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Centro Internacional de Agricultura Tropical, CIAT
Apartado Aéreo 67-13. Cali, Colombia, S. A.
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(December 31, 1970)

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(as of December 31, 1970)

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	Pathologist
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Reinhardt Howeler, Ph.D.	Visiting Scientist, Soils
Julio Toro, M.S.	Study Leave

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Gary Adams, D.V.M., Ph.D.	Pathologist
Radmiro Todorovic, D.V.M., Ph.D.	Hemoparasitologist

Foreword

The year 1970 was one of basic organizational activity and implementation of research and training projects. Seven senior staff members joined CIAT during the year, increasing the total number of continuing and term appointments to twenty-six. In April, CIAT headquarters was moved from Cali to "El Porvenir" farm, where staff offices and housing facilities for some trainees have been temporarily located in the renovated farm buildings, pending completion of the permanent installations. Work began in June on the construction of the first permanent building, Station Operations.

Two organizations joined the Rockefeller, Ford and W. K. Kellogg Foundations in the operational funding of CIAT programs during 1970. The Agency for International Development (USAID) contributed \$ 275,000 to help finance research and training activities in plant proteins and cassava. The Interamerican Development Bank (IDB) now helps to support CIAT training with a \$ 300,000 contract which provides for 50 man-years of crop and livestock production specialist training.

In December, eleven graduates in animal sciences and veterinary medicine completed the first course of the livestock production specialist training project, which attempted to solidify and complement university training with direct on-the-job experience in the solution of specific livestock production problems. This group of young men, after completing an intensive three-month training period at CIAT headquarters, spent eight months on cattle ranches on the north coast of Colombia.

Through the cooperation of the Instituto Colombiano Agropecuario (ICA), foundations were laid for work on beef production systems. Grazing trials were started on the north coast, at the Carimagua Research Center in the eastern plains (los Llanos) and at CIAT headquarters.

Results of breeding efforts with rice led to the joint decision of CIAT and ICA to name IR930-31-1-1B as the variety CICA 4 for release in early 1971. This dwarf variety has yielded 70 per cent more than Bluebonnet 50, a variety popular with farmers and consumers, in trials in Colombia. Along with CICA 4, CIAT and ICA will release seed of IR22, developed and named by the International Rice Research Institute (IRRI) in late 1969. While this variety was being multiplied and adopted by farmers in Southeast Asia, CIAT and ICA found, in accelerated tests in typical lowland rice fields in Latin America, that IR22 yielded about 60 per cent more than Bluebonnet 50. The long, slender grains of CICA 4

and IR22 are clear when milled and cook dry and fluffy, demonstrating grain quality desired by Latin American consumers.

Despite the nutritional advantages of high-lysine maize, problems of producer and consumer acceptance have been encountered. As most of these problems relate to the floury, soft endosperm of the opaque-2 maize, efforts to develop a flint-type maize which retains the high-lysine characteristic were accelerated, and preliminary results are encouraging.

The cassava germ plasm collection, begun in 1969, was expanded to include a total of 2,193 cultivars, these coming from Colombia, Ecuador, Puerto Rico, Panama and Peru. This collection, now being classified, will be the basic material for the cassava production systems program, which is directed toward an increase in the production and utilization of improved quality cassava in the lowland tropics.

The swine production program developed a life-cycle feeding system which replaces traditional commercial protein supplements with high-lysine opaque-2 maize. Depending on prevalent local market prices of these commercial protein supplements, the possibility of substantial savings, especially for small farmers, appears feasible.

Individual, program, and commodity work at CIAT is directed toward the development of integrated production systems. Specific inputs presently being developed will eventually form a part of total farm production systems appropriate to the varying conditions of the lowland tropics. Through such an orientation, CIAT hopes to help incorporate areas of low production within the lowland tropics into the mainstream of the national economies of Latin America.

Beef Production Systems

Several factors have influenced the development of a large beef industry in the tropics. There are extensive pasture lands and generally abundant feed resources. Internal and external demands for beef are strong. Beef cattle have fit well in the evolutionary development of new lands and the exploitation of marginal lands not suited for crop production.

CIAT's Beef Production Systems program is directed toward development of an adequate technological base and the training of action-minded production personnel to support an efficient beef cattle industry in the tropics.

PASTURES AND FORAGES

Work in pastures and forages concentrates on two ecological environments representative of the humid, semi-humid lowland tropics of Latin America: alluvial soil grassland regions and latosolic grassland areas.

Alluvial Soils

Coastal plains and river valleys

Pasture vegetation in more alluvial soil areas includes introduced grass species (generally from Africa) such as Guinea grass (*Panicum maximum*), Puntero grass (*Hyparrhenia rufa*), Para grass (*Brachiaria mutica*) and Molasses grass (*Melinis minutiflora*). Beef production in these pastures is commonly 70 to 80 kg/ha, while the potential productivity is more than 300 kg/ha. Productivity of these pastures decreases rapidly

with depletion of soil nitrogen. With the decrease in nitrogen fertility, overgrazing results as the grass species lose their vigor, and the effective grazing area is continually decreased through weed invasion.

Farmers control weeds principally by hand, although in some instances they use organic weed killers which also kill the native nitrogen-fixing leguminous species.

Activities in this area, therefore, focus on improvement of soil fertility through application of appropriate management in terms of stocking rate, grazing systems, and increasing soil nitrogen levels. Establishment of mixed grass-legume pastures and introduction of legumes into existing grass pastures receive attention as nitrogen fertilizer application on pastures used for cow-calf systems does not appear economical at present.

Coastal alluvial plains such as the northern coast of Colombia often contain two distinct zones: (1) fertile valleys (such as the Sinu Valley) with a high watertable, and a dominance of Para grass and (2) rolling hill regions with poor quality soils, and a dominance of Puntero grass, such as in the Department of Bolivar, where cow-calf operations predominate.

In cooperation with ICA, CIAT will establish a grazing trial at the Turipana Research Center in the Sinu Valley to determine the effects of management on the productivity of Para grass pas-

tures for beef fattening. Three grazing systems will be used — continuous, alternate (two-paddock rotation), and rotational (six-paddock rotation). Each of the systems is to be tested under three stocking rates.

Preliminary arrangements have been made to set up trials on the introduction and establishment of tropical legumes in Bolivar in 1971. Grazing trials using grass-legume mixtures will also be established in connection with CIAT's Livestock Production Specialist Training Program.

Fertile, high-value land near population centers

Near large population centers, livestock production is often a secondary occupation. But local demand for animal products is high, so poorer lands tend to be used for livestock production. The Cauca Valley in Colombia, the Guayas river basin in Ecuador, and some of the land surrounding Lake Maracaibo in Venezuela are examples of this type of enterprise.

Beef production becomes more intensive through competition with other types of farming. Inputs increase to improve total animal output per unit area, and nitrogen fertilization and irrigation take priority. This type of enterprise is directed toward growing-finishing rather than breeding operations.

A study of beef production costs under an intensive management of Pangola (*Digitaria decumbens*) pastures with nitrogen fertilization and irrigation is underway at CIAT's farm. Nitrogen levels used are 200, 400, 600 and 800 kg/ha/year. Three stocking rates are superimposed on the nitrogen treatments in a 4 x 3 factorial design. All treatments are irrigated according to needs.

Para grass (*Brachiaria mutica*) dominates in the humid valleys of Colombia and is widely used for finishing beef cattle. A similar trial to determine beef

production costs using Para grass under intensive management with nitrogen fertilization is also planned. Three levels of nitrogen — 200, 400, and 600 kg/ha/year — will be used. A single stocking rate will be adjusted to the production of forage in wet and dry seasons.

A trial initiated in December, 1969, was designed to measure the effect of castration, stilbestrol implantation (DES), and injection of vitamin A on the growth of grade bulls and steers. A group of 284 animals was separated into bull and steer groups. Treatment in each group included the following: control, 30 mg DES implantation, 400 IU vitamin A injection, and 30 mg DES implantation plus 400 IU vitamin A injection.

Partial results of this experiment are shown in Table 1. In general, weight gains showed an inverse relationship to the amount of rainfall, i.e., when rain increased, live weight gain decreased. This is possibly associated with a marked decrease in forage intake during the rainy season, which in turn may be caused by the increase in moisture content of the pasture (low concentration of digestible energy and digestible protein), as well as by the stress of the wet weather on the animals.

Over the entire period DES implantation markedly increased weight gains in steers but not in bulls. However, response to DES in steers was observed only during the months of high weight gain. DES seemed to have a negative effect in both steers and bulls during the low weight gain months. No response was obtained from vitamin A injection. The experiment will continue during 1971.

Latosolic grassland areas

Beef production levels are low on existing native grass pastures due to inherent low nutritive value of these grasses and further accentuated by extensive systems of exploitation resulting

in undergrazing, which, in turn, leads to grazing overly-mature pastures of low nutritive value. Consequently, study of improved management systems for native pastures seems advisable.

Since grazing intensification is usually associated with a change in the botanical composition of native pastures, low nutritive value species presently dominant in the savannah (as a sub-climax of fire, poor soil fertility, and undergrazing) could be replaced by species of higher feeding value under more intensive grazing systems.

One experiment in Carimagua uses two grazing systems and three intensities of grazing to determine the effect of pasture rotation and stocking rates on the productivity of the native pasture. Changes which take place in botanical composition as a result of pasture rotation and stocking rate are observed. Continuous grazing and four-paddock rotational grazing treatments each have stocking rates of 0.2, 0.35, and 0.50 animals per hectare.

Preliminary observations at the Carimagua Research Center and on private ranches in the Llanos indicate that improved grasses such as molasses grass (*Melinis minutiflora*) and puntero (*Hyparrhenia rufa*) can be satisfactorily established. Although establishment costs are high, particularly where fertilizer is applied, this initial investment in improved pasture can probably be quickly recovered if these pastures are used for weaners, during breeding sea-

son and for fattening steers, and all periods during which adequate nutrient intake is highly critical.

At Carimagua a study is underway to determine the productivity and the economic feasibility of growing and finishing cattle on molasses grass pastures, with and without phosphate and potash fertilization and using varying grazing intensities. Fertilizer treatments used when establishing the pasture plots were: no fertilizer; 500 kg/ha of basic slag (75 kg of P_2O_5); and 500 kg/ha of basic slag plus 100 kg of muriate of potash (50 kg of K). Three grazing intensities are used. The fertilizer effect has been apparent in that fertilized plots were ready for grazing 100 days after seeding, while the unfertilized plots were not ready after 300 days.

Production Systems

Beef cattle production levels are notoriously low in the Colombian Llanos using traditional management practices. Preliminary evidence indicates that productivity and profitability could be substantially increased using sound pasture management, feeding, breeding and herd health practices, combined with some improved pastures.

A series of beef cattle production herds using grade Zebus native to the area are being set up to test this hypothesis. Comparisons include 1) traditional versus improved cattle and pasture management systems, 2) native grass versus native plus some improved grass

TABLE 1. Effect of Stilbestrol implantation on bulls and steers during periods of moderate-to-light and heavy rainfall.

	Average daily gain in grams			
	STEERS		BULLS	
	M-L Rain	H-Rain	M-L Rain	H-Rain
No-Stilbestrol	475	245	583	300
Stilbestrol	586	164	585	229
Stilbestrol response	111	-81	2	-71



Grazing trials serve to measure the effectiveness of pasture treatments (CIAT headquarters at "El Porvenir").

(*Melinis minutiflora*) versus all improved grass (*Melinis minutiflora*), and 3) continual back-crossing with Zebu bulls versus rotational cross breeding using Zebu and San Martinero, a local breed.

Animal Husbandry

Particular attention will be given to providing adequate nutrient intake during the dry season. Primary consideration is identifying grasses and grass-legume mixtures that provide an adequate diet through the dry season. However, where available forage does not provide adequate nutrient intake, attention will be given to protein, and perhaps energy supplementation.

Many soils of the lowland tropics are of low fertility, resulting in pasture forage deficient in certain minerals, especially phosphorus. Definitive studies are needed to characterize mineral composition of these grasses, and consequently year-round supplemental mineral needs.

In Palmira, attention will be given to by-products and crop residue utilization, and the use of cultivated forages for dry season feeding.

ANIMAL HEALTH

Toxic plant studies

A syndrome referred to as "vacas caídas" (fallen cattle) by ranchers of the lowland tropics has long been recognized. This disease attacks all ages of cattle, but is more prevalent in young calves. Lack of muscular coordination is usually accompanied by a wheezing laryngeal sound, and when animals are moved any distance they collapse from exhaustion. In an initial survey of the cattle-raising areas of Colombia this syndrome was observed throughout the north coast area, the Magdalena valley, and the Valledupar region. Insecticide intoxication, parasitism, vitamin E-selenium deficiency, and various plants were mentioned as possible etiologic factors. Common in all these areas was the presence of two weeds, cansaviejo (*Mascagnia concinna*) and anamu (*Petiveria alliacea*).

Detailed investigations are being carried out in the new ICA-CIAT veterinary research laboratories in Turipana. A condition similar to that observed in the field has been produced by feeding cattle fresh anamu at a rate of 2 gm/kg live weight. In addition to producing



Disking native range in preparation for seeding into *Melinis minutiflora*.

a muscular dystrophy, the plant also appears to be toxic for the kidneys. Studies in progress include pathogenesis of the disease syndrome, soil and plant analysis, and description of the disease in the field.

