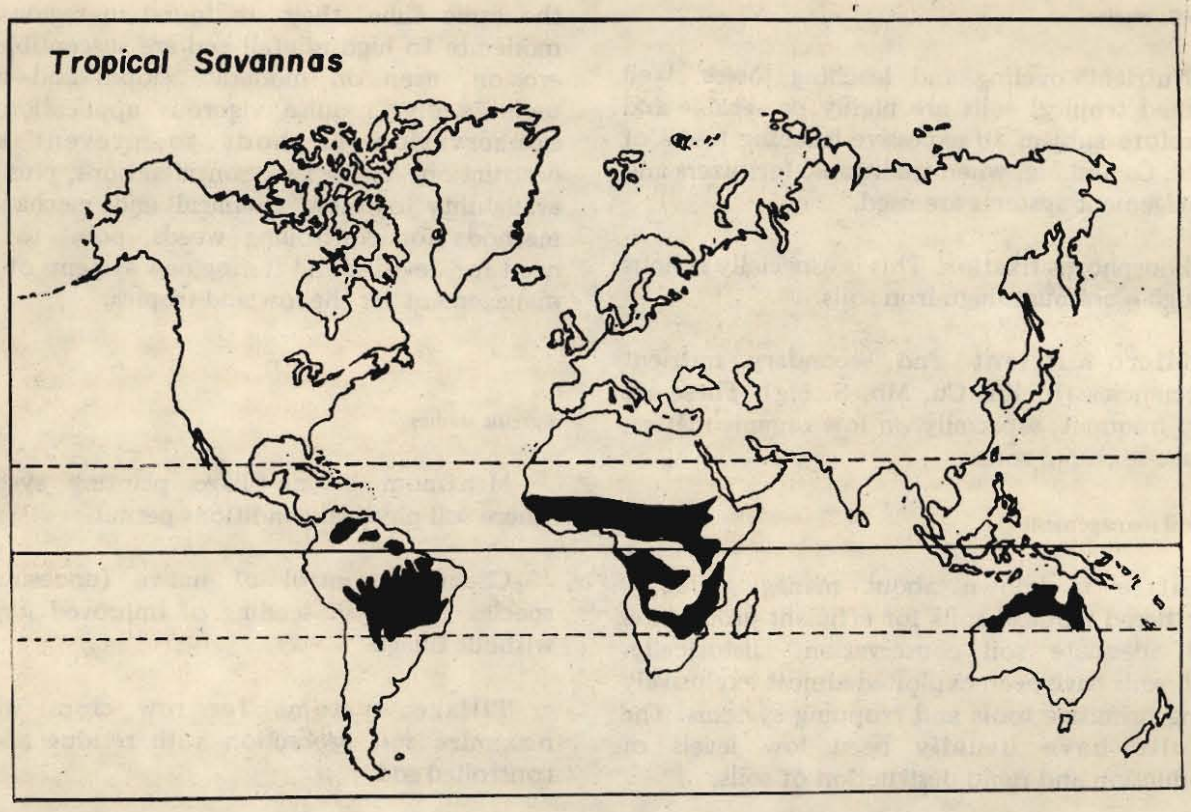
-Chemical control of native (undesirable) species for direct seeding of improved forages without tillage.

-Tillage systems for row crops which maximize soil protection with residue and/or controlled sod.

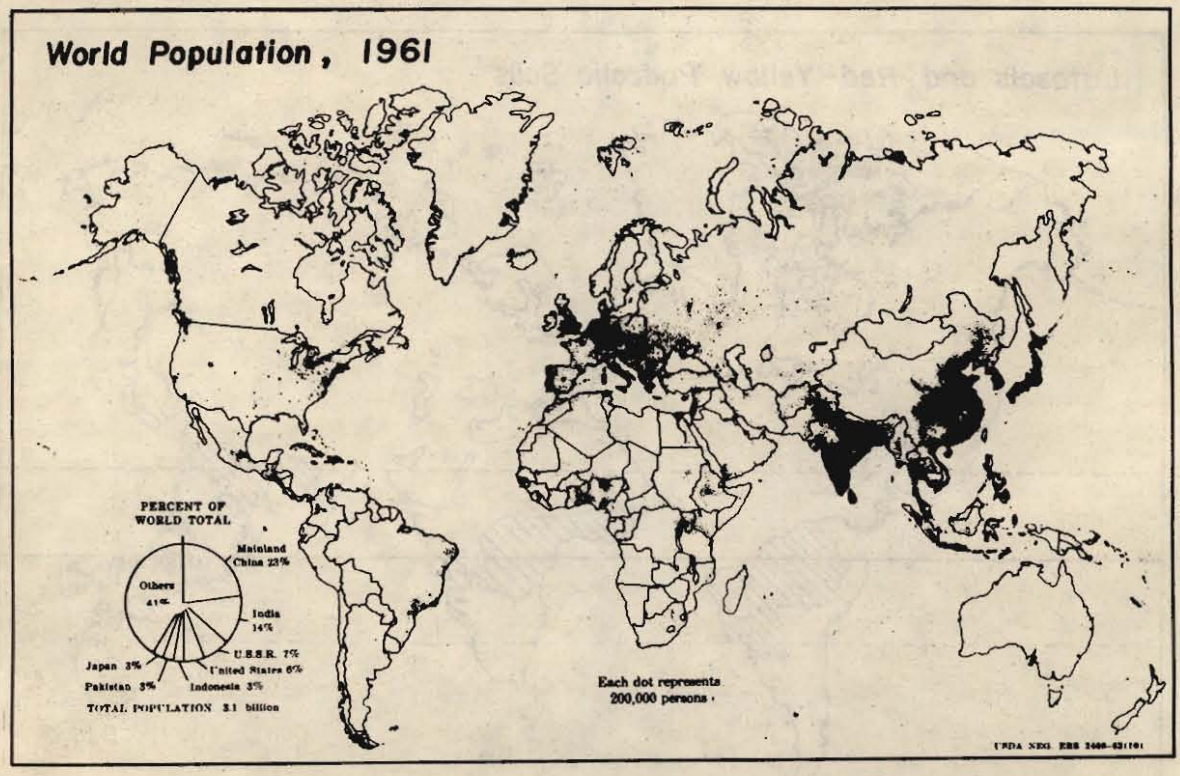
-Direct seeding methods for flooded rice, including seeding into water and into mud.



Approximate world distribution of latosols and red-yellow podzolic soils. These highly weathered soils are generally found in tropical or subtropical regions of high rainfall and smooth to rolling terrain.



Tropical savannas are usually found on highly weathered soils and relatively smooth terrain.



In tropical America, the lowland plains and plateaus are almost uninhabited with the exception of alluvial valleys and coastlines.

Reclamation of saline and sodic soils

Many tropical alluvial soils are naturally poorly drained and subject to salinization unless adequate artificial drainage is provided. Irrigation aggravates the problem if water quality is poor and/or adequate drainage is not provided.

The CIAT farm near Palmira, has large areas of saline soils and some sodic soils. The latter are especially difficult to reclaim because of their low permeability. Saline soils are also common at Turipana and in other irrigation projects on the North Coast of Colombia. These first hand problems, coupled with the general occurrence of similar problems in many lowland valleys, emphasize the need for investigation in this area.

Specific studies

-Leaching of saline and sodic soils using traditional amendments including $CaSO_4$ and elemental sulphur.

-Surface leaching of these soils where low permeability prohibits vertical leaching, using amendments to displace sodium. This procedure should be especially useful for rice soils where water leveling is indicated.