Anamu is aromatic and palatable, and grows in the shade of fence rows. Animals in the experiment appeared to have a strong predilection for or ad-

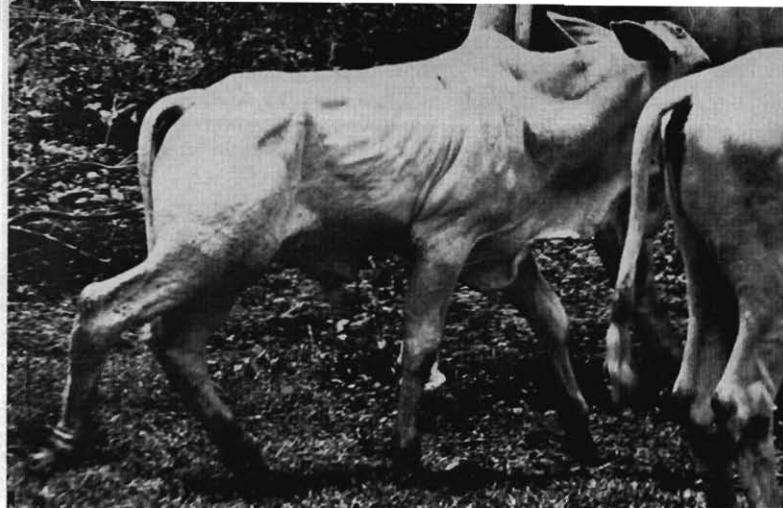
diction to the plant. This suggests that animals grazing on weedy pastures consume anamu throughout the year.

Another important disease syndrome in Colombia is "piel caída" (fallen skin), or photosensitization. A great variety of plants produces this disease. Studies are underway at Turipana to assay various local plants for their ability to produce this syndrome.



Melinis minutiflora seedlings three months after seeding.

Crippled calf grazed on anamu-infested pastures showing clinical signs of muscular dystrophy.



Bovine enzootic hematuria

Bovine enzootic hematuria is a tumor condition of the urinary bladder

which results in serious economic losses to the cattle industry. In many developing zones it is the major limiting factor for efficient meat and milk production.

A cooperative project has been initiated at "La Esmeralda" farm near CIAT headquarters where pastures have been indentified as having high, low, and intermediate incidence of hematuria. Plant classification studies and soil analyses are in progress. Bracken fern (***Pteridium aquilinum***) is commonly found in pastures of high-disease incidence. This plant is also associated with hematuria in other parts of the world.

Calves have been placed in each of the three pastures to verify the incidence of hematuria. Complete urinalysis, hemograms and serum calcium/phosphorus analyses are being performed.

Of approximately 900 randomly selected urinary bladders from cattle in the Manizales area, 28 percent had gross lesions and 50 percent had microscopic lesions. Twenty-six percent of the males and 32 percent of the females had lesions, thus eliminating sex of the animal as a variable. Electron microscopy of this material is in progress.

Anamu (***Petiveria alliacea***) is associated with a muscular dystrophy of calves. This plant grows primarily in the shady areas of fence rows.



Hemoparasitic diseases

Bovine anaplasmosis, babesiosis and trypanosomiasis cause large production losses and mortality of cattle in the lowland tropical areas of Latin America.

Since irradiated vaccines have been successful with other protozoa and metazoa, an attempt is being made to adapt these methods to bovine babesiosis caused, in this case, by **Babesia bigemina**. Purified blood isolates containing 1×10^{10} organisms were subjected to 24,000 to 60,000 rad of gamma irradiation and were inoculated once into four groups of calves, each with positive and negative irradiated controls, as well as heat-inactivated organisms and two lower dilution groups. Twenty-eight days following the inoculation of the irradiated blood, all calves were challenged with **B. bigemina** organisms. Sufficient time has not elapsed to check the exact degree of immunity, but in general immunity increased as radiation dosage decreased. It appears, therefore, that there are possibilities for future use of a radiation-attenuated vaccine.

Premunition against bovine babesiosis has been studied using Ganaseg and the new Burroughs-Wellcome compound 4A65. Ganaseg was administered to

calves at levels from 0.5 to 2.5 mg/kg eight days after inoculation of virulent **Babesia bigemina** and **Babesia argentina**. Results showed that 0.5 mg/kg was nearly as effective as 2.5 mg/kg in treating the early infection. It did not sterilize the infection, thus giving excellent co-infectious immunity. Compound 4A65 was used for treatment of babesiosis at dosages of 0.3 and 2.0 mg/kg eight days after inoculation of virulent organisms. At 0.3 mg/kg the compound was not effective for control of **B. argentina**, but did control **B. bigemina**. The 2.0 mg/kg dosage sterilized the calves, leaving them fully susceptible to reinfection.

Premunition against bovine anaplasmosis with oxytetracycline and Burroughs-Wellcome compound 356-C-61 has also been studied. The two drugs were used separately at 5 and 12 mg/kg, respectively, to treat cattle 21 days after exposure to the disease, with relatively little success. The most successful treatment consisted of a combined dosage of 12 mg/kg of oxytetracycline and 5 mg/kg of 356-C-61, which was applied 21 days after exposure to virulent **Anaplasma marginale**.

Simultaneous premonition against anaplasmosis and babesiosis now



Pasture samples for analysis collected from areas where hematuria is present.

appears feasible. After inoculation with a frozen inoculum of known infective dose titers containing *A. marginale*, *B. bigemina*, and *B. argentina* (and hence known incubation periods and clinical responses), treatment consists of 0.75 mg/kg of Ganaseg eight days after exposure, and a combination of 5 mg/kg of 356-C-61 and 12 mg/kg of oxytetracycline 21 days after exposure. Large numbers of doses could be produced at low costs.

It also may be possible to induce premunition of bovine babesiosis without treatment using only *B. argentina* at low titers. Anaplasmosis, however, will probably require treatment. Premunition usually induces a solid immunity if homologous strains of the organisms are used.

The efficacy of Burroughs-Wellcome compound 4A65 for the simultaneous treatment of bovine anaplasmosis and babesiosis was evaluated. It was extremely effective against *B. bigemina*, very effective against *B. argentina*, but much less effective against *A. marginale*, even at relatively high dosages. Effective dosages of anaplasmosis sterilized the calves against babesiosis, hence making them very susceptible to this disease upon re-exposure.

Evaluation of compound 4A65 in sterilizing bovine anaplasmosis and babesiosis carriers is underway. Preliminary results indicated that the drug was effective in the sterilization of cattle against babesiosis, but its effect on anaplasmosis sterilization is not yet known.

Babesia bigemina was isolated from calves infected by the tick *Boophilus microplus*. Since *B. argentina*, *A. marginale* and *Trypanosoma vivax* have a longer incubation period than *B. bigemina*, blood from the infected animals was passed through a series of five splenectomized calves at 24-hour intervals or less in order to purify *B. bigemina*. Similarly, *A. marginale* was isolated but by using Ganaseg to eliminate *Babesia* and *Trypanosoma* organisms.

Pathogenesis studies on bovine anaplasmosis, babesiosis, and trypanosomiasis included clinical, clinical-pathological, histopathological and immunofluorescent studies of the life cycle of the organisms within the bovine host. Lesions caused by the growth and development of the protozoa in the tissues of the cattle were also examined. These studies may reveal a weak link in the vertebrate cycle of the protozoa where the organism could be arrested without injury to the host.

Colonies of non-infected *B. microplus* ticks are being established in order to infect them with *A. marginale*, *B. bigemina*, or *B. argentina*. These infected ticks will be used as a source of inoculum for premunition with treatment. They will also be used to study the life-cycle of the organisms in the ticks.

Vesicular Stomatitis (VSV)

Vesicular Stomatitis (VSV) affects cattle, swine and horses in Latin America. It frequently complicates recognition of hoof-and-mouth disease (FMD) since the two diseases are undistinguishable in the field. The source of virus is still unknown. The natural history of VSV is being studied. During 1970 two outbreaks were followed. An investigation of the ecology of this virus was started at a farm which usually has this disease. A master's thesis is in progress to study the role of white blood cells during VSV infection in cattle.

"Vacas infladas"

"Vacas infladas" (inflated cows) is a condition of the pregnant bovine female characterized by excessive fluid accumulation (up to 100 liters) within the uterus. It usually results in death of the fetus or birth of weak calves, few of which survive. The etiologic factor or factors are not known nor the pathologic process within the animal. The disease is localized in the Llanos of Colombia east of 33° latitude. Observations over the past five years indicate

an increasing incidence. During 1970-71 a serious outbreak occurred.

During 1970, eight naturally-occurring cases were evaluated clinically, biochemically, pathologically, and microbiologically. Conclusions to date indicate that fluid accumulation occurs in the chorioallantois. The basic defect is a necrosis of the trophoblast of the chorion, followed by mineralization of the placental tissue. The mineralization is limited to fetal tissues. Electron microscopy of placental tissues has shown the presence of a C-type particle, and 50 percent of the sera from cattle in the area have been positive for bovine abortion agent (Psittacosis) complement-fixation antibody. It thus appears that there is abnormal endocrine function possibly related to or influenced by an infectious agent which remains to be isolated.

Training

During the year, four post-graduate interns received in-service training in pastures and forages, animal husbandry and animal health. One special trainee from the United States completed three months training in livestock production on the north coast of Colombia, and another from the Netherlands for six months in pasture management at Carimagua. CIAT supported two animal health graduate students in the ICA graduate school, and CIAT staff are supervising thesis research of seven other graduate students including Colombians enrolled in the ICA graduate school and in schools in the USA, and another from the Netherlands.

Livestock Production Specialist Training Project

Graduation of the first livestock production specialist training group in December, 1970, marked the completion of the first phase of an experimental effort to integrate theoretical knowledge and practical experience in the solution of specific production problems.

The definitive training program began on January 7, 1970. The theoretical phase of the program was conducted on the CIAT farm. Classes held through March, 1970, covered nutrition, animal health, breeding and improvement of farm animals, pasture and forage management, ranch management, agricultural economics, agricultural engineering, statistics, and communication. These subject matter areas were covered in 435 class-hours presented by 70 instructors or conference participants representing 18 agencies.

This was followed by an eight month in-service training period on eleven private ranches in the Bolivar savannahs. Following a preliminary survey conducted in December, 1969, an in-depth analysis was made of those ranches which the initial survey showed to have the greatest potential as collaborators with the training project, and as multipliers within the community. On the eleven ranches selected a trainee was assigned to each for 30 days to give the program and the rancher opportunity to evaluate each other, and to provide the program with data essential to the development of a specific production improvement program. Nine ranches with a total area of 10,500 hectares and a range in size from 170 to 4,000 hectares were included in the program. These ranches had a total of 10,500 animal units of cattle with a range of 250 to 4,000 animal units. Seven of the nine ranches were essentially owner-operated, and the other two were visited once or twice weekly by the owner.

Provision was made in technical assistance contracts to pay reasonable fees for services rendered. The production improvement program, as developed in conference with each rancher, was appended as part of the contract, as well as some allowance for limited extension efforts in the surrounding area, to work with marginal farmers. As of December, 1970, 17 additional ranchers had requested contract services. Sincelejo was the base of field operations.

Typically, weeds grow abundantly in tropical pastures, reducing grazing area and feed quality of herbage.



The program cooperated with professionals in the area including Banco Ganadero, Caja Agraria, FEDEGAN and INCORA and ICA. In the latter case, there has been a good deal of interchange and collaboration with the personnel of the Turipana Research Center. The veterinary research laboratory in Turipana was not yet operational in 1970, and therefore veterinary diagnostic laboratory work was handled through the local ICA laboratories.

Collaborative ICA-CIAT weed control studies initiated on several ranches will continue in 1971. Other collaborative ICA-CIAT on-ranch studies are planned.

In the remote hot tropics of the Bolivian savannahs, major cattle production problems (technical and otherwise) which the program has identified and has concerned itself with are:

1. The general lack of acceptance of and confidence in existing animal technicians by both the ranch-owner community and the ranch-worker community.
2. The general lack of suitable ranch-accounting and record-keeping systems.
3. The general lack of proper pasture development and management, and soil conservation and fertility management.

4. The general lack of proper application and consideration of accepted preventive veterinary medicine procedures.
5. The general lack of proper personnel management.
6. The general lack of proper livestock management.
7. The general lack of knowledge regarding the control and identification of toxic plant poisoning of cattle.

Thus far, it appears that this program provides an excellent vehicle for quickly identifying production problems. The next most essential step—that of applying available or rapidly adaptable technology in resolving the problems identified—was begun on each of the ranches. To date, only immediately available or rapidly adaptable technology has been applied. The resulting magnitude and speed of improvement in productivity, at present, can only be evaluated subjectively. Quantitative determinations await, initially, the collection and analysis of a full-year production cycle, and then possibly a three-to-five-year annual follow-up analysis. However, the following appraisals are possible:

1. The program has been well accepted in the work area by both the ranch-owner community and the



Digging of wells to provide water for livestock is a necessary management practice in a cattle enterprise.

ranch-worker community, with the gradual building of goodwill.

2. Proper records are being maintained which allow the rancher to better understand his enterprise and his herd status with respect to production, costs, inventory, health, and reproduction. As records accumulate, some quantitative analyses will be undertaken to examine the present management systems.
3. Proper applications of herbicides for weed control in pastures greatly increased the recommended stocking rates at relatively low cost. The dividing of large pastures further increased carrying capacity, as did improved rotation practices. Native tropical legumes are being identified and encour-

aged through proper herbicide application and grazing practices.

4. The application of animal preventive medicine procedures has been most successful. Mortality and morbidity losses have been reduced, particularly in calves. Calving percentage has been increased with the elimination of brucellosis carrier animals, and elimination of non-fertile animals.
 5. To improve personnel management, trainees instructed each worker in reading and writing so as to help maintain records and understand written records and instructions; obtaining job skill competency; and understanding and taking proper health precautions for himself and his family.
- As a result of these increased abilities, some owners gave salary increases

or incentives. Where needed, improved water facilities were established as were proper sanitation facilities. The trainees helped the owners work out job responsibilities and weekly work schedules.

Of the trainees who graduated, three are continuing work begun with CIAT in Sincelejo, accumulating data at collaborating ranches for a complete livestock production period; three are employed by ICA; one is working with a semi-private livestock development organization called the Fondo Ganadero; one is at the Caja Agraria, an agricultural credit agency of the Colombian government; and three are heading in-field training programs at major veterinary medicine schools in Colombia.

CIAT expects that these trainees will disseminate the practical orientation to problem solving which formed the basis of their training. The multiplier effect that these trainees will have on key educational and agricultural assistance organizations within Colombia, and their ability to effect change in the orientation of national programs and the general philosophy and approach of decision-makers, will be the ultimate measure of the success of this project. In the coming year, the project will strive to identify the training techniques which could lead to less costly (more trainees per unit cost), more effective programs for tropical regions of the Americas.

To this end, a ranch enterprise model is being developed which will be used to simulate the overall functional operation of collaborating ranches. This will provide the trainee insight and understanding of the total operational and organizational structure of a particular ranch (of which he is to identify

the production-limiting factors and then program the specific production improvement practices to increase productivity).

AGRICULTURAL ECONOMICS

In view of poor or non-existent statistics on most aspects of the cattle industry in Colombia, a large-scale, on-the-farm study was begun in 1970. The questionnaire to be used has been field-tested on the north coast. Data on calving rates, mortality rates, and growth rates in different areas of the country, as well as transport and marketing systems in each of the regions, will be included.

INTERNATIONAL COOPERATION

Representatives of CIAT pastures and forages, animal husbandry, animal health, and agricultural economics sections are members of a technical advisory committee for the INIAP Beef Cattle Program in Ecuador.

A memorandum of understanding between CIAT and the Agricultural University at Wageningen, the Netherlands, was implemented with the arrival of a student who began training in tropical animal husbandry.

The CIAT hemoparasite program is directed by the Texas A&M University group, is carried out in collaboration with ICA, and is funded by USAID and The Rockefeller Foundation.

Members of the CIAT beef production program also helped substantially in the organization of the III Meeting of the Association Latinoamericana de Produccion Animal (ALPA).

Cassava Production Systems

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

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

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

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

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

During 1970, work was conducted in the following areas:

- I - Collection and evaluation of germ plasm material.
- II - Cultural practices.
- III - Plant quarantine and plant pathology studies.
- IV - Agricultural economics.
- V - Swine feeding.

I - Germ plasm collection

During 1970, additional material from Colombia and other Latin American countries was added to the collection of cassava cultivars started in 1969. This collection now includes 1884 cultivars from Colombia, 123 from Ecuador, 60 from Puerto Rico, 118 from Panama and 8 from Peru. An additional 33C cultivars collected in Venezuela are in quarantine in Bogotá. Upon certification of freedom from diseases this material will be transferred to CIAT headquarters. Another group of 70 cultivars was collected in Mexico and will be transferred to Colombia in the near future.

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

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

TABLE 1. Cassava response to fertilizer and plant spacing.

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

1. Spacing yield differences are not significant.

2. Means followed by the same letter are not significantly different at the .05 level.

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

II - Cultural practices

Cassava fertilization and plant population study

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

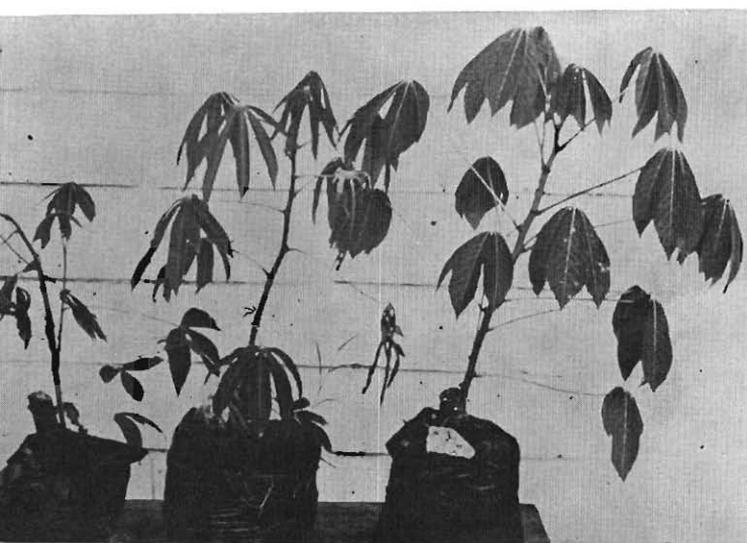
An experiment was established in a clay loam soil with PH 7.0, a high phosphorus level, and a medium potash content. Potassium chlorate and a 14-14-14 fertilizer were mixed to give a 1-1-2

ratio and was broadcast and incorporated into the soil prior to forming ridges for planting the crop. Rate of fertilization was 0, 60 + 60 + 120, and 120 + 120 + 240 kg/ha of N, P₂O₅, and K₂O, respectively.

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

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

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



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

III - Plant disease and quarantine studies

Cassava diseases

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

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

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

Quarantine treatment

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

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



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

IV - Agricultural Economics

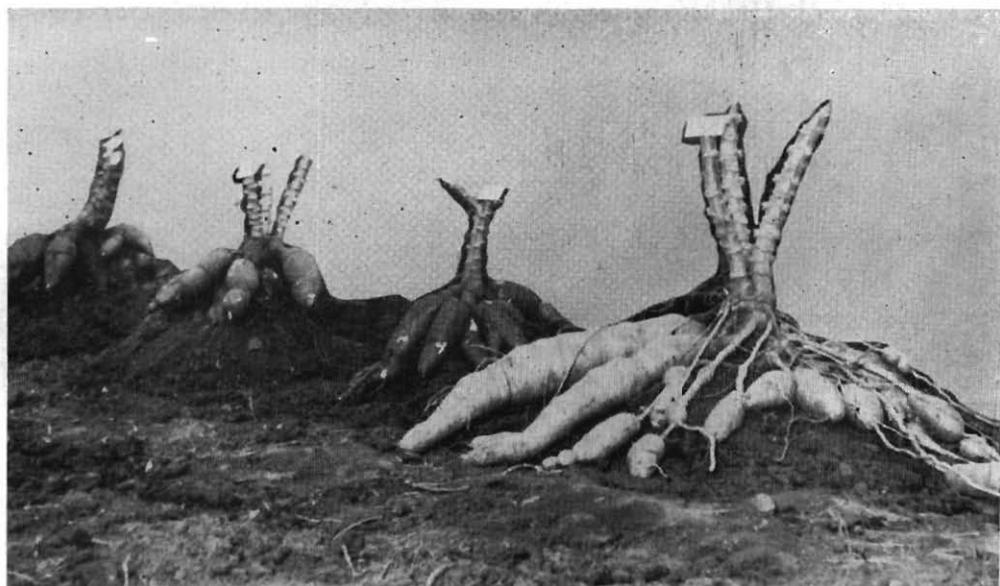
A compendium of world data on cassava production, yield, and cultivated area for all producing countries has been prepared at CIAT from secondary data, particularly FAO publications. Production per capita has also been calculated for each country for the last 10 years.

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

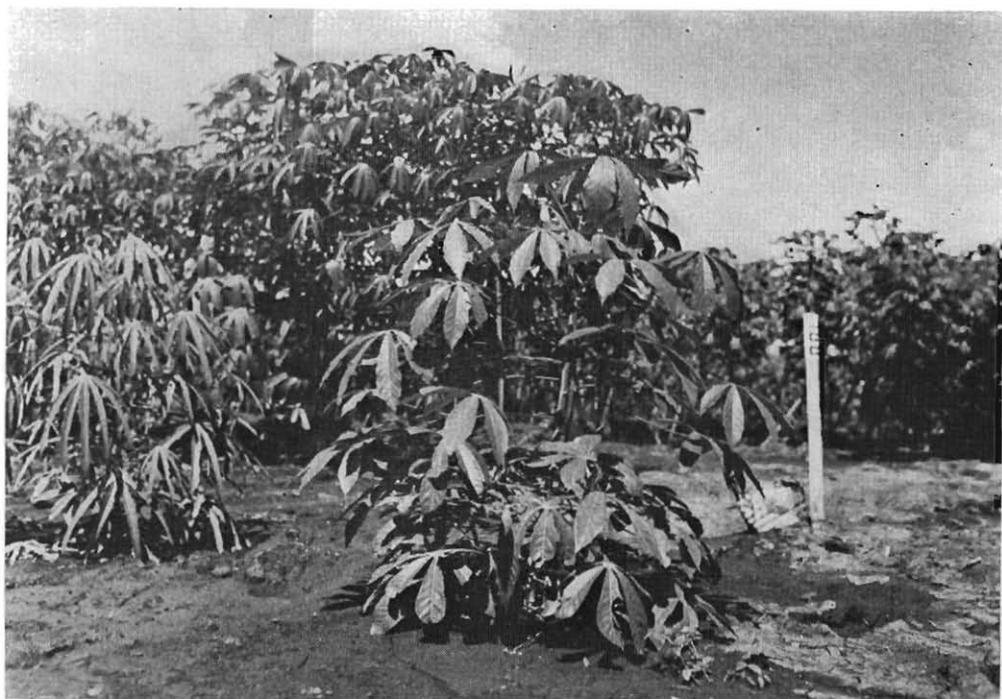
Other studies in progress include wholesale and retail cassava prices in 14 Colombian cities over the past 10 years, consumer demand for cassava, cassava flour and starch in the United States during the last 14 years; a description and analysis of cassava starch-producing facilities in Colombia; the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

V - Cassava utilization through swine feeding

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



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



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

Swine Production Systems

CIAT's swine program contributes to the increase of pork production in the lowland tropics through collaboration with national agencies in the development of production systems based on utilization principally of non-grain feedstuffs available in the tropics, and through training swine production and research specialists for national institutions.

Opaque-2 maize

The use of opaque-2 maize to replace normal maize greatly reduces the quantity of supplemental protein that is required for swine production. Research completed during 1970 demonstrated that a 12 percent protein diet based on opaque-2 maize plus a protein supplement can replace a 16 percent protein diet based on normal maize plus a protein supplement for pigs during the growing period from 10 to 50 kilograms weight. During the finishing period (50 to 90 kilos), supplemental protein can be completely eliminated when opaque-2 maize is used to replace a 12 percent protein normal maize-protein supplement diet.

A variety of supplements can provide the additional protein in opaque-2 maize diets for growing pigs. Optimal results have been obtained with soybean meal, fish meal, and meat meal, or combinations of fish and meat meal with cottonseed meal. Less favorable results have been obtained when cottonseed meal or a combination of cottonseed and soybean meal is used,

demonstrating that the level of lysine in cottonseed meal is not adequate to supplement properly the opaque-2 maize when used in diets with suboptimal levels of protein.

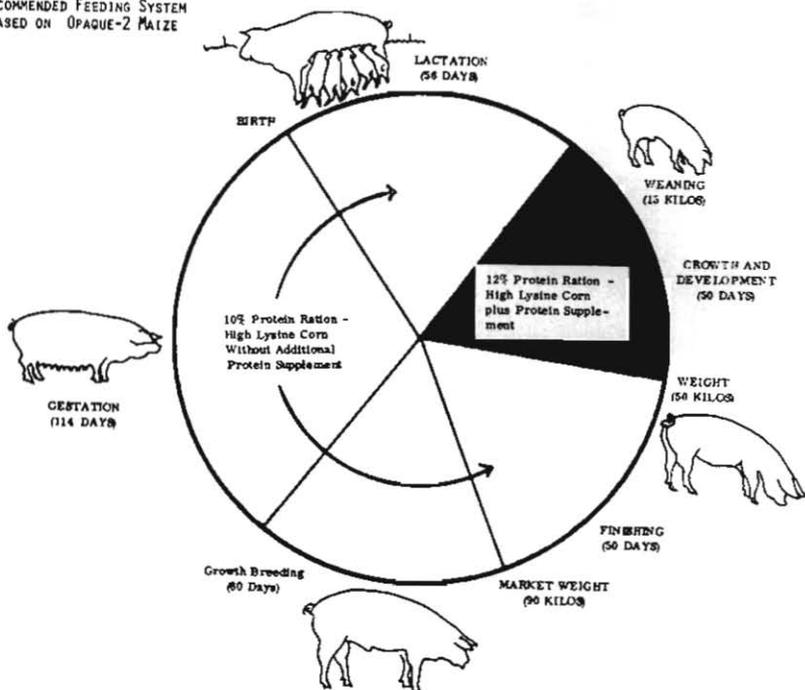
Diets similar to those fed growing pigs have also been fed lactating sows. Equal numbers of equal-weight pigs can be produced from diets composed solely of opaque-2 maize plus a proper vitamin and mineral supplement. This opaque-2 diet replaced the recommended 16 percent crude protein diet based on feeding normal maize and soybean meal.