-Incorporation of residues or green manure crops to improve structure, permeability and internal drainage. Decomposing vegetation should also aid in displacing excessive salts.

Soil microbiology

Soil microbiology has been neglected in most of tropical America. CIAT's concern for forage and grain legume production requires strong support in the area of symbiotic nitrogen fixation. Little is know of the specific Rhizobia requirements of legume species and varieties adapted to the region.

Non-symbiotic nitrogen fixation is apparently more important in the tropics than in temperate regions, yet little is known in detail as to specific organisms and processes involved. There is clear need for increased research activity in this area, especially in relation to tropical forage grasses.

Specific areas of research will be identified and developed by a soil microbiologist, soon to join the CIAT staff.

Studies at CIAT's site and other research centers

CIAT's farm near Palmira and ICA's Turipana research center are the major sites for research on alluvial soils. Research will include soil management and soil microbiology studies, and reclamation of saline and sodic soils.

The Palmira site is now ready for initiation of field research, especially that related to reclamation of saline soils. Drainage has been improved during 1969 by the installation of a perimeter open ditch drain and some internal drains which should facilitate salt removal by leaching since annual rainfall is approximately 1,000 mm. One irrigation well is operative but adequate distribution ditches are still lacking. Irrigation water quality is good.

Soils at the CIAT site are being mapped in detail. Field work is being executed, with emphasis on soil salinity and profile depth. Major land leveling will be required in several fields, where soil depth is sufficient, to provide for adequate surface drainage and to permit irrigation.

A systematic sampling of the farm is underway. Laboratory analyses have revealed low Ca:Mg ratios in many fields with levels of exchangeable magnesium often higher than exchangeable calcium. The implications of this situation are not entirely clear but there are apparent damaging effects, either direct or indirect. Boron deficiency was observed (and confirmed by later greenhouse experiments) in a commercial field of grain sorghum on the site in 1969. Further research is in progress to check the possibility that Ca:Mg ratios may effect B availability or metabolism.

Laboratory experiments conducted in ICA's lab, at Palmira, indicate that sodic soils will be difficult to reclaim by vertical leaching because of extremely low permeability. On the other hand, surface leaching appears to be feasible, especially on rice soils which are water leveled. The removal of high sodium water from areas being surface leached without damaging adjacent fields or farms along the drainage canal may be a problem.

Table 1. Soil chemical characteristics for El Porvenir (CIAT headquarters at Palmira), Turipana and Carimagua research stations

Sample identification	P.H.	% Organic Matter	P.(PPM) Bray 11	Al	Ca	Mg	K	Na	C.E.C. *
					Milliequivalent/100 g of soil				
Porvenir (0-30)	6,7	4,4	47,5		11,6	10,6	0,69	0,67	24,4
Carimagua (0-20)	4,5	4,6	3,0	2,6	0,40	0,38	0,28	0,08	11,3
Turipana (0-10)	7,0	1,2	15,2		13,7	7,4	0,26	0,74	19,8

* Cation Exchange Capacity

The cooperation of the ICA soils program has provided valuable support to field studies and made possible the initiation of soil characterization studies.

Lack of irrigation water at Turipana has seriously limited agronomic research at that site. Land leveling research and demonstrations were initiated in 1967 to permit the study of various irrigation and surface drainage systems as well as management of irrigated soils. This work will continue when irrigation water becomes available.

Research on highly weathered soils in Colombia will be conducted primarily in the Eastern Plains (Llanos Orientales). The soils staff has participated actively over a period of four years in the execution of regional trials in the Llanos. Based on experience gained with these trials, a suitable site for an experiment station was selected. An 18,000-hectare ranch known as Carimagua was purchased by ICA in 1969 and developmental activities were initiated late in the year. Most of the land will be devoted to livestock research and demonstration. A small area will be used for agronomic research with emphasis on forage crop establishment and management, flooded and upland rice production problems, cassava, sorghum and grain legumes. Soil management, microbiology and fertility studies are basic to the successful management of all these crops.

A soils program trainee has been assigned to Carimagua where an agronomy research field of approximately 20 hectares is being readied. A small irrigation system has been installed to permit dry season (January-April) research and to provide for flooded rice production research. A chemist was hired late in 1969 to work temporarily in the ICA Soils Laboratory at Palmira until CIAT laboratory facilities are available.

Work is underway with soils from several sites in the Llanos and from the CIAT Center. Two sodic soils from the latter site are included in a column leaching experiment being conducted in the ICA laboratory.

Agronomic systems

Status and strategy

The Agronomic Systems program seeks to identify solutions to problems encountered in the production of crops on a commercial scale. Where sufficient background information is available, recommended practices for crop production are employed in the evaluation of net returns using some of the alternative practices which normally are available. Where experimental evidence is limited, the program initiates and conducts investigations as needed to provide a base for the selection of alternative cropping practices which can fit into the management systems on farms. These practices should provide for high economic returns to the producer and must contribute to the production of foods and feed materials which are needed and can be used in the lowland tropics.

The overall objectives of this program are to evaluate:

1. Production costs and returns from current cropping practices and systems.

2. Net returns where more intensive management and cultural practices are followed. This includes irrigation, high fertilization, more than two harvests per year and multiple cropping systems.

3. Production systems for miscellaneous crops which appear to have high food production potential but are presently grown on a limited non-commercial scale.

4. Production problems and solutions to these problems, when:

A. More intensive cultural practices, such as continous cropping, short rotations or "off-season" cropping practices, are implanted.

B. Results from small scale experiments begin to be applied to commercial operations.

C. Land forming or other land modification practices are followed in preparation for irrigation or drainage.

D. Presently grown varieties were developed for "hand" type of cultural practices rather than mechanization.

E. It is necessary to produce sizable quantities of various crops which may be used for further studies in storage, processing and utilization.

Considerable work has been done to breed and evaluate the production potential of numerous crops. This work must be reviewed and continued because of changes in technology and the shifting needs of the world. Further work should be done to integrate and evaluate crops and varieties into rotations, monocultures and combinations in cropping programs for areas with differing climatological conditions. Close cooperation and coordination with national programs are essential to avoid duplication of work.

The following listing of general work areas is not all inclusive and other areas of work will develop as the program progresses.

1. Choice of crops or crop adaptation and crop sequence.

   A. Annual crops: a single crop harvested from each planting.
      a. Food or feed crops.
      b. Crops for industrial and manufactured use.

   B. Biennial or perennial crops which can be harvested several times from a single planting.

   C. Perennial crops which would be utilized primarily for forage purposes either as pasture, green chop or silage.

   D. Perennial fruit and nut crops utilized for food, feed and industrial purposes.

2. Cultural practices or systems.
   A. Land preparation
   B. Crop establishment
   C. Seedling management
   D. Ratoon crop managment, particularly, sorghum. Varieties, fertilization, tillage practices, irrigation, harvesting systems, residue disposal.

3. Harvesting, storage and utilization.
   A. Grain, oil and starch crops.
   B. Harvesting of perennial forage crops and problems related to continued production of these crops such as irrigation, fertilization, soil compaction and others.
   C. Harvesting of seed and other propagation material.

4. Miscellaneous considerations for crop production.
   A. Climatological data.
   B. Physiological and ecological data.
   C. Specialized crop production and utilization programs such as opaque-2 corn production, processing and utilization.

Research and related activities

Crop production at CIAT farm

The majority of the work on Agronomic Systems in 1969 was carried out the CIAT farm. Some land was officially turned over to CIAT on March 1 and seeding of the first crop began March 4. The primary objectives of the work were to evaluate soil conditions and the production potential and problems of corn, soybeans and sorghum on the 70 hectares planted. Records were kept on all fields to permit an analysis of costs. Most of the machine work was done with rented equipment. As the growing season progressed, numerous problems were investigated on a rather broad scale. About 100 hectares were planted to sorghum, soybeans and corn the second semester. Crops were rotated on the land cropped the first semester to evaluate differential crop or variety response.

Results and observations

In both semesters, soil salinity was found to be a problem in many of the fields. Numerous relatively small areas were found which had a sodium content as high as 50 percent. In these areas, soil structure was poor and presented difficulty in seed bed preparation and poor seed germination in all crops.

Corn

Corn was most seriously affected by soil or climatic conditions on the farm. The hybrids H207, H208 (opaque) and H253 were grown but production was unsatisfactory. In some areas, plant development appeared normal but there was no kernel development. Further work will be done to ascertain the cause of this problem as moisture conditions at pollination time in both semesters appeared to be adequate and no simple explanation could be found.

Sorghum

Two sorghum varieties were grown for grain: ICA Pal 1, a dwarf variety, and P-25, a moderately tall variety. ICA Pal 1 displayed a stunted type of growth accompanied by white streaks in the leaves. Foliar application of micro-nutrients failed to give any improvement; however, these applications may have been made too late. P-25 showed some of the same symptoms but to a lesser degree. Sorghum yields were considerably better than corn yields.

Soybeans

Soybean production from the varieties Hill and Pelican was approximately two ton per hectare which is slightly above the average for the area. No serious problems were encountered in soybean production. Essentially, all the soybeans grown in the Cauca Valley are hand pulled and placed in windrows. A combine with a pickup attachment is then used to thresh the soybeans. This system provides labor for many persons but presents numerous problems. Some of the disadvantages are dirt adhering to the roots, the seed harvested is often dirty, reduced acreage harvested per day because of insufficient hands to pull the soybeans, difficulties in labor or personnel management, shelling losses from handling the mature plants and additonal production costs. Direct comparisons between soybean harvesting systems were not possible because combines equipped for picking up windrows and cutting directly were not available.

A cost analysis and soybean loss evaluation was made between the variety Hill (hand pulled) and Pelican (combined). Results indicate that direct combining is possible with costs approximately equal to hand pulled systems. Seed losses are slightly higher when soybeans are combined directly but these higher losses are offset by no charges for pulling, less dirt and dockage in the seed and reduced combining and hauling charges which are based on a fixed charge per bag.

Some preliminary work with soybean irrigation indicated that further problems in pulling soybeans might be expected since root systems in irrigated plants remain viable longer and were difficult to pull.

Minimum tillage operations

Minimum or reduced tillage operations were done to keep production costs as low as possible. Initial soil preparation in the first semester consisted in disking with a heavy Rome disk followed by one or more light diskings instead of the usual plowing and numerous diskings. Satisfactory seedbeds were formed in all cases except in the saline areas.

In the second semester the land was plowed but, because of the dry condition, disks did not break up the large chunks. A land leveler was used to level the land and to reduce the size of the chunks. After the first rain, the lumps slaked down and a field cultivator with a springtime harrow attachment was used for final land preparation.

The reduced tillage operations left the soil in a loose condition which permitted rapid infiltration of subsequent rains. Further work with reduced tillage is warranted to lower production costs, to reduce land preparation time and to provide optimum root environment for plant growth.

Pesticide application methods

As ground equipment was not available to apply pesticides, all applications were made by airplane or helicopter, or manually. Aerial application of herbicides to all three crops and insecticides to soybeans gave very satisfactory results. Insecticides applied by air did not give satisfactory control of insects attacking the whorl of the corn plant. Excellent control was obtained when granular material was applied by hand.

Large variations were found in the quantity of material applied by different workers. Minimum recommended application rates were as effective as the higher rates often applied.

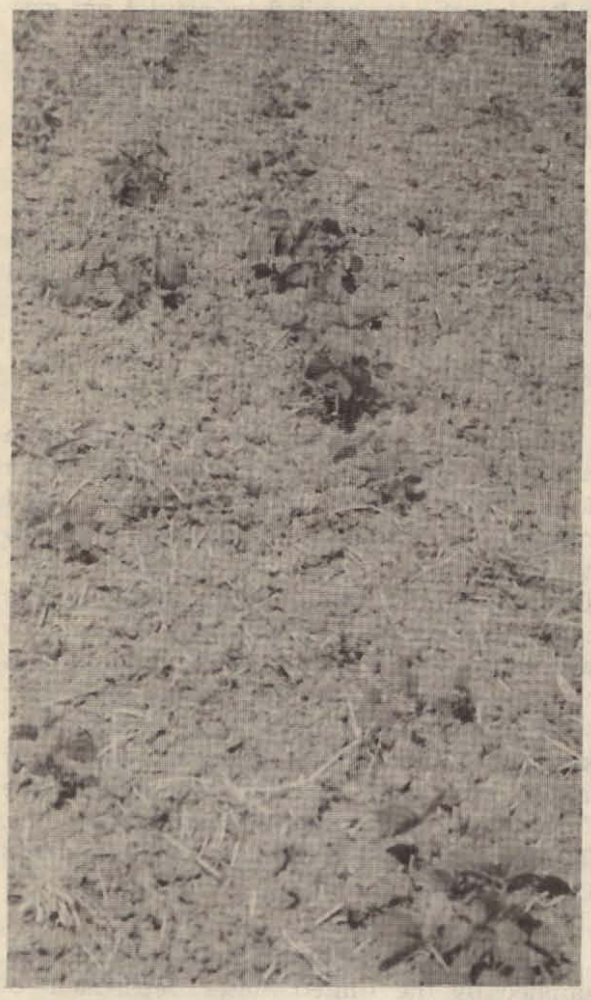
Bird control

Numerous species of birds present some damage to crops throughout the area. One of the most serious problems is caused by the eared dove *(Zenaida auriculata)*. This large dove eats the cotyledons of emerging soybeans, either killing or greatly retarding the seedling. The most effective control, at the present time, is to have people in the field chasing the birds. This may require one or more persons per hectare for a period of 4 to 7 days. Flag "scarecrows", skyrockets, firecrackers, shotguns and other devices were tried in efforts to increase the effectiveness of the people chasing the doves. The amount of benefit from any of these devices is questionable.

A preliminary trial with a chemical, DRC-736, supplied by the United States Department of Interior (Bureau of Sport Fisheries and Wildlife, Division of Behavioral Research), gave good results in small plots. Further testing in larger plots and evaluation of costs, residues and other factors affecting its potential use, will be made.

Crop production at Turipana

Cooperative work with ICA has been carried out on the North Coast of Colombia at Turipana. Approximately, 40 hectares of land were leveled to correct drainage problems and to permit surface irrigation. Cuts and fills ranging up to almost a meter in depth are found in the area. The work initiated was designed to evaluate practices which are needed to restore or increase productivity on these areas where land forming has been done. Actual work accomplished during 1969 was limited because the above normal rainfall prevented seeding the crops on time. Delays in the completion of the irrigation system prevented any work with irrigation during the dry periods.



An unsatisfactory stand of soybeans. Nearly 100 o/o of the cotyledons were eaten by the eared dove when untreated seed was sown. Most of the plants shown in this photo survived because the first true leaves were large enough to continue their growth after the cotyledons were removed. (Photo taken 40 days after planting).

A satisfactory stand of soybeans was obtained when seed treated with a 10 o/o Mensural solution was sown. Approximately, 25 o/o of the cotyledons were removed by the doves when the seedlings emerged. (Photo taken 40 days after planting).