A life-cycle swine production system based on opaque-2 maize was developed on the basis of these results and additional data from Purdue University relating to gestating sows. A graphic representation of this system is presented in Figure 1.

A substantial saving of protein supplement can be achieved with this system. For example, per sow per breeding season, 214.5 kilos of protein supplement containing 50 percent protein can be replaced by 256.2 kilos of opaque-2 maize. Small and family farmers can use such a system for efficient production without buying protein supplement.

The overall economics of the system can be determined by considering existing prices within specific areas. If the price of maize is high in relation to protein supplements, there will be little if any economic advantage in using an opaque-2 maize system; conversely, if

RECOMMENDED FEEDING SYSTEM
BASED ON OPAQUE-2 MAIZE



RECOMMENDED FEEDING SYSTEM
BASED ON NORMAL MAIZE +
SOYBEAN MEAL

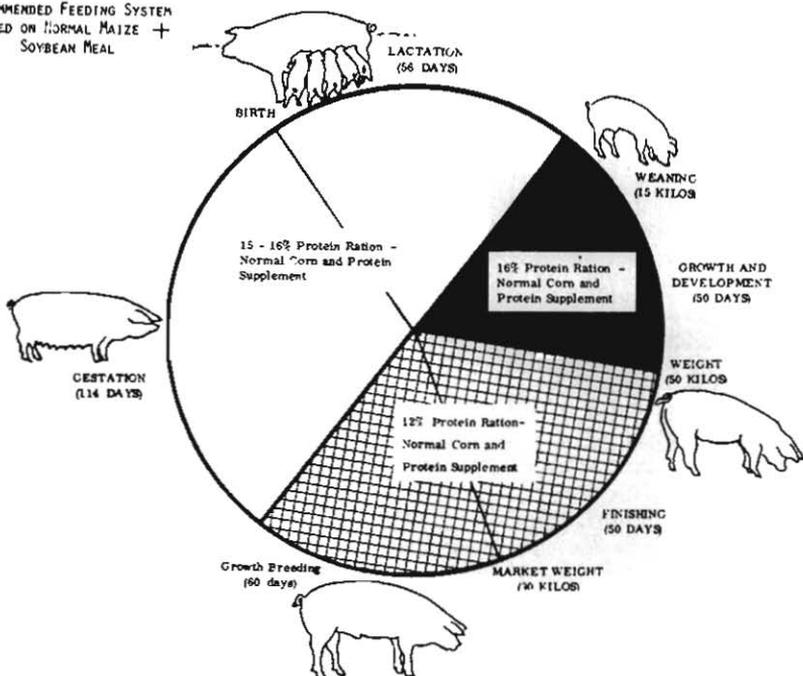


FIGURE 1. Life-cycle swine feeding systems based on conventional or opaque-2 maize diets.

TABLE 1. Lysine and tryptophane analyses of selected grains of the opaque-2 hybrids H-208 and H-255¹.

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

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

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

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

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

The crystalline samples tended to have higher levels of protein than the opaque kernels. The lysine and tryptophane levels of the opaque and crystalline H-208 samples were similar to those of

the opaque H-255 samples, although the crystalline H-255 contained significantly lower levels of both amino acids.

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

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

Floury-2 maize

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

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

Cassava

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

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

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

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

Data in this experiment indicate that, in the absence of beef tallow (fat), methionine supplementation increased gains, as did a 10 percent increase of fat alone to the diet. However, when both fat and methionine were present, a depression in gains was recorded.

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

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

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

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

Bananas and Plantains

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

TABLE 2. Performance of pigs fed banana meal as a replacement for maize during the growing-finishing period.

Diet	1	2	3	4
Level of Banana Meal, %	00	25	50	75
Days to 90 kilograms	119	121	124	128
Average daily gain, kg.	0.67	0.65	0.63	0.61
Feed Consumed daily, kg.	2.45	2.54	2.54	2.55
Feed efficiency	3.66	3.88	4.04	4.19

livestock feed. In collaboration with INIAP in Ecuador, CIAT's swine program has developed a life-cycle feeding system based on these reject bananas for gestating and growing-finishing pigs. Bananas can be used as a major energy source if an adequate protein supplement is available.

Lactating sows nursing litters are, however, unable to consume adequate quantities of ripe bananas to meet their daily energy requirements. In addition, consumption of more than 13-15 kilograms per day brings about digestive problems in the sow leading to diarrhea which, in turn, creates sanitation problems in the farrowing crates.

To overcome this problem and to extend the area of usefulness of reject bananas, studies have been carried out to evaluate green banana meal as a possible replacement for ripe bananas. This green banana meal, in contrast to fresh bananas, can be stored for long periods of time after drying, and can be transported economically to areas of demand far removed from the banana zone.

Research results obtained in collaboration with INIAP demonstrated that dry green banana meal can replace maize as an adequate energy source for lactating sows, supplying up to 53 percent of the lactating ration without reducing the number of pigs weaned or weaning weights.

This dry green banana meal can also be used in the diets of growing-finishing pigs. Levels of up to 75 percent of the diet have been tested with only small losses in daily gains. Each 25 percent increase in the level of green banana

meal as a replacement for maize in the diet reduces daily gains by approximately 20 grams. Efficiency of feed utilization is also affected, with each 25 percent substitution of green banana meal increasing by 200 grams the quantity of feed required to produce a kilogram of gain. (See Table 2.)

Efficient economical use of fresh or dried bananas instead of maize as the principal energy source for swine production depends upon local prices of protein supplements and of swine, as well as price per kilo of banana meal, which should be approximately 50 percent of that of maize, according to the studies in Ecuador.

Rice

Increasing rice production in Latin America points to the possibility of its future use as a replacement for maize and other grains in swine diets. In view of this, the swine program at CIAT has studied the biological value of rice and its by-products in relation to that of other feeds.

Results of biological evaluations of white rice, brown rice, and rice polishings, as compared with normal and opaque-2 maize, are shown in Table 3.

Both white and brown rice supported gains and demonstrated a feed conversion efficiency 2.5 times that of normal maize in rat growth studies at CIAT. However, neither of these two kinds of rice equalled the performance levels of opaque-2 maize, which supported gains 47 percent higher than those obtained with either white or brown rice.

TABLE 3. **Biological comparison of white rice, brown rice, rice bran, normal maize, and opaque-2 maize** ¹.

	Feed Source				
	1	2	3	4	5
	White Rice	Brown Rice	Rice Polishings	Normal Maize	Opaque-2 Maize
Average daily gain (grams)	2.18	2.17	3.30	0.85	3.21
Feed efficiency ²	5.42	5.13	3.91	12.05	3.97
Protein efficiency ratios ³	2.42	2.18	2.27	0.96	2.70

1. White rats were used in this study.

2. Grams of feed per gram of gain.

3. Grams of gain per gram of protein consumed.

In another study, these rice products replaced normal maize in swine diets during the growing-finishing period. Results indicated that white rice, brown rice, paddy rice, or a 50-50 mixture of rice polishings and white rice could replace normal maize in growing-finishing pig diets, although rice polishings alone significantly reduced gains. Efficiency of feed utilization was similar for all treatments except ground paddy rice, which required larger quantities of feed per kilo of gain, as the indigestible rice hulls were not removed from the ration.

Rice and rice by-products can, therefore, be used efficiently to replace normal maize in swine diets during the period from weaning to market, if the price of rice is below that of maize.

Sugar

Refined sugar has been shown to be an excellent source of carbohydrates for swine. Research has demonstrated that increasing the amount of refined sugar in the diet, up to a level of 45 percent, results in a corresponding improvement in pig performance and feed efficiency. However, as sugar is an export crop needed to balance the dollar drain in most of the producing countries in Latin America, there is little possibility that it will become available for national swine production.

Reports from England and the United States have indicated that sucrose

may play an important role in producing high blood cholesterol levels and arteriosclerosis in swine. In feeding trials carried out at CIAT, where high sucrose (refined sugar) levels were used, blood samples were taken from the pigs and cholesterol levels determined. At slaughter, the heart and aorta were collected from each pig and examined for lesions of fatty degeneration. Results of these analyses indicate that there were no increases in aorta lesions associated with this treatment, although blood cholesterol levels were somewhat higher than those of control animals fed diets containing no sucrose.

A second study compared a control diet of normal maize and soybean meal with diets containing 10 percent animal fat, 60 percent sucrose, or a combination of these two ingredients. The animals remained on these diets for 182 days to allow adequate time for lesion development. Blood samples taken near the end of the study demonstrated that diets containing animal fat significantly increased the cholesterol level, whereas the sucrose diet did not produce an increase. No aorta lesions were associated with the diets employed in this study.

The difference between these results and those reported in the previous study may be related to differences in diet composition, as the first study used purified diets, while the second used natural ingredients.

Cowpeas

Such protein supplements as soybean meal, fish meal, meat meal, cottonseed meal, and sesame meal often prove economically inefficient in swine diets because of limited supply, scarcity, or high cost.

CIAT is evaluating other protein sources, particularly those that can be grown and used in the farm with minimal processing. Initial work has been with cowpeas (*Vigna sinensis*) because of their wide range of adaptability and ease of production. Initial tests with pigs demonstrated that cowpeas, as other grain legumes, contained growth-inhibiting factors which limited their usefulness. Results of rat studies indicated that germination, as well as heat treatment, destroys or reduces these inhibitory factors. When supplemented with low levels of methionine, germinated cowpeas supported results equal to those obtained with a control diet of soybean meal.

Animal Health

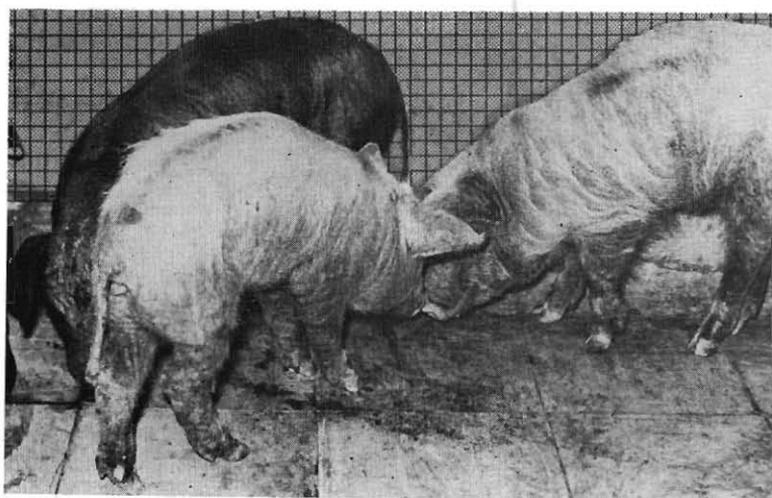
Swine research in animal health has focused on two principal infectious diseases, mycoplasmosis and hoof-and-mouth disease, as well as protein defi-

ciencies. Although these studies are continuing, some preliminary conclusions may be drawn.

Mycoplasmosis results in arthritis, pericarditis, and pleuritis in young swine. Initial research in this area has been started in collaboration with the ICA Graduate School at Tibaitata. A segment of the swine population is being sampled for primary isolation, and a serologic survey is underway. To date, *M. hyorhinis* has been isolated from swine having excessive pericardial fluid.

Hoof-and-mouth disease of swine and lack of an effective vaccine continue to result in serious economic losses. A project to study the pathogenesis of this disease, field outbreaks, the role of trauma in transmission, and production of the clinical disease, will terminate in 1972.

A study made to determine organ regeneration in swine following protein depletion was completed in 1970. After an initial period of depletion using a diet of common maize alone, three groups of pigs were fed separate diets containing common maize, opaque-2 maize, and casein as the only protein sources. Following the regeneration period, histological evaluation of the di-



Sarcoptic mange, a common skin problem in protein-deficient swine.



Characteristic lesions of foot-and-mouth disease in swine.

gestive tract, liver, and bone from the animals in each group was made. Results indicated that opaque-2 maize was particularly effective in supporting regeneration. However, the diet based on protein from casein proved to be inadequate for liver regeneration, which may possibly be associated with a significant deficiency of methionine in the casein.

It had been observed at the Universidad del Valle Hospital that epithelial regeneration was initiated when intestinal flora were controlled in protein-deficient patients. In collaboration with the Universidad del Valle, CIAT measured the effect of antibiotics in the regeneration of the intestinal epithelium of swine during protein depletion and repletion. Three basic diets with and without antibiotics were used. Preliminary results indicate that antibiotics have a detrimental effect at a low protein level, whereas a beneficial effect is observed with nutritionally adequate

diets. Additional evidence in this direction was provided by determinations of serum cholesterol, total protein, and alkaline phosphatase levels, as well as gastric, duodenal, and jejunal epithelial thickness measurements.

Training and international collaboration

Two Colombian scientists received training in the swine program during 1970, one as an in-service trainee, and the other as a research fellow. An Ecuadorian research scholar is continuing training at the ICA Graduate School.