Crop protection

Environmental conditions in the humid, hot lowlands of the tropical world favor accelerated reproduction and growth of insects, diseases and weeds. Their individual or combined effects have traditionally constituted a strong limitation to an efficient and diversified agriculture.

Any economic crop production system for the tropics must, therefore, include scientific knowledge of these detrimental factors (including superior animals like rodents, etc.) as well as the information required to efficiently counteract their devastating effects.

CIAT's efforts in the areas of plant pathology, entomology and weed control wil be focused on understanding the complex interactions among predators, pests, diseases and weeds and their effect on the economy of crop production. This multi-disciplinary approach will include assessing the economic importance of pests and diseases, and developing efficient control measures accordingly. In close collaboration with crop production specialists, research will be carried out to identify genetic resistance and to incorporate it into improved varieties.

Agricultural engineering
(and station operations)

Since the beginning of CIAT, the agricultural engineer has been in charge of Station Operations, guiding the development of the experimental farm while at the same time developing plans for future agricultural engineering research and training activities.

The Agricultural Engineering program will be oriented toward the solving of problems which limit economic production, harvesting, transport, processing, packaging, storage and marketing of food in the lowland tropics. Most of these problems occur in the following areas: drainage, roads, fences, land clearing, water supply, irrigation, land preparation, cultivation, pest control, harvesting of crops, processing, electric power, machinery usage, machinery maintenance, machinery development and structures.

The orientation will be towards engineering design, planning, decision making and supervision to solve problems rapidly and economically. Mechanical, electrical, chemical and civil engineers, as well as manufacturers and other persons will be drawn into the solution process to strengthen and complement the activities of "ingenieros agronomos" and agricultural engineers.

The balance of this section reports on Station Operations activities in 1968 and 1969.

In developing the experimental farm the first step was to obtain a map of the area. A request for serial photographs and a base map drawn upon these photographs was made in June 1968. Photographs were taken to the Instituto Geografico "Agustin Codazzi" and a map, scale 1:2000, with 2-meter contours, was prepared from the photographs by October 1968. The land for the experiment station was not available for mapping during this period, but maps with 2-meter contours were obtained in November 1968. Limited available data on soils and topography did not permit detailed planning.

In January 1969, some office space was made available by the owners of the land and permission given to enter the farm to take levels at the building site areas. A topographer, contracted to obtain detailed levels on an area of 82 hectares in the center of the farm, completed this work in February. This area was disked and fenced and arrangements made for right-of-way to the highway for the main entrance. At this point, mapping and planning was postponed until other portions of the land were turned over by the owner in April, July and October, respectively.

Mapping continued from March to October, with the final map being completed in October.

Roads, drains and wells

Three dump trucks and a loader arrived in August and ballasting of the roads started. Additional dump trucks were contracted to finish the main roads before rains made traffic impassable. Approximately, 13,000 cubic meters of gravel were applied to about 16 kilometers of roads.

The first drainage work started in May but the peripheral drain was begun in July and completed in December. Approximately, 52,000 cubic meters and 13,800 lineal meters of peripheral drain were made to serve as main and interceptor drains. These drains also serve as a natural barrier, reinforcing the perimeter fence. The drains removed considerable water even during the dry season. Soil excavated from drains served as a perimeter road base.

One irrigation well and pump with 2000 GPM capacity was on the property when purchased. Drilling operations for five more wells started in December.

Irrigation system, bridges and fences

The design and installation of an irrigation system depends upon the use of the land, soil type and quality, and funds available. Land use and soil data are being assembled and plans being made to level areas to be irrigated. In the meantime, surface ditches for irrigation are plowed as needed.

Approximately, 30 kilometers of old three - and four-wire fences were salvaged; the wire and posts were removed and saved for reuse. A total of 7,000 new concrete posts were set, and 16,000 linear meters of four-wire fence were rebuilt with the salvaged wire.

Service facilities and electrical power

General floor plans were drawn for a group of service buildings to house agricultural engineering, motor pool, farm equipment, farm shop, farm operations, and supply rooms. An additional group of buildings of similar construction was drawn to house field operational sections of the plant and animal sciences.

While permanent building plans are being developed and implemented, an old dairy stable and field laborers quarters are being used for shops, offices and supply rooms. These became available in July and have served as temporary housing with a minimum of remodeling.

Training and communication

The establishment of the Centro Internacional de Agricultura Tropical provided opportunities to incorporate from the beginning philosophies, programs and facilities so that training and communication might be effectively integrated into the research and developmental activities of the organization.

By doing so, CIAT expects to reduce significantly the time lags which usually exist between the discovery of a new variety or agricultural technique and its widespread adoption by farmers. At the same time, CIAT's program provides opportunities for decision makers in the various countries to interact effectively with agricultural scientists on policies relating to development and economic growth.

During the first 18 months of CIAT development, one of the principal concerns of the senior staff was how to integrate -- physically, conceptually and administratively -- the behavioral science approaches necessary for effective training and communication with the projected production-oriented, multi-disciplinary team approaches to the solution of agricultural and economic problems in the lowland tropics.

These considerations have significantly influenced the basic design of buildings and offices to facilitate the inter-disciplinary interaction and communication desired as well as to provide the specialized facilities necessary to handle visitors, hold symposia, process information, house and feed trainees and conferees and expedite intra-organization communication.

These developmental steps provide a firm foundation upon which to build, as part of the overall CIAT operation, the International Continuing Education and Conference Center visualized in the initial proposals.

Behavioral science approaches to information dissemination and training are the basis of all training and communication activities in CIAT in contrast to the more traditional concepts associated with publications, public relations, information, extension and adult education.

These approaches to understanding, predicting and influencing human behavior have practical applications in information dissemination, organizational administration, academic instruction, in-service training, continuing education and agricultural extension. Successful development depends not only upon the technological breakthroughs which research makes possible, but also upon the ability to solve key behavioral problems and to influence people's attitudes and what they know, understand and are able to do. Few technical problems are independent of people or social issues.

Program development

Goals and objectives for the training and communication program have been clarified and expressed in the context of the overall mission and operational philosophies of CIAT.

The specific objectives of the training and communication program are:

1. To develop strategies and techniques for the rapid spread and adoption of improved agricultural materials and practices.

2. To provide specialized instruction and experience in specific research fields for young scientists, and to provide opportunities for such persons to engage in supervised research on problems of significance to their countries.

3. To develop and demonstrate more productive approaches including various intern programs, for pre- and in-service preparation of professionals and non-professionals as agricultural production specialists.

4. To assist other institutions to establish, conduct and evaluate educational and training programs appropriate to the needs and institutional capabilities.

5. To help national leaders and policy-makers understand and assess the agricultural potentials of their countries and how these can be realized.

6. To provide information and instructional materials for reference and use in training programs of other institutions.

7. To provide orientation and communication services for the staff of CIAT.

These objectives were forged in discussions with the CIAT staff, in meetings of the Board of Trustees, and in conferences with representatives of other organizations. Long range plans were projected in the report of a Program Study Team which visited nine institutions in Mexico, Central America and Colombia, in January 1969. This team of veterans in adult and continuing education identified training needs and suggested how CIAT might meet these working in cooperation with other institutions.

Early in 1969, the director of CIAT and an architect visited Michigan State University to inspect the Kellogg Center for Continuing Education and to confer with university officials associated with the management of the facilities, conference, and educational activities. Later, the head of Training and Communication visited continuing and adult education centers in California, Oklahoma, Nebraska, Iowa, Michigan and New Hampshire to gather background information on physical design, programming, equipment and furnishings and operational problems.

He selected a consultant on kitchen design and food service from Michigan State University who later spent two weeks in Colombia surveying local food purchasing and processing routines, conferring with equipment manufacturers and distributors and developing preliminary designs.

Meanwhile, buildings on the old hacienda on the CIAT construction site were renovated to serve as a temporary training base. The bunkhouse was converted into a dormitory for 20 trainees; part of the milking stable was remodeled to provide a large classroom plus three offices for the training staff and the remodeled kitchen began regular food service the first week of 1970. In March 1970, offset reproduction and other equipment, already on hand, will be installed in the school building which will serve as headquarters for the Training and Communication program until the new construction program is completed.

Training

Initial training activities were limited by the lack of physical facilities, but within the first six months following July 1, 1968, a few trainees were enrolled in programs ranging in length from a few months to master degree programs of 18 to 24 months.

Post graduate interns

With the acquisition of most of the headquarters site, CIAT established a new training category, the post graduate intern, to provide direct, on-the-job agricultural production experience for new agricultural college graduates. These one-year appointments, in addition to benefiting the trainee directly, demonstrate to educational institutions a simple way to fulfill an urgent need for farm experienced graduates. At the same time, such appointments give CIAT an opportunity to evaluate and train a number of future junior staff members for itself and other institutions. By year's end, 12 interns had been named.

Between July 1, 1968, and March 31, 1969, 11 trainees completed short training periods with CIAT and ICA working at ICA experiment stations. These included eight Ecuadoreans (three in rice, three in plant pathology, one in

seed certification and one in swine production); one Costa Rican, in rice production and two Colombians, one each in soils and crop production. In Table 2 these 11 trainees were retroactively classified as post-graduate interns.

Production specialists

Many of the livestock and crop production problems can be resolved economically by adapting and applying existing or new technology and management techniques. This process requires a capable generalist working in the field directly with producers. The generalist, as envisioned here and as contrasted to the usual extension worker, is an individual capable of applying production packages and conducting practical research and field trials in local environments. The generalist is a link between the specialist and the producer but today there are few such generalists.

Such a generalist-specialist, it is projected, must have or acquire through training and experience a set of complementary competencies:

1. *Technical* competency, or the level of the knowledge and understanding, relevant to the crops or livestock the farmer produces, the production practices involved, and the physical environment in which the production takes place. This includes, but is not limited to, the ability to diagnose typical problems and abnormalities correctly, plus knowledge and understanding of the application of proper treatments.

2. *Economics* competency, or the ability to weigh (e.g., calculate cost-benefit ratios, interest, etc.) alternative farm production management and product commercialization strategies. This includes, but is not limited to, determination of that strategy which:

a) *Minimizes* costs in the production of crop and/or livestock yields that are significantly greater than those obtained by the farmer using his present practice and its associated input costs; and

b) *Maximizes* production commercialization profits sufficiently that net return (balance to the farmer after payment of input costs) are significantly larger than those obtained by the farmer using his present practice and its associated input costs.

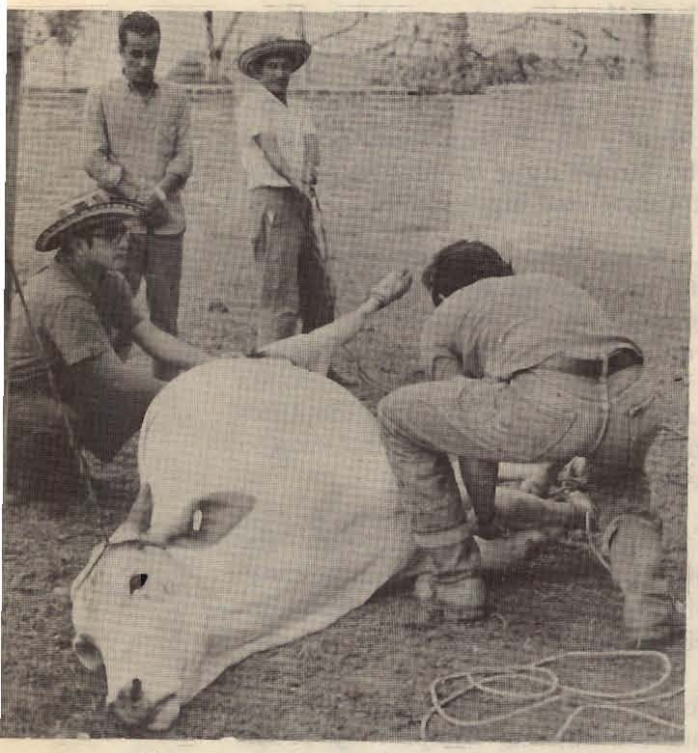
3. *Scientific* competency, or the ability to conduct a simple, replicable experiment which objectively tests (in a microenvironment) that employment of the innovation has as its reward points 2a. and b (listed above), and identifies factors which may require adaptation to the environment.

4. *Farming* competency, or the willingness and skill to perform the range of physical tasks involved in producing a specific crop or animal. This includes, but is not limited to, the ability to perform the range of physical tasks within the existing competency of the farmer. Also, as mechanization advances, he must have the relevant knowledge, understanding and skill in the operation and maintenance of various kinds of motor-driven machines and processes.

5. *Communication* competency, or the ability to identify specific behavioral objectives for various audiences, for example, farmers or trainees. This includes, but is not limited to, understanding of the value of feedback and ability to obtain it, and the ability to plan, prepare and present *appropriate messages* considering the cultural, social, economic and performance status of the audience.

If he is to be successful in his work with farmers or future trainees, the generalist must be confident in his own abilities, be dedicated to an objective in the pursuit of development objectives and possess a sense of urgency. It is expected that he will develop or acquire these attitudes and orientations as a by-product of the training and through interaction with senior staff members involved in his training.

Reports on the production training activities in beef, rice and corn are presented in those sections, respectively.



The CIAT trainees get firsthand experience in animal and plant production systems.

Research scholars

M.S. candidates

Arrangements were completed with the National University of Colombia and the University of Valle, Cali, for cooperative academic and research programs through which some CIAT trainees each year might work toward advanced degrees. One research scholar, from Ecuador, was enrolled in 1969, and three more, one each from Colombia, Ecuador and Brazil, were accepted for the academic term beginning January 1970.

Three Colombian agronomists, selected for their potential as future staff members in training and communication, were enrolled in the new master's program in agricultural communication at the National School of Agriculture, Chapingo, Mexico. In this program they have full opportunity to work and learn in the Puebla Project, a program designed to increase rapidly corn yields on small holdings.

Doctoral candidates

CIAT continues to explore arrangements with graduate level funding organizations in various countries whereby doctoral candidates at universities in the developed countries might do their dissertation research on agricultural problems of the lowland tropics under the direction of CIAT scientists. One doctoral candidate from Purdue University, funded by the Foreign Area Fellowship Program, arrived in late summer to undertake research in field beans on a joint project between the ICA experimental station at Palmira and CIAT.

Continuing education activities

Effective agricultural development programs depend, first of all, upon dynamic, well-informed leadership above the technical level. Those who make and influence national policies, control and allocate credit and resources, manage manufacturing and distribution systems, and provide such facilities as transportation, marketing, processing and storage need unbiased sources of reliable data and estimates of production potentials and requirements.

Moreover, agricultural scientists have a responsibility to communicate effectively with this leadership -- to make known what agricultural developments are feasible and what policies and facilitation are required to increase productivity in specific areas and countries. The developing CIAT program will include facilities and activities whereby national leaders may interact with the scientists of CIAT as well as those of the national agencies.