Close collaboration has continued with the ICA swine program in Colombia as well as the swine program of INIAP in Ecuador. Arrangements have been completed to aid in the development of a swine program in Costa Rica in collaboration with the University of Costa Rica and the Ministry of Agriculture. Requests for program collaboration have been received from Paraguay, Bolivia, and Peru.

Rice Production Systems

CIAT's rice program is oriented toward the solution of problems limiting rice yields in Latin America. Although many factors affect yields throughout the hemisphere, the need for research is particularly critical in three areas: production of high-yielding dwarf varieties having superior cooking and milling quality; incorporation of stable resistance to the rice blast disease; and development of cultural practices for responsive varieties grown under both irrigated and upland conditions.

During 1970 the effects of the green revolution started to be felt in Latin America through increases in rice production because of the use of high-yielding varieties, especially IR8. The United States Department of Agriculture estimates that 91 percent of Cuba's spring crop (105,000 hectares) was planted with this variety. The same variety was planted on about 20,000 hectares each in Colombia and Venezuela and on approximately 5,000 hectares in Ecuador.

IR8 and IR5 occupied 12.5 percent of Peru's rice area and, for the first time in years, Peru is nearing self-sufficiency in rice production. It is likely that Colombia would have had to import rice if it were not for the exceptional yields of IR8. It is questionable, however, whether IR8 will continue to increase markedly. As countries achieve self-sufficiency or have small stocks for export, the price for IR8 will decline rapidly because of its inferior grain quality.

RICE BREEDING

Crosses

Following the specific breeding objectives detailed in the 1969 report, a total of 89 crosses was made in 1970. Of these, 36 were single crosses of dwarfs using various selections of IR579, IR665, IR841 and IR930. Colombia 1, a line highly resistant to the blast disease in Colombia and at the International Rice Research Institute (IRRI) in the Philippines, was used as a parent in 42 single and line X F_1 crosses. The highly blast-resistant varieties Tetep, Mamoriaka, Dissi Hatif, and C46-15 were used as parents in 11 crosses with selections of IR665 and IR841.

Nurseries

Six plantings of segregating material were made during 1970 at the ICA experiment station at Palmira (January, March, May, July, October, and November). These included 13,462 pedigree rows that were evaluated for vigor, earliness, plant type, cooking quality, grain appearance, and resistance to **Sogatodes**, hoja blanca, and blast. All material in the program is now dwarf, and the majority has acceptable grain characteristics. Fixed lines (F_2) from the first crosses made in 1967 will be advanced to preliminary yield trials in 1971.

Additionally, 80 F_2 bulks of 4,000 to 6,000 plants each were grown and selected. Those bulks having a blast-resistant, tall-statured parent were thor-

oughly rogued of all tall plants after flowering to allow survival and selection of the dwarf segregates. Failure to cut out the tall segregates in directly-sown bulks would result in the loss of the desirable dwarf plants through competition for light.

Four international blast nurseries with 356 varieties each, and four of blast moderately resistant varieties with 212 each, from IRRI, were planted for evaluation at ICA's La Libertad Station. Some of these varieties were already present in the CIAT nursery and, thus, a combined nursery was formed which will be distributed to Latin America in 1971.

Yield trials

A total of 289 varieties and lines was grown in unreplicated observational yield trials. The majority were introduced

from Brazil, the Philippines (IRRI), Mexico, and the United States Department of Agriculture. The USDA material, comprising new promising USA lines, was received specifically to test its resistance to blast, hoja blanca, and **Sogatodes**. All of the Brazil and the USDA material was discarded because of low tillering and tallness. The Mexico and IRRI lines yielded well, nearly all being dwarf, but most were eliminated because of lateness and poor grain traits.

One hundred forty replicated yield trial entries were evaluated. Outstanding material included selections from the following crosses: IR8x (Peta/5 x Belle Patna), (Peta/3 x TNI) x Khao Dawk Mali, and IR8 x IR12-178-2-3.

Fifteen selections of the most promising long-grain dwarfs selected during the past three years were grown

TABLE 1. Crosses and pedigrees of 15 lines transplanted in March, 1970. (Yields of the most promising five lines, which were directly seeded in September, 1970, are also included.)

Cross	Pedigree	Grain March (0.2 ha)	Yields Sept. (1.5 ha)
Nahng MonS4 ^{1/2} x TNI	IR480-14	discarded	
IR8 ² x Pankhari 203	IR822-347	segregating,	reselected
IR8 x (Sigadis x CPSLO)	IR661-1-140-3	discarded	
IR8 x IR12-178-2-3	IR930-31-1-1B (CICA 4)	8.53	7.17
IR8 x (Peta/3 x Belle Patna)	IR665-1-1-6	discarded	
IR8 x IR12-178-2-3	IR930-31-10	discarded	
IR8 x F ₂ (CPSLO x L. Yai34)	IR634-9-5-2	discarded	
(Peta/3 x TNI) x TKM6	IR532-1-33	discarded	
(Peta/3 x TNI) x Khao Dawk Mali	IR841-63-5-1B	segregating, reselected	
IR22	—	7.72	6.40
IR8 x (Peta/3 x Belle Patna)	IR665-33-3-4	discarded	
"	IR665-34-2-3	discarded	
"	IR665-23-3-1-1B	9.43	8.15
"	IR665-33-5-8-1B	8.31	6.23
"	IR665-33-1-3-1B	8.38	6.03

TABLE 2. Agronomic characteristics of the five most promising rice lines selected for seed multiplication.

Line	Tillers m ²	Ht. cm	Days Flower	Grain Straw Ratio	1000 seed	% dorm- ancy	% head rice	% total rice	Disease and Pest Reaction						
									Gelat. Temp.	% amylose	Hoja blanca	Blast	% Ana- ranja- miento	Sogata	Diatrea
IR930-31-1-1B (CICA 4)	328	94	106	1.00	22.1	51	64.7	69.7	Interm.	27	R	S	0	R	MR
IR22	290	99	98	0.88	22.9	98	63.1	69.4	Low	29	MR	S	15	R	R
IR665-23-3-1-1B	322	109	92	1.19	28.3	96	49.2	67.5	Interm.	27	R	S	20	R	MS
IR665-33-5-8-1B	294	94	91	1.26	26.1	96	61.1	64.8	Interm.	28	R	S	0	R	MR
IR665-33-1-3-1B	325	98	90	1.00	26.9	97	60.8	67.5	Interm.	30	R	S	5	R	MR

on the CIAT farm in March to purify and increase seed and to further evaluate their agronomic value.

Concurrently, the 15 selections were planted on several experiment stations and farms in Colombia. Seed of all or most of the 15 lines was sent to Argentina, Brazil, British Honduras, Costa Rica, Dominican Republic, Ecuador, Guyana, Honduras, Panama, Peru, Trinidad, Uganda, Uruguay, and the International Institute of Tropical Agriculture (IITA) in Nigeria for wider testing.

Of these 15 selections, five lines were chosen for further multiplication and testing in September. Each was directly seeded in 1.5 hectare fields on the CIAT farm. Ten hectares of each were planted by ICA, and approximately two hectares of each were transplanted by the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Ecuador.

Table 1 presents the crosses and pedigrees of the original 15 lines transplanted in March, plus the yields from the March and September plantings of the five most promising lines. Agronomic characteristics and yields from other locations for these five lines are presented in Tables 2 and 3, respectively.

The upland results in Table 3 are particularly noteworthy. The test in Pan-

ama included 84 lines, of which IR930-31-1-1B gave the third highest yield. Five of the 10 most productive lines were selections of IR930. The 10 lowest yielders were all selections of IR665. Additional evidence that IR930 is adapted to upland culture is the high yield of IR930-31-1-1B in Costa Rica. In a preliminary test at Tumaco, Colombia, the same line yielded 4.9 ton/ha. This was 2.2 ton/ha greater than that of any other entry.

Release of new varieties

Repeated inspection of the trials reported in Table 3 and elsewhere led CIAT and ICA to jointly name and release IR930-31-1-1B as the variety CICA 4 to be released next year. This variety was obtained by three cycles of selection of segregating material received from IRRI in 1968.

ICA has about 45 tons of seed of CICA 4 of which the major portion will be multiplied by registered seed producers in Colombia. The remainder will be distributed by ICA to small, marginal upland rice farmers.

About half of the 10 tons of breeders' seed of CICA 4 produced by CIAT will be distributed outside of Colombia. The remainder is being planted in one hectare regional trials in Colombia.

TABLE 3. Yields (ton/ha of the five most promising rice lines in regional tests.

Line	Testing Country			
	Colombia/a	Ecuador/b	Costa Rica/c	Panamá/d
IR930-31-1-1B (CICA 4)	6.8	5.76	5.04	5.65
IR22	6.4	6.87	4.18	5.04
IR665-23-3-1-1B	7.6	8.96	4.88	2.67
IR665-33-5-8-1B	6.8	5.34	4.67	2.77
IR665-33-1-3-1B	6.3	6.08	4.99	2.48
IR8	6.9	7.05	3.39	4.08
Bluebonnet 50	4.0	4.45	—	—

a) CIAT-ICA: average of 17 tests, direct-seeded.

b) INIAP : average of five tests, irrigated, four transplanted.

c) Ministry of Agriculture: average of three tests, upland, heavy rainfall.

d) National University: one test, upland, moderate rainfall.

CICA 4 has shown a wide range of adaptability to upland and irrigated culture including direct seeding and transplanting, and also to areas of relatively low air and water temperatures. It has excellent seedling vigor and thick, sturdy culms. The grain is long and vitreous and has excellent milling and cooking qualities. On the more favored irrigated lands it should replace both IR8, because of its superior quality, and the traditional varieties, because of greater yield potential.

Strong farmer interest in the variety IR22 in several Latin American countries led to a joint CIAT-ICA decision to produce and distribute seed of IR22. This variety, released by IRRI in 1969, is recommended for irrigated tropical areas. IR22 appears to be somewhat



Harvesting of CICA 4 rice at CIAT headquarters near Palmira.



more sensitive to low temperatures than CICA 4. Both varieties are resistant to **Sogatodes** and to hoja blanca, thus reducing greatly the need for insecticide applications.

CICA 4 has flag leaves that extend above the panicles. This trait apparently protects against species of black-birds, doves, and sparrows that damage traditional tall varieties having panicles borne above the foliage.

In nearly all tests of irrigated rice in Colombia and Ecuador, the line IR665-23-1-1B has yielded more than other selections (Tables 1 and 3). It will not be released, however, because its production of unbroken grains during milling is relatively low (Table 2).

As individual plants appeared to differ in milling quality, several hundred plants were selected and evaluated individually. About one hundred of these will be multiplied and reevaluated for milling quality in 1971.

The two lines in multiplication, IR665-33-5-8-1B and IR665-33-1-3-1B

CICA 4 rice grown under upland culture in Ecuador (Photo courtesy of INIAP).

(Tables 1, 2, 3) were discarded as being inferior to CICA 4 and IR22.

A number of crosses involving CICA 4 and related IR930 selections are being screened to identify lines that have earlier maturity, leaves that remain green until harvest, tighter threshing, and slightly less amylose in the endosperm.

RICE PATHOLOGY

Blast disease

The search for varieties with genes controlling horizontal (general) resistance to the blast disease, *Pyricularia oryzae*, was intensified in cooperation with ICA plant pathologists at La Libertad Station. Two hundred fifty varieties have kept their resistance through 14 plantings from April, 1969, through December, 1970, in the Llanos and the northern coast of Colombia. However, a test carried out in the jungle of Peru showed that about half of these varieties were susceptible. This points to the need for further testing of these varieties under conditions favorable to the development of the disease.

Preliminary results of a study of the nature of a horizontal resistance of rice to *P. oryzae* indicate that susceptible varieties have more type 4 lesions, and in general more lesions than moderately resistant varieties. The average size of the lesion in millimeters for Fanny (susceptible) was 29.1; Bluebonnet 50 (susceptible), 11.0; Perola (moderately resistant), 4.2; and Colombia 1 (resistant), 1.9. Sporulation started earlier and lasted longer in the susceptible varieties as compared to the resistant ones, and the number of spores produced was significantly lower in those moderately resistant. Fewer lesions per leaf area, longer time to start sporulating and fewer spores produced by a lesion during its lifetime are three common features of varieties having horizontal resistance.

New fungicides and methods of application for controlling rice blast were

also studied. Direct applications to the soil or to the irrigation water, as well as combinations of seed, soil, and foliage applications, were tested. Five fungicides widely used in temperate zones to control this disease are being tested in the field in plots of 5 X 3 meters. An experiment is also underway to test 40 fungicides in screening plots of 1 m². Results will be reported in 1971.

In a preliminary experiment, the systemic fungicide Benomyl applied at 40 or more kg/ha protected the rice plant from infection up to 300 days under continuous cropping. This wettable powder, or other systemic fungicides, applied in a granular form to the soil or to the irrigation water appears to offer an efficient and relatively low cost control when combined with a partially resistant variety.

Hoja blanca virus

A previously developed method of isolation and purification of this virus was improved. An antiserum was obtained which will be used internationally to search for possible strains of the virus. Electron microscope studies of the nature of the transovarial passage of the virus through several generations of the vector *Soqatodes oryzicola* are being carried out in collaboration with the University of Hokkaido, Japan.

Information exchange on resistance to rice blast has been started with IRRI.

RICE AGRONOMY

Rice agronomic research at CIAT was expanded in mid-1970 with the addition of a rice agronomist to the staff. Research in rice agronomy has been concentrated on obtaining information about cultural practices appropriate to the new varieties produced, before releasing them to farmers.

Yield trials

In addition to the yield trials reported



Rice varieties showing various degrees of horizontal (general) resistance to ***Pyricularia oryzae***.

under Breeding, the five most promising lines were compared to two widely grown varieties, IR8 and ICA 10, under uniform cultural practices.

Results show that two of these new lines, CICA 4 and IR665-23-3-1, produced higher yields than IR8, while the other three produced from 80 to 86 percent of the IR8 yield. The yield of ICA 10 was also higher than IR8. On commercial farms, however, yields of this variety are generally much lower because of its susceptibility to rice blast.

Fertilizer requirements

Five different levels of nitrogen (0, 25, 50, 75 and 100 kg/ha) and two

levels of P_2O_5 (0 and 50 kg/ha) were applied to CICA 4. One-half of the nitrogen and all of the P_2O_5 were applied 33 days after seeding, and the remainder of the N was applied 52 days after seeding. Two additional treatments were included in which all of the fertilizer was applied 33 days after planting.

Although there were some differences in height and maturity because of the higher rates of nitrogen, there was only a slight response to nitrogen at the 50 kg/ha rate and no response to phosphorus. Yields were depressed by the higher rates of nitrogen. There did not appear to be any advantage to making more than one fertilizer application to CICA 4 on this fertile soil.

Rates of seeding

Opinions differ greatly as to the correct amount of seed to use for direct seeding of rice. It is generally believed that varieties which do not produce a large number of tillers should be planted at a higher rate. To gain information on this matter, two different types of rice (IR665-23-3-1-1B and ICA 10) were grown at widely differing rates of seeding.

Yields of both varieties were slightly lower at the 25 and 50 kg/ha seeding rates. There was practically no difference in yields between the two types of rice at the higher seeding rates.

Although the results from this experiment show that it is possible to obtain high yields with much lower seeding rates than are commonly used, it appears desirable to use from 100 to

125 kg/ha on commercial plantings because of increased weed competition at lower seeding rates. Rates higher than 150 kg/ha seem to be unnecessary and increase production costs.

Time of nitrogen application

It is a general practice in Colombia to make three to four applications of nitrogen to direct-seeded rice crops. An experiment was designed to determine the most effective times for applying nitrogen to one of the new lines, IR665-33-5-8-1B. The applications were timed to coincide approximately with the following growth stages of this variety:

Tillering	25 days after seeding
Panicle initiation	60 days after seeding
Booting	67 days after seeding
Heading	77 days after seeding

Results indicate that no benefit was derived from incorporating the nitrogen in the soil prior to planting. As there were no significant differences between this treatment and the unfertilized plot, it appears that the nitrogen was lost before the rice plants were sufficiently developed to use it.

The most effective treatments were those in which 50 kg/ha of nitrogen were applied 25 days after seeding, during the tillering stage. There was no benefit from the application of additional nitrogen during the panicle initiation, booting or heading stages.

Effect of soil moisture on nitrogen response

Low availability of nitrogen is one of the principal factors limiting rice yields in many parts of the world. With transplanted rice it has been found most effective to incorporate the nitrogen in the soil just prior to transplanting. However, such applications with direct-seeded rice are not possible without damaging the rice plants. The two common methods of application are to incorporate it in the soil prior



Under the Crop Production training program, students obtain practical experience and knowledge from CIAT's technical staff.

to planting or to broadcast it in the growing rice as a top-dressing.

In an experiment designed to compare the effectiveness of these two methods on the soil of the CIAT farm using IR665-23-1-1B and a nitrogen rate of 100 kg/ha, it was found that the application on dry soil produced the highest yield. The lowest yield occurred on the plots in which nitrogen was incorporated before planting. Yields obtained from the applications on wet soil and in the water were 87 and 70 percent of that obtained from the application on dry soil. To equal the yield produced by the dry soil application, 140 kg/ha would have to be applied in the irrigation water.

Activities at other locations

Experiments are continuing at the Carimagua station, where flooded rice has been successfully grown for two semesters, with yields of more than six ton/ha in the second semester. A number of management problems have been solved, including soil puddling, pre-plant flooding, and water seeding. Considerable progress has been made in describing the chemistry of flooded oxisols. Iron toxicity, which appears to be a limiting factor for flooded rice, may require pre-plant flooding for satisfactory results.

Seed exchange

During 1970 CIAT supplied 584 seed lots, including fixed lines, segregating lines, and bulk populations, to cooperators in 14 countries. A selection of low temperature tolerant material was obtained from IIRI for trial in Rio Grande do Sul, Brazil.

Training

Nine trainees from Argentina, Brazil, Colombia, Dominican Republic, Ecuador, Peru and the United States received approximately six months training in rice breeding, agronomy, and seed production. Under CIAT sponsorship, ICA's rice quality specialist received five months training at IIRI.

Agricultural economics

A brief publication entitled "Report on Rice" was prepared in cooperation with the rice program. It outlines the present status and future prospects of CIAT's rice program and some of the economic consequences of increased rice production in Latin America.

An expanded version of the economics of rice improvement is being prepared for the Seminar on Rice in Latin America to take place in October, 1971.

Maize Production Systems

The primary objectives of the maize program at CIAT are to increase production and to improve the nutritional quality of maize throughout the lowland tropics, with emphasis in Latin America.

Maize is an important ingredient in the diet of Latin America. For example, estimates of maize consumption from Central America indicate that 60 percent of the calories and 50 percent of the protein come from maize.

In Colombia, maize supplies approximately 30 percent of the total caloric intake. Maize production is increasing, partly because of an increase in land area dedicated to the crop, and partly because of higher yields per hectare. Average production, however, remains between one and two tons per hectare. Moreover, many farmers operate at the subsistence level. More than half of the farms engaged in maize production have less than five hectares, and more than 80 percent cultivate less than 20 hectares. In most cases the crop is grown and consumed on the farm, and only about 20 percent of the crop enters commercial channels.

Migration to urban centers accentuates problems of food supply and nutrition. Preferences for maize and maize products, as well as particular tastes for certain types of maize, are carried from the rural areas into the city. New maize varieties or hybrids with greater productivity and improved quality must incorporate grain characteristics which

are known and accepted by the intended customer.

MAIZE BREEDING

During 1970, a concerted effort was made to bring in commercial hybrids, open-pollinated varieties, and variable populations from maize programs in Asia and the Americas in order to test these materials in the Andean zone and make them available to national programs. Composite populations among these introductions include material from widely diverse commercial sources, as well as maize from the germ plasm banks. These mixtures and new ones will hopefully contain a potential for wide adaptation and a relatively wide resistance to disease and insects. All these maize introductions will be grown in observation plots during the next year, and promising individuals and selections will be combined for further observation and testing.

Early progeny testing and recombination of lines in improved maize populations led to success in Kenya and appear to promise substantial improvement in CIMMYT's international program. CIAT will begin with several basic populations (including opaque, brachytic, Andean-zone low altitude, Andean-zone high altitude, and the world composite), and test early selections from these populations in a number of locations in collaboration with ICA, INIAP, and other national programs. These locations will include a minimum

of three low-elevation and one intermediate elevation stations. Evaluation at high elevation stations will be accomplished by national programs in the zone. Most recombination will be done in the intermediate altitude of CIAT headquarters in Palmira (1,000 meters), and further selections tested in the several regional stations.

In addition to the concentrated effort in maize, a small nursery for sorghum introductions was planted in 1970. Germ plasm collections, promising varieties, and commercial hybrids have been requested from programs in several continents. These genotypes will be planted in 1971, observed in the nursery, and selected for desirable plant type and early maturity. Promising selections will be available at any stage



of development to national programs and commercial companies in the tropics.

MAIZE PHYSIOLOGY

Wider adaptation of varieties or hybrids can lead to greater use of improved maize types by bringing these to a wider range of micro-climates. This will also reduce the number of commercial materials and minimize complicated and expensive seed production procedures. Factors which influence adaptation include photoperiod and temperature sensitivity, wide-based resistance to insects and pathogens, and a minimum susceptibility to drought or high water levels, strong winds, and other adverse climatic conditions.

Work on photoperiod insensitivity continued during 1970, and several relatively insensitive lines were identified in the field. The photoperiod sensitive reaction in maize appears to have two critical light intensity levels. There is a marked delay in differentiation and flowering when sensitive genotypes are exposed to intensities greater than five to seven footcandles, and the same materials are delayed slightly at intensities between one to five footcandles. In these studies, lower intensities had no apparent effect.

Preliminary results indicate a critical day length of 14½ to 15 hours for maize. Quantitative interactions between day length and light intensity have not been studied. There is no apparent effect of day length on growth rate as long as the temperature is constant for contrasting day length conditions. A cooperative project is being planned with CIMMYT to study a uniform set of materials at three altitudes in Colombia and three altitudes in Mexico to explore the interactions of temperature and photoperiod sensitivity.

Excessive plant height and resultant lodging severely limits yield in many coastal areas (Photo taken at Pichilingue, Ecuador).

Efficient energy conversion into plant dry matter and grain are crucial to increased productivity per hectare. In the tropics, where a year-round growing potential must be utilized, yield evaluation should include production per hectare per day, per unit leaf area, and per unit of light intercepted. Recent advances in the measurement of light, leaf area, and physiological maturity have made it possible to measure more of these efficiency parameters at a lower cost. These new approaches may be included in a program directed toward improved growth and production efficiency in tropical maize.

Recent research suggests that the ideal productive maize plant of the future may have fewer but more efficient leaves, short stature, upright leaves, multiple ears, yield-response to high levels of applied nitrogen, and genetic insensitivity to photoperiod and temperature changes. It should be resistant, or at least tolerant, to short periods of excessive moisture or of drought.

Further work on the growth and physiology of tropical maize will help define this ideal plant in more detail.

MAIZE AGRONOMY AND PLANT PROTECTION

1. Management systems

It had been observed in several maize fields on the CIAT farm that kernel development was inhibited on otherwise normal plants. A trial was started to ascertain the effect of different plant populations, fertilization, and boron application on the development of the H-207 and H-208 opaque hybrids. While yields were not high, it was clear that boron improved yields. Distinctly different responses between varieties and between seasons indicate the need for further research. More detailed results for both maize and sorghum are presented in the section on Agricultural Production Systems. That section also includes results from intercropping studies with cassava, and from regrowth studies in sorghum.

2. Insect control

A trial to evaluate the effect of furadan, a systemic insecticide effective in rootworm control (*Diabrotica* sp.), was made to determine whether this chemical would also offer residual insecticidal properties against the fall army worm (*Laphygma* sp.) attacking the whorl of the plant. Evaluation of army worm damage in the early growth stages shows that furadan, applied in granular form to the whorl of the plant or as a foliar spray, was more effective than the conventional granular chemicals applied to the plant whorl. Furadan applied to the soil was not effective. As the plant developed, the residual effect of furadan did not prevent army worm damage to the new leaves. Insect damage at this stage of growth may not appreciably affect yields.

Typical maize culture in the small farms of the Andean zone. Maize is often combined with other crops (in this case with beans, in the highlands of Ecuador).





CIAT must work with national agencies in order to reach the marginal farmers with improved varieties and practical production systems adapted to their conditions.

Furadan applied to the foliage was also effective in preventing leaf damage to young plants by the adult root-worm beetle. Ordinarily, this damage does not merit control measures.

In this test, severe lodging occurred in the field after tasseling due to heavy winds and rains. There was significantly less lodging in the furadan-treated plots than in the non-treated ones. Yields were higher in plots treated with higher rates of furadan but the overall yield level was so low that the profitability of such a treatment is questionable.

MAIZE ECONOMICS

1. Factors Associated with Low Yields

A multidisciplinary analysis of the factors associated with low maize yields

in Colombia is in progress. The objectives of the study are 1) to identify important factors associated with low maize yields among small farmers in certain selected regions of Colombia, 2) to determine the interrelationships among these factors, 3) to suggest avenues of approach to the problem of increasing yields, and 4) to develop a methodological framework which may be applied in similar studies in other regions.

Information has been obtained from three sources: a) small farmers, b) input suppliers, and c) local agricultural extension and lending agencies. Personal interviews, field observations, and soil tests were used as means for obtaining the information. Analyses of these results will be completed in 1971 and the study will be extended to other countries in the Andean zone.