Encouraged by the success of several continuing education centers established in the United States by universities, as well as by those of major industries for executive training and community service, the CIAT operation envisions a similar facility, appropriately designed and staffed. The facility will serve the leadership of many countries handling not only the functions described above, but also housing the training and communication staff, providing rooms for the trainees in residence at the Center, and daily preparing and serving food for conference and scientific symposia attendees, trainees, staff and visitors.

Although CIAT's own facilities are not yet available, plans and activities for a series of conferences and symposia are already in process. One international conference, on the utilization of opaque-2 corn, was held in 1969 (see Corn). Such activities are developed and carried out jointly by the training and communication staff and the leaders of the commodity programs directly involved.

In late November, the head of Training and Communication met in Bangkok with agricultural extension, training and development officers working in Southeast Asia. This preliminary meeting considered the timeliness and appropriateness of scheduling a large international conference, or a series of regional symposia, beginning in late 1970, on the system-wide factors necessary for carrying out effective agricultural development programs. A report was prepared for wide circulation among agencies concerned with sponsoring or funding agricultural development. Further developments are expected.

Information services

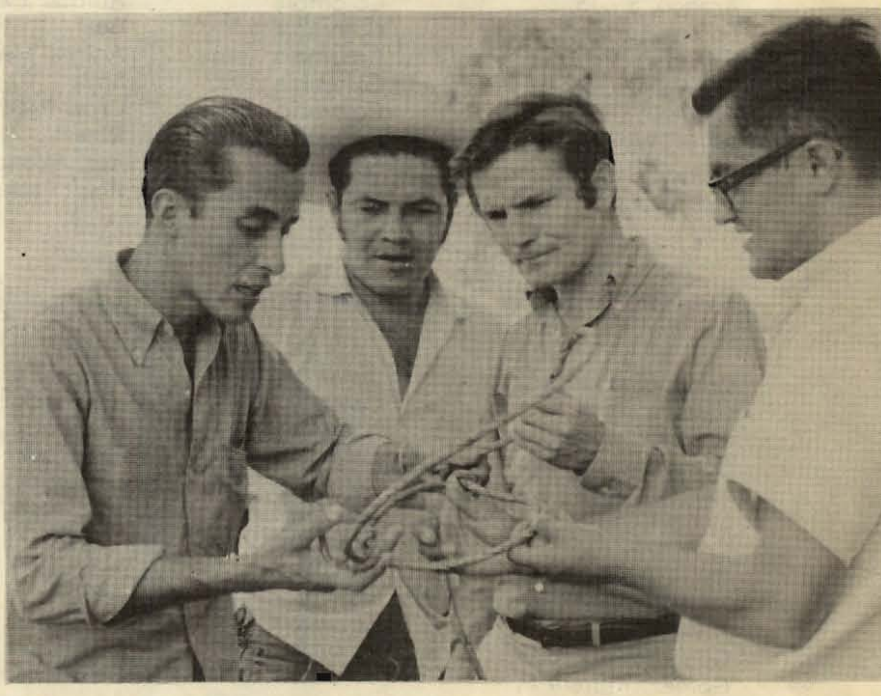
One publication, CIAT Special Report No. 1, entitled "Alternate Beef Production Systems for the Eastern Plains of Colombia," was produced in a preliminary English edition. After further refinement and translation, a Spanish language version will be printed.

Other information activities during the year included a number of special memoranda for the Board of Trustees; Administrative Memorandum No. 4, "Policies and Procedures for Administering Trainees," written in consultation with the senior staff and published on May 12, 1969; the manuscript for a bulletin on the CIAT training programs for circulation to prospective trainees and their employees; brief articles about CIAT for various publications, and materials for the livestock production specialist training project. A major feature, "A Matter of Life and Death," summarizing the work in Colombia on opaque-2 corn, appeared in *The Rockefeller Foundation Quarterly*, No. 1, 1969, and later an abridged version, in Spanish, in *Agricultura de las Americas*, November 1969.

Work was begun on a brochure about CIAT for general circulation throughout the world. By November, the manuscript was completed, the photographs and artwork selected, and the materials forwarded to the printer.

Cooperative and advisory services

The International Rice Research Institute invited the head of Training and Communication to participate for two weeks in the 1969 Rice Production Training Program in the Philippines in which 36 students from 14 countries were enrolled. Following this, he visited Vietnam Ceylon, India, West Pakistan and Thailand to



Group participation in all aspects of farm life stimulates awareness of practices as well as theoretical considerations.

follow up on previous trainees and to assess current and projected needs of these countries for training related to rice research and production.

Field projects and social research

Activities in this area were limited to preliminary discussions with various agencies, within and outside Colombia, about possible cooperative research projects and the design of questionnaires to be used in connection with socio-economic studies associated with the opaque-2 and livestock production specialist training projects. In both cases, the work was in cooperation with the agricultural economists of CIAT and participating agronomists and livestock specialists.

Preliminary discussions with social scientists from universities of the Midwest Consortium suggested the possibility of developing cooperative arrangements for future research projects involving staff members and graduate students of those universities.

Table 1. CIAT Trainees 1968-1969

Post Graduate Interns	Country	Field	Length of Training Period (Months)	Status December, 1969
Salvador, Julio César	Ecuador	Rice	6	Completed
Rodríguez, Marat	Ecuador	Plant Pathology	5	Completed
Navia, Daniel	Ecuador	Plant Pathology	6	Completed
Orellana, Hugo	Ecuador	Plant Pathology	8	Completed
Arévalo, Miguel	Ecuador	Rice	10	Completed
Andrade, Francisco	Ecuador	Rice	10	Completed
Abad, Fausto	Ecuador	Seed Certification	2	Completed
Hervas, Eduardo	Ecuador	Swine	5	Completed
Murillo, José I.	Costa Rica	Rice	6	Completed
Bravo, Eduardo	Colombia	Soils	12	Continuing
Angel, Alberto	Colombia	Yuca	12	Continuing
López, Gildardo	Colombia	Plant Pathology	12	Continuing
Montoya, Nelson	Colombia	Plant Pathology	12	Continuing
Lasso, Héctor	Colombia	Agr. Engineering	12	Continuing
Arango, Silvio	Colombia	Animal Health	5	Completed
Forero, Orlando	Colombia	Beef	12	Continuing
Guzmán, Víctor H.	Colombia	Animal Health	12	Continuing
Rodríguez, Mario	Colombia	Soils	12	Continuing
Agudelo, Fernando	Colombia	Crop Production	12	Continuing
Jetter, Wolfgang	Argentina	Rice	9	Begin 1/70
Rivas, Libardo	Colombia	Agr. Economics	12	Begin 1/70
Huerta, Hernando	Perú	Plant Pathology	3	Begin 1/70
Production Specialists				
Domínguez, Hugo	Colombia	Livestock	18	Continuing
Gallo, Luis O.	Colombia	Livestock	18	Continuing
García, Fernando	Colombia	Livestock	18	Continuing
Gómez, Francisco	Colombia	Livestock	18	Continuing
Herrera, José Benito	Colombia	Livestock	18	Continuing
Ortiz, Camilo	Colombia	Livestock	18	Continuing
Cruz, Javier	Colombia	Livestock	18	Begin 1/70
Barrera, Jaime	Colombia	Livestock	18	Begin 1/70
Flórez, Bernardo	Colombia	Livestock	18	Begin 1/70
Alvarez, Alonso	Colombia	Livestock	18	Begin 1/70
Góngora, Santos	Colombia	Livestock	18	Begin 1/70
Gómez, William F.	Colombia	Livestock	18	Begin 1/70

Table 1. (Cont.) CIAT Trainees 1968-1969

Production Specialists	Country	Field	Length of Training Period (Months)	Status December, 1969
Barreneche, Rafael	Colombia	Opaque-2 Corn	12	Continuing
Bonilla, César	Colombia	Opaque-2 Corn	12	Continuing
Escobar, Carlos	Colombia	Opaque-2 Corn	12	Continuing
Gómez, Iván	Colombia	Opaque-2 Corn	12	Continuing
Sánchez, Hernán	Colombia	Opaque-2 Corn	12	Continuing
Vera, Gustavo	Colombia	Opaque-2 Corn	12	Continuing
Reinoso, Ernesto A.	Dominican Rep.	Rice	6	Begin 1/70
Cabrera, José I.	Dominican Rep.	Rice	6	Begin 1/70
Escurra, Celso	Perú	Rice	6	Begin 1/70
Pérez, Iván	Colombia	Rice	6	Begin 1/70
Salvador, Julio César	Ecuador	Rice	2	Begin 1/70
Villegas, Gustavo	Colombia (CIAT)	Multiple Cropping	5 (IRRI)	Begin 2/70
Higuita, Fabio	Colombia (ICA)	Multiple Cropping	5 (IRRI)	Begin 2/70
Research Scholars (M.S. Candidates)				
Flor, Carlos A.	Colombia	Communication	18-24 Chapingo	Continuing
Cano, Jairo	Colombia	Communication	18-24 Chapingo	Continuing
López, Marceliano	Colombia	Communication	18-24 Chapingo	Continuing
Rodríguez, Marat	Ecuador	Plant Pathology	18-24 (ICA)	Continuing
Resende, Mauricio	Brazil	Animal Health	18-24 (ICA)	Begin 1/70
Clavijo, Héctor	Ecuador	Swine	18-24 (ICA)	Begin 1/70
Arango, Silvio	Colombia	Animal Health	18-24 (ICA)	Begin 1/70
Doctoral Candidates Supported by Others				
Porter, Wayne	USA-Purdue	Field Beans	24	Continuing

Table 2. Summary of CIAT Trainees, by Training Status, 1968-1969

	Terminated	Completed	Continuing	Beginning 1/70	Total
Post Graduate Interns	1	10*	9	3	23
Production Specialists					
Livestock	0	0	6	6	12
Opaque-2 Corn	0	0	6	0	6
Rice	0	0	0	5	5
Multiple Cropping	0	0	0	2	2
Research Scholars	0	0	4	3	7
Doctoral Candidates	0	0	1	0	1
Total	1	10	26	19	56

* Short-term trainees classified retroactively as Post Graduate Interns.

Library

One of the present objectives of CIAT is the establishment of a Library as rapidly as possible to support its research and training programs. It is anticipated that eventually the Library will become a major international center for the collection and dissemination of information on tropical agriculture and also will play an active regional role in the advancement of cooperation among agricultural libraries.

The Library will be developed in close consultation with CIAT's scientists, and always around CIAT's multi-disciplinary approach to agricultural problems. The suggestions, requests and needs of CIAT's researchers will constantly be solicited and examined to insure the collection will meet, as far as possible, all demands placed upon it.

The Library will make every attempt to collect and make available papers, reports, documents, etc., in relevant fields. It is realized that in many cases publications such as these are essential to research and that the Library must provide access to these materials.

Service will be the keynote of the Library. It is felt that there is little use in cataloging and classifying information without actively exploiting it and bringing it to the attention of those who need it. The Library will constantly seek new ways to do this, and to develop strong and viable lines of communication with CIAT's staff and others interested in tropical agriculture.

The Library will be able to perform literature searchers and prepare bibliographies on demand. Since it will be several years before the Library will have resources approximating those of the outstanding tropical agricultural libraries, there will be established lines of communication with these and other agricultural, scientific and medical libraries of the world to produce needed information as required.

The Library will be able to provide rapid and inexpensive duplication service from printed materials and from microforms. If needs dictate, a microfilming unit may be established.

The linguistic problems of a library, whose materials will be an estimated 85 percent in English, in providing services to an international center in a Spanish-speaking part of the world are obvious. To alleviate and ameliorate these problems as much as possible, the Library will provide services in Spanish and English, and whenever necessary will provide translations of articles in any language desired.

Most libraries in the world have limited financial resources, and to this the CIAT library is no exception. In order to exploit regional and international bibliographical resources, the Library will participate in inter-library cooperation, including inter-library loans, consultations and other services. The Library will be developed in terms of regional resources already existing and proposed. Library development will be seen in the context of service, cooperation, sharing of resources and mutual assistance.

The CIAT Library was established in temporary quarters at CIAT's center near Palmira in October 1969.

A nucleus of a collection already existed at that time. It consisted of some botanical and scientific journals, a few books dealing with various aspects of tropical agriculture, some bibliographical works, and a large number of papers, reprints and documents concerned with Colombia and Colombian agriculture. This material was arranged for use by the end of 1969.

A large number of publishers in the United States, England and Latin America were contacted for catalogs. Book orders were placed mainly for library reference books, trade bibliographies, reference books in science and agriculture, books on tropical agriculture, Colombia and Latin America. More than three hundred titles in Spanish were purchased to meet the immediate needs of CIAT's livestock trainees. Five hundred periodical subscriptions, selected in consultation with CIAT's scientists, were ordered. Catalogs were requested from

about 200 manufacturers and dealers of equipment and supplies suitable for CIAT's programs. Plans for the permanent library building were developed and refined.

An exchange program will be initiated shortly. The exchange addresses of the ICA Library in Bogota were acquired, and the East African Forestry and Research Organization in Muguga, Kenya, was contacted in an attempt to obtain African exchange addresses. It is expected that exchanges will become a most important part of the Library program.

Four significant gifts were received in the few months of the Library's existence: a collection of back issues of important botanical journals, which came through The Rockefeller Foundation; a large collection of reprints dealing primarily with physiology and back runs of several important veterinary journals; a collection of farm journals and light reading materials; and a collection of agricultural and scientific books and journals.

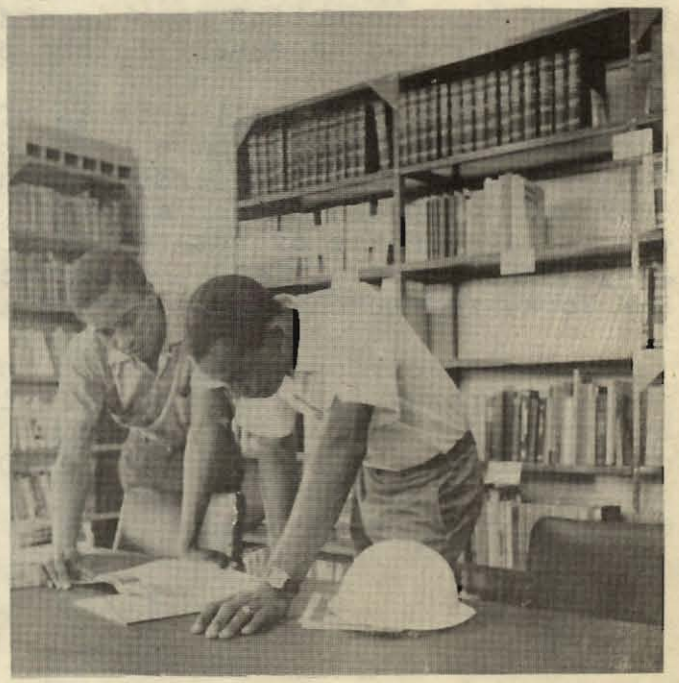
Communications and consultations were established with the Instituto Colombiano Agropecuario Library, with the Universidad del Valle Library in Cali (without whose generous lending of bibliographies and reference books the initial book orders could not have been compiled so quickly) and with the Library of the College of Agronomy of the Universidad Nacional at Palmira.