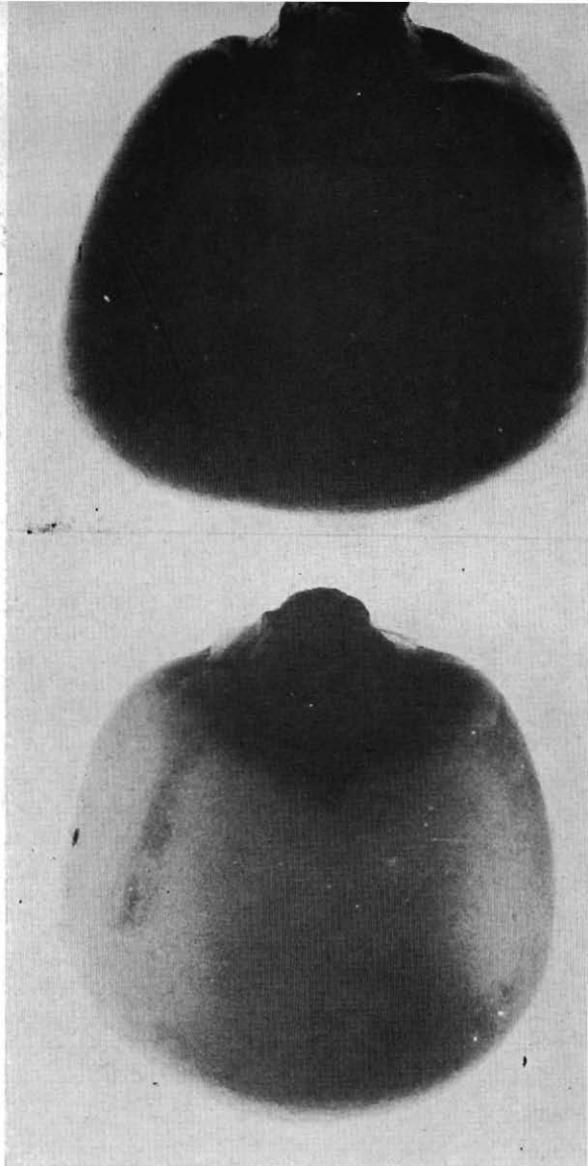
2. Feasibility Study of Opaque-2 Maize

The objectives of the study were to identify the main obstacles to a successful expansion of the production, marketing, and human consumption of opaque-2 maize, and to suggest ways by which these obstacles may be overcome. Basic data were obtained from interviews with producers, marketing agencies, and consumers.

It was found that a rapid expansion of the production and consumption of opaque-2 maize was limited by: 1) low consumer acceptance, 2) wholesalers' lack of interest in handling the product, 3) low relative farm yields in comparison with high-yielding hybrids, 4) low producer acceptance among small farmers, and 5) storage problems. These items directly relate to the floury and soft endosperm of opaque-2 maize, as compared to the commonly grown flint-type maize. The softness of opaque-2 results in low resistance to insect attacks, low kernel density, and undesirable appearance and cooking characteristics.

Results suggest that success in introducing and expanding commercial production for human consumption of the present varieties of opaque-2 would depend on a considerable government subsidy to farmers in conjunction with promotional campaigns among producers, marketing agencies, and consumers. However, if a flint type high-lysine maize with a high-yielding capacity could be developed, government support could be reduced or even eliminated.

Although home consumption of the present floury opaque-2 maize among low income farmers could be promoted at a somewhat lower government cost, such a program would demand a concentrated extension effort, and provision should be made to help the farmer expand his production of ordinary maize or some other cash crop to cover the cost of opaque-2 seed and other additional inputs.



Improved protein quality in opaque-2 maize will be of little advantage if people do not accept the floury-type endosperm (below): the kernel on top has been selected to combine a flint endosperm with high quality in the grain.

MAIZE PROTEIN QUALITY

1. Production of flint-type opaque-2 maize.

The nutritional advantage of opaque-2 maize gives this product high priority in CIAT's genetic improvement pro-

gram. If the genes which modify endosperm type can be identified and concentrated in maize without losing the protein quality advantage of the opaque-2 major gene, many of the production, storage, and acceptability problems associated with present varieties can be eliminated. As a first step toward obtaining a more desirable type of opaque-2 maize, flint and semi-flint grains from commercial harvest of the opaque-2 have been selected and also from lines, single crosses, and other backgrounds with the opaque-2 gene. Preliminary results from laboratory and biological studies are presented under Swine Production Systems.

2. Yields of opaque-2 maize

A field program was launched in 1969-1970 to evaluate the production of opaque-2 commercial hybrids on the farm. Traditional cultural methods were compared with improved technology, including use of fertilizers, weed control, insect control, and irrigation where possible. This study compared the new opaque-2 hybrids with regional varieties, and with the recommended hybrid for each zone. Six Colombian agronomists assisted farmers in planting 110 trials in two seasons in 14 different departments of the country.

In the trials harvested, opaque hybrids were the highest yielding in 15 locations. Over all locations, the recommended normal hybrids yielded 14 percent more than the opaques. More significantly, the opaque-2 hybrids yielded more than 40 percent over the regional varieties, either under improved or traditional cultural methods. From these results, it was apparent that replacement of traditional varieties by an opaque-2 hybrid would significantly increase both the yield and the quality of a small farmer's maize crop.

3. Effects of altitude, temperature, and solar energy on quality

A cooperative study has been initiat-

ed with Purdue University and CIMMYT to evaluate the effects of altitude, temperature, and solar energy on protein content and quality. This is a five-year study of adaptation which also can lead to a better understanding of plant growth and efficiency.

4. Nutrition work with opaque-2 maize

Studies continued during 1970 on the recuperation of undernourished children. This work is carried out by the Department of Pediatrics of the University of Valle and the Metabolic Unit of the Departmental Hospital of Valle. This laboratory has continued to collaborate with both ICA and CIAT in the analysis of protein and lysine in maize samples. Research on several manufactured foods has continued with the cooperation of private industry. Duryea, a baby food made by Fruco-Maizena, S. A., uses opaque-2 maize as a source of protein. Further results in the use of opaque-2 maize in swine nutrition are presented under Swine Production Systems.

PROMOTION OF OPAQUE-2 MAIZE

Although there are field production and marketing problems with the present floury-endosperm opaque-2 hybrids, their tremendous biological value suggests an immediate rural extension effort to begin to alleviate rural nutrition deficiencies.

A cooperative ICA-CIAT project was planned to promote the adoption of the present commercial opaque-2 hybrids among small farmers in Colombia, and to stimulate its industrial utilization in an effort to improve nutritional levels among urban populations. To attain these objectives, the project will attempt:

- 1) To achieve institutional coordination and integration of the various agencies working in the agricultural sector of Colombia;

- 2) To design long-range cooperative projects among research, extension, and public health institutions;
- 3) To organize short courses, seminars, conferences, and symposia to communicate the objectives of the program to technical personnel;
- 4) To use all possible forms of media to inform the public about the purposes of the program and the importance of opaque-2 maize hybrids; and
- 5) To act as an executive agency to advance the Colombian national program for opaque-2 maize.

A program to plant 40 tons of opaque-2 seed in the second semester of 1970 included 2,400 hectares of land, with an expected total yield of 4,800 tons. A total of 182 tons of seed of the two opaque hybrids was distributed to 123 municipalities in 12 departments in Colombia for the first planting season of 1971.

To examine strategies for the promotion of opaque-2 maize, a meeting was held with CIMMYT specialists in Mexico. CIAT staff members also met with officials of the Ministry of Agriculture

of Panama, along with representatives from other agricultural organizations, to discuss seed production and emphasize the nutritional advantages of opaque-2 maize. During the past year, samples of the two opaque hybrids have been sent to about 35 countries in Latin America and throughout the world.

TRAINING IN MAIZE IMPROVEMENT

Training in maize production and improvement continues to carry a high priority. The six Colombian agronomists who conducted regional testing of opaque-2 hybrids completed their training in 1970. One agronomist worked as a trainee in the maize-breeding program for four months before joining the CIAT staff as a research assistant. A scientist from Haiti will soon finish his master's degree in Mexico and join CIAT's maize program as a research fellow. An Ecuadorian agronomist will join the group of research fellows in 1971. In addition, training in the agronomic aspects of maize production is an integral part of the crop production specialist training project reported under the section of Training and Communication.



Research results in maize production systems are an integral part of CIAT's training program.

Agricultural Production Systems

Much of the work at CIAT is directed toward developing, testing, and establishing viable production systems for specific commodities — beef, swine, rice, maize, food legumes, and cassava.

Practical considerations dictate specific attention, as well, to the diverse multi-commodity production operations already to be found in the lowland tropics or which are likely to be acceptable, economically sound, and viable in certain tropical environments.

Consequently, the CIAT staff considers such significant issues as these: a) rotations between and among crops; b) complementary animal-crop systems; c) multi-cropping and inter-tilling; and d) the complementary and competitive aspects of various commodities with respect to allocation of land, labor, credit, machinery, power, water, and other resources. Other considerations must include domestic and export markets, the local marketing and processing potentials, and overall, the relative benefits of various systems to individuals and society. As a consequence, the range of issues with which CIAT must contend, either directly or through national, regional, and other international agencies, is broad and complex.

Multiple cropping

Various maize and soybean inter-cropping schemes with Llanera cassava were planted to test their possible advantages under tropical conditions.

Six treatments were set up, three using the cassava planted into already

existing stands of ICA Pelican soybeans, 51 days after the latter was planted; two involving simultaneous plantings of cassava with either soybeans or H-253 maize; and a control plot of cassava planted alone.

Cassava cuttings, 20 cm in length, were planted at a 45 degree angle, 180

In the tropical lowlands the multiple cropping system offers many advantages to the small farmer (left). A ñame plant (center) grows in a field cultivated with maize and cassava.



TABLE 1. Yields and gross returns of cassava, corn and soybeans in various inter-cropping schemes.

Treatment	Yield ¹ Kg/ha		Gross return ² per hectare
1. Cassava alone	36,330 ³	A	\$ 23,614.50
2. Cassava planted at same time as soybeans	31,650	AB	20,572.50
Soybeans	615		1,599.00
			\$ 22,171.50
3. Cassava, each third soybean row removed	28,870	BC	18,765.50
Soybeans	1,857		4,828.20
			\$ 23,593.70
4. Cassava between every third and fourth soybean row	28,820	BC	18,733.00
Soybeans	1,915		4,979.00
			\$ 23,712.00
5. Cassava planted into every third soybean row	25,590	CD	16,633.50
Soybeans	1,984		5,158.40
			\$ 21,791.90
6. Cassava planted at same time as maize	21,380	D	13,897.00
Maize	4,364		7,200.60
			\$ 21,097.60

1. Time between planting and harvesting was 12-1/2 months.

2. Cassava price at \$ 650 Col. per ton. Soybean price at \$ 2,600 Col. per ton. Maize price at \$ 1,650 Col. per ton.

3. Means followed by the same letter are not significantly different at the .05 level.

TABLE 2. Sorghum yields under different management treatments. (Non-replicated field trial.)

Semester A Treatments ¹	Yield (Kg/ha)	Semester B Treatments ¹	Yield (Kg/ha)
P-25 With Irrigation	2942	Fertilized and field cultivated	5290
		Fertilized	5466
		No fertilizer	4589
P-25 Without Irrigation	2042	No fertilizer	5612
		Fertilized	6226
		Fertilized and field cultivated	6109
ICA-Pal-1 With Irrigation	1520	(Regrowth from the ICA-Pal-1 did not warrant leaving the stand for further harvests)	
ICA-Pal-1 Without Irrigation	1234		

¹ Irrigation treatments consisted of two irrigations each semester. Fertilization consisted of an application of 200 kg of urea after the first harvest. Field cultivation was made with a single shovel on a cultivator passed between the rows.

cm between rows, and 110 cm between plants, for all treatments.

Results are presented in Table 1. Cassava yields were lowered by the competition for light, water and nutrients from the companion crop; however, total gross return was quite similar for all cropping systems. If costs of production are considered for the double cropping systems, the difference in net return between the various systems would be very slight.

Production of cassava planted in existing stands of soybeans was apparently related to the amount of space available for plant growth. Yields were highest when cassava replaced soybeans in the row (Treatment 3), and lowest when cassava was planted into the soybean row (Treatment 5). The cassava was more competitive than the soybeans when both were planted at the same time, and tended to crowd the soybeans out.

The maize companion crop grew considerably taller and faster than the cassava. Maize competed for a longer time than the soybeans planted earlier than the cassava.

Sorghum management systems

Sorghum regrowth

Two varieties of sorghum, P-25 and ICA-Pal-1, were planted in a field trial to evaluate length of sorghum survival through regrowth under different levels of management. Plots with and without irrigation were planted for both varieties. ICA-Pal-1 failed to give sufficient regrowth after the first harvest for further harvests. Various treatments were applied to the remaining irrigated and non-irrigated plots of P-25, as follows: 1) fertilization and field cultivation; 2) fertilization alone; and 3) neither fertilization nor field cultivation. Yields in this experiment are presented in Table 2.

Higher yields of the non-irrigated treatments of the regrowth can be ex-

plained by the fact that the treatment under irrigation matured considerably earlier, resulting in an estimated 20 percent loss of seed because of bird damage. The non-irrigated plots did not suffer as much bird damage because seed was produced at a time when other fields were maturing, providing larger areas for the feeding birds.

Both for the irrigated and non-irrigated regrowth plots, field cultivation appears to have resulted in lower yields when compared to the plots that were fertilized only. This may be explained in terms of root pruning by the field cultivator. Differences were quite small.

Additional field observations within this experiment point to the fact that normal combine harvesting results in a considerable loss of seed, which then germinates and produces harvesting problems of the regrowth because of a wide variation in maturity.

Grain and forage residue production

In another experiment designed to evaluate sorghum grain and forage residue production at different levels of maturity, it was found that some varieties are well-suited for early grain harvest with a 25-30 percent moisture content. A system should then be used for recovering the stalk and grain residues from the combine. In this manner, sorghum regrowth would permit a second harvest considerably earlier than would be possible if a new planting were established.