The ICA Library in Bogota provided invaluable assistance for the establishment of the CIAT Library, and an arrangement was made by which it became possible for the acquisitions librarian of the ICA Library to purchase books in Bogota for the CIAT Library.

Abroad, contact was established with the National Agricultural Library and the National Library of Medicine in the U.S., the Royal Tropical Institute in Amsterdam, the Library of the State Agricultural University in Wageningen, Netherlands, the Tropical Products Institute and the International Association of Agricultural Librarians and Documentalists in London, and the Asociacion Interamericana de Bibliorecarios y Documentalistas Agricolas, Turrialba, Costa Rica.

At the end of December 1969, all complete back volumes of journals were either bound or in the process of being bound.

The Library staff consisted of the Librarian, a secretary, and a part-time library attendant.



Library work is basic in any student training program. All trainees at CIAT have opportunity to broaden their professional competence by consulting basic references in their particular fields of study.

FINANCIAL REPORT

Annexed are the Balance Sheet, the Statement of Income and Expenses, and the Statement of Changes in the Fund Balance as audited by Price Waterhouse, and distributed at the meeting of the Board of Trustees held in Cali, Colombia on July 16-18, 1970.

REPORT OF THE AUDITOR

PRICE WATERHOUSE & CO.

APARTADO AEREO 180
CALI-COLOMBIA

May 8, 1970

To the Board of Trustees of

Centro Internacional de Agricultura
Tropical (CIAT)

We have examined the balance sheet of Centro Internacional de Agricultura Tropical (CIAT) as of December 31, 1969 and the related statements of income and expenses and of changes in fund balances for the year. Our examination was made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Certain commitments as of December 31, 1969 for future purchases and expenses have been included in the financial statements. As a result, expenses (mainly materials and supplies), property and equipment, other assets (books and periodicals) and accounts payable are overstated by $88,275, $56,962, $12,632 and $29,109 respectively and the advance to The Rockefeller Foundation, New York, for purchases is understated by $128,760.

In our opinion, except for the matter referred to in the preceding paragraph, the accompanying financial statements examined by us present fairly the financial position of Centro Internacional de Agricultura Tropical (CIAT) at December 31, 1969 and the results of its operations for the year, in conformity with generally accepted accounting principles.

Price Waterhouse & Co.

BALANCE SHEET

DECEMBER 31,1969

(EXPRESSED IN US DOLLARS - NOTE 1)

ASSETS (Note 2)

Cash and banks	443,009	
Time and demand deposits	1,190,132	1,533,141
Advance to The Rockefeller Foundation, New York, for purchases	13,285	
Advances to employees and others	12,465	
Miscellaneous accounts receivable	12,458	38,208
Property and equipment (Note 3):		
Land	3,206	
Furniture, fixtures and office equipment	92,251	
Laboratory equipment	38,942	
Farm equipment	175,814	
Vehicles	123,094	
Construction in progress	108,663	541,970
Leasehold land improvements		62,559
Other assets:		
Experimental livestock	23,578	
Books and periodicals	15,442	39,020
Total assets		2,314,898

LIABILITIES AND FUND BALANCES

Liabilities:		
Accounts payable	51,570	
Accrued employees' benefits	19,924	
Total liabilities		71,494
Fund balances (accompanying statement)		
Capital Asset Fund	1,886,685	
Operating Fund	356,719	
Total fund balances		2,243,404
Total liabilities and fund balances		2,314,898

STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1969

(EXPRESSED IN US DOLLARS)

Income:		
Operating grants received:		
The W.K. Kellogg Foundation, Battle Creek	133,032 (Note 4)	
The Rockefeller Foundation, New York	522,363	
The Ford Foundation, New York	500,000	
		1,203,151
Interest	35,178	
Sale of farm produce and miscellaneous income	12,578	47,756
		1,155,395
Expenses:		
Salaries, wages and employees' benefits	427,984	
Agricultural and other materials and supplies	193,944	
Freights and miscellaneous shipping expenses	50,656	
Travel	98,650	
Trainees' allowances and expenses	59,562	
Maintenance and repair of equipment	25,156	
Consultants and professional fees	30,263	
Conferences	8,631	
Insurance	8,073	
Telephone, telegraph and postage	7,798	
Rent	7,504	
Trustees' compensation and travel	6,655	
Security services	2,375	
Entertainment expenses	1,667	
Exchange loss	2,983	
Subscriptions and books	1,952	
Miscellaneous	13,554	
		947,407
Excess of income over expenses		255,744

See following page for "Notes to Financial Statements"

NOTES TO FINANCIAL STATEMENTS
DECEMBER 31, 1969
(EXPRESSED IN US DOLLARS)

NOTE 1:

All foreign exchange transactions are controlled by the Colombian government and, accordingly, all foreign exchange received in Colombia must be sold through official channels. The following exchange rates were used to translate Colombian pesos (P) to U.S. dollars ($):

	P/$1	
Peso balances included in cash and banks, deposits, advances, accounts receivable, other assets and liabilities	17.85	Approximate year-end exchange rate
Peso disbursements for property and equipment and expenses	17.46	Average monthly rate of exchange applicable to sales of dollars
Peso income	17.44	Average monthly rate of exchange applicable to sales of dollars

NOTE 2:

CIAT operates under an agreement signed on November 7, 1967 with the Colombian government. The most important stipulations of this agreement are as follows:

1. The agreement is for ten years but may be extended if so desired by the parties thereto.
2. CIAT is of a permanent nature and termination of the agreement would not imply cessation of CIAT's existence.
3. If CIAT ceases to exist, all of its assets will be transferred to a Colombian educational or other institution considered appropriate by the parties to the agreement.
4. CIAT is exempt from all taxes.
5. CIAT is permitted to import, free of customs duties and other taxes, all the equipment and materials required for its programs.
6. The government is to provide land for CIAT's purposes under a long term rental contract at a nominal rent.

NOTE 3:

In conformity with generally accepted accounting principles applicable to nonprofit organizations, CIAT does not record depreciation of its property and equipment.

NOTE 4:

Grants received from the Foundations are normally designated as to purpose (acquisition of capital assets or payment of expenses). However, in the case of a grant of $191,015 received from The W.K. Kellogg Foundation no such specification was made. Accordingly, the part of these funds used to purchase capital assets, $57,983, has been included in the capital asset fund and the remainder, $133,032, is shown as income.

STATEMENT OF CHANGES IN FUND BALANCES
FOR THE YEAR ENDED DECEMBER 31, 1969
AND OPENING BALANCE FOR 1970
(EXPRESSED IN US DOLLARS)

		Operating Fund	Capital Asset Fund
Fund balances, December 31, 1968			
Capital grants received:		100,975	
The W.K. Kellogg Foundation, Battle Creek:			
Cash			1,157,715
Cash (part of general grant used for equipment purchases)			57,983
The Rockefeller Foundation New York:			
Cash			509,445
Equipment (assigned by the Foundation in 1968)			151,012
Adjustment of capital grant received in 1968 and charged to expenses in that year			10,530
		255,744	
		356,719	1,886,685
Minus: Reimbursed Unexpended Balance during 1970	347,631		
Adjustment of Capital Asset Fund from Interest received on Capital Funds	9,088	356,719	+ 9,088
Fund Balances, November 15, 1970			1,895,773