Boron and urea applications

Foliar micro-nutrient applications on sorghum had failed in 1969 to show a visible response in correcting severe leaf-streaking observed in sorghum. As boron deficiency is rather common throughout the Palmira area, a large-scale field trial evaluated the response of sorghum to boron.

A commercial planting of P-25 sorghum had shown slow regrowth after

Effect of boron on two maize hybrids produced under similar cultural practices at CIAT's headquarters near Palmira.



harvest in March. Plants were cut back with a rotary mower and various treatments applied. Boron, in the form of borax, was broadcast as a foliar application at rate of 20 kg/ha. In another treatment, the same amount of boron was applied in combination with 150 kg/ha of urea. In addition to a control plot, two other treatments of 300 and 150 kg/ha of urea were included.

No visible improvement was observed in the borax treatments. However, yields were slightly higher when compared with the urea treatments. There were no apparent cumulative effects when boron and nitrogen were applied together.

Boron application in maize

Maize is much more severely affected by boron deficiencies than adapted sorghum varieties such as P-25. An application of borax was made on part of a production field with little or no apparent effect on the first maize crop seeded after application. Differences between no boron treatments were dramatic in the second crop of maize. The lack of response by the first crop is not entirely understood but was probably associated with inadequate incorporation in the soil. Boron has been known to be limiting for alfalfa and citrus on many Cauca Valley soils for a number of years but had not been

reported as limiting for either maize or sorghum.

Soybean management systems

Irrigation and soil variability

Two recently-leveled fields were planted to ICA-Lili and ICA-Pelican soybeans to observe soil variability following leveling and to evaluate the effects of irrigation on soybean production.

Soybeans in the irrigated treatments were planted on raised soil beds shaped with a bedder following the formation of ridges with a lister-type cultivator. Two rows, 70 cm apart, were planted on each bed. One furrow irrigation was made at flowering.

The effects of irrigation were shown in both varieties by a considerable yield increase. In one of the two fields occupied by the experiment, however, soybeans were poorly developed and displayed symptoms of physiological stress. These symptoms were similar to those observed in plants infected with soybean mosaic or damaged by 2, 4-D, and occurred in rather large patches in the field. Cause of this phenomenon has not as yet been identified, although as the same symptoms appeared in the same areas upon replanting, this would seem to rule out the possibility of an infectious disease unless it were a soil-borne organism.

Bird damage control

The chemical DRC-736* showed promising results last year for controlling bird damage caused by the eared dove (*Zenaida auriculata*) to emerging soybean seedlings. Trials this year provided more evidence of its effectiveness.

In previous trials, the chemical was mixed with a sticker-spreader substance (Roplex AC33) to provide better adhesion of the chemical to the seed. The wetting action of this substance caused some damage to the seed coat. Consequently, corn oil was studied as a substitute for Roplex AC33. The combination corn oil - DRC-736 repelled the doves just as effectively.

Minor difficulties were encountered in planting soybean seed treated with the corn oil - DRC-736 mixture. A gradual caking of this mixture in the revolving planter plates causes a slower rate of planting, which can be corrected by increasing the planting rate.

Soils at CIAT's farm, El Porvenir

Previous field observations led to the conclusion that iron deficiency might be a serious limiting factor in sorghum, pangola grass, and perhaps soybeans. Greenhouse experiments in 1970 confirmed the iron deficiency in sorghum on many soils at El Porvenir.

Zinc appeared to be limiting rice production on both CIAT and ICA farms in the Palmira area where soils had been cut in the leveling process.

In addition to micronutrient deficiencies, nitrogen deficiencies were common on most non-leguminous crops. Severe phosphorus deficiency was confirmed on at least one exposed subsoil.

Detailed sampling revealed narrow

* DRC-736 is the designation used by the U.S. Dept. of Interior, Fish and Wildlife Services, Bureau of Sport Fisheries and Wildlife, Denver Federal Center, for Bay 3734 (Mensurol), a carbamate insecticide developed by The Bayer Chemical Co.

Ca/Mg ratios to be common throughout the CIAT farm. Calcium usually decreased with depths as magnesium increased, with ratios of .60-.70 at 80-100 cm depths. Increasing magnesium is often accompanied by increasing sodium. The implications of low exchangeable calcium, high exchangeable magnesium are not yet clearly known.

Rice was grown successfully on poorly drained soils, including saline spots. Rice yields of more than 10 tons per hectare were obtained. An upland crop has not yet been grown following the rice to permit appraisal of the effect of flooded rice on saline soils. Water quality is sufficiently good to expect a significant improvement.

A sodic soil from El Porvenir was used in a column-leaching experiment in which different rates of sulfur and gypsum were superficially applied and incorporated. Best results were obtained when gypsum was applied on the surface of the soil, but the leaching rate was too slow to be of any practical value.

Cooperative work at ICA's Carimagua Center.

At the ICA Carimagua Center, located in the Colombian Llanos Orientales, research was initiated on forage crops, flooded and upland rice, and sorghum during 1970.

Forage crops

Phosphorus levels are low in the soils at Carimagua (3 ppm with Bray II extractant). A few species of forage crops can be established without added phosphorus from fertilizer; but establishment is usually slow, and excessive seeding rates are required to get good first season stands. Applications of 75 kg/ha of P_2O_5 resulted in rapid seedling establishment and development of molasses grass (*Melinis minutiflora*) using 12.5 kg of seed/ha, about half the rate locally recommended. Large plots (176 ha total) for a grazing trial were established with three fertilizer treatments:

1) no fertilizer; 2) phosphorus; and 3) phosphorus plus potassium. Fertilized plots were ready for grazing three to four months after seeding, whereas non-fertilized grass normally requires a full year before grazing.

Three experiments were conducted using herbicides to control native sod, and then introduced species were surface-seeded with no mechanical seedbed preparation. Delapon was the only herbicide tested which consistently gave good control of the native grass composed primarily of *Trachypogon vestitus* and *Axonopus purpureii*. Where control was adequate, satisfactory stands of molasses grass were obtained, and, in some cases, seeding of *Stylosanthes guyanensis* was successful.

The establishment of grasses in this manner is of interest from several standpoints: 1) erosion hazard would be much less on rolling land surfaces than with mechanical seedbed preparation; 2) machinery investment could be kept to a minimum, with herbicide being custom-applied either by airplane or ground equipment or with smaller, non-motorized equipment; 3) much less time would be required than with mechanical seedbed preparation; 4) reduction of the overall cost of seedling establishment might be possible by substituting chemical for mechanical control.

Establishment of the forage crops was slow even on plots where excellent vegetation control was achieved, probably because of poor seed-soil contact. Further trials are projected in which a rolling ripple-blade coultter will be used to prepare a narrow strip of soil where seed and fertilizer will be banded.

In another experiment, a number of legume and grass species were seeded alone and in limited mixtures at three fertility levels, with conventional seedbed preparation. Preliminary observations indicate that several species were easily established, even with no fertilizer or with phosphorus only. The most promising legumes include *Stylosanthes guyanensis*, *Calapogonium muconoides*,

Desmodium intortum, and *Pueraria phaseoloides*. The grasses which show most promise for this area are *Melinis minutiflora*, *Hyperrhenia rufa*, and *Brachiaria decumbens*.

Rice

Two major problems have been encountered in growing rice on oxisols. The first is one of reducing permeability, often as high as 1,000 mm/day in freshly plowed Llanos soils. Permeability must be greatly reduced to grow flooded rice successfully. The highly aggregated soil at Carimagua was puddled with a mounted rotary tiller working in water, and infiltration was substantially reduced. The first crop was grown from March to June, and, after the rains started, the pump was required only once for 45 minutes to maintain a constant depth of water in the field.

The other problem is a physiological disease known as "anaranjamiento" or "orange leaf". Greenhouse and laboratory research results obtained in 1970 support the view that iron toxicity is in part responsible for this disease. Extreme phosphorus deficiency also appears to be involved. Preplant flooding for three weeks alleviated this problem to some extent. Flooding and subsequent reduction normally bring about many changes in the soil, including a rapid increase in pH, decrease in Eh (redox potential), and an initial increase in iron concentration in the soil solution. After an initial, and sometimes sharp and rapid increase, iron concentration usually decreases to a level intermediate between the initial level and the high reached in most inorganic soils within two to three weeks.

A series of greenhouse experiments on Eh, pH, electrical conductivity, and soil solution concentrations of iron, manganese, and phosphorus in flooded oxisols indicate that the soils at Carimagua are quite low in fertility and that upon flooding reduction proceeds very slowly until fertilizers are added. Negative Eh values were never mea-

sured without the addition of fresh organic material, even after 18 weeks of flooding.

It is believed essential not to drain the soils at Carimagua once they are flooded and puddled, as draining would interrupt the reduction process and might result in critical post-plant levels of soil-solution iron. Drainage would also result in soil cracking and a partial loss of the effect of puddling. Rice, therefore, should be seeded into water. Pregerminated seed has been successfully seeded into 5-7 cm of water, and stands have generally been good. Yields in a farm-size paddy of IR8 grown during the second semester of 1970 ranged from 4,500 to 6,300 kg/ha dry paddy.

The Inter-American Center for Photo-interpretation (CIAF) has provided a complete photo-mosaic and a tentative soils map based on photo-interpretation of the 20,000-hectare Carimagua Center. The soils map will serve as the basis for locating a livestock management unit in a long-range research program involving several thousand hectares at Carimagua.

Training

Eleven post-graduate interns received in-service training during 1970 — two in soils, four in plant pathology, two in agricultural engineering, and three in crop production. A research fellow was appointed for one year to work in plant protection; and a research scholar is enrolled at the ICA Graduate School, working toward a master's degree in plant pathology. In addition, two special trainees completed training in multiple cropping at IRRI under CIAT sponsorship. Eleven of the above-mentioned trainees are from Colombia, one is from Ecuador, and one from Peru. One special trainee from the United States is carrying out research in field beans as part of a doctoral program under the sponsorship of the Foreign Area Fellowship Program.

Two graduate students from Cornell University are conducting doctoral re-

search with soils from the Colombian Llanos. One was in Colombia during 1970, conducting field research at Carimagua and laboratory research at ICA's Tibaitata Center near Bogota. The other student was in residence at Cornell University, and plans to return to Colombia early in 1971. He will live and work at Carimagua, concentrating on the "orange leaf" anomaly of rice grown on flooded oxisols.

A post-doctoral visiting scientist worked independently on flooded oxisol systems with experiments in the laboratory, greenhouse, and field. His work has contributed to understanding the physiological disease called "orange leaf".

Cooperative projects at Monteria

A CIAT research assistant was assigned to the cooperative CIAT-ICA crop production program at ICA's Turipana Center near Monteria on the north coast to collaborate in the overall planning and work implementation in crop rotation, fertilization, and tillage practices.

Work begun in 1968 on land leveling for crop production was completed, and modifications in the drainage and irrigation canal system for the field were made.

Rainfall during the cropping season was again above normal in 1970, and this caused serious crop management problems the first semester, and land preparation and planting difficulties in the second semester. Irrigation water, available from INCORA's Cordoba II Project for the first time, was used for supplemental water needs with irrigated rice.

A plot was planted to maize in December to evaluate production under irrigation conditions during the dry season. Studies on fertilization, subsoiling, and crop rotations were planned and laid out according to land slope in an attempt to reduce drainage problems. This layout was also designed to permit irrigation during the dry season.

TABLE 3. Origin of 1,000 plant introductions from USDA tested in 1970.

Country of Origin	Number of PI entries	Country of Origin	Number of PI entries
China	8	Belgium	3
United States	4	Argentina	2
Turkey	572	India	82
Venezuela	5	Guatemala	37
Ruanda Urundi	3	Switzerland	3
Canada	60	Holland	9
Iran	21	Nepal	2
South Africa	29	France	1
El Salvador	12	Italy	5
Mexico	27	Germany	17
Chile	10	Syria	15
Australia	2	Libya	12
Colombia	9	Yugoslavia	4
Brazil	3	British Camerouns	10
Paraguay	4	Nigeria	3
Ecuador	5	French Camerouns	2
Bolivia	4	Congo	2
Peru	3	Ethiopia	8
Arabia	2		

Higher yields of around 4,500 kg/ha indicated a promising potential for rice production in this area on poorly drained soils.

Maize yields of about 2,700 kg/ha were obtained with the ICA varieties H-104 and H-154. The closeness of the water table to the soil surface (25-50 cm, as measured by INCORA) makes maize production difficult in this area, and therefore a system of marking ridges to raise the plants out of the water has been utilized. The same problem also affects other cultivated crops, such as soybeans, sorghum, and sesame.

Food Legume Production Systems

Food legumes are considered an exploratory commodity thrust under CIAT's production systems orientation.

A cooperative ICA-CIAT project to increase and evaluate the bean germ plasm collection of the United States Department of Agriculture under tropical conditions was initiated during the second semester of 1970. Its initial phase included 1,000 PI entries of *Phaseolus vulgaris*. Part of the seed will be sent to the United States and part will be stored in Palmira to be used by CIAT and ICA. The 1,000 en-

tries tested in 1970 were planted in single row plots 6 m long and 60 cm wide. Table 3 shows the origin of these entries.

Germination was between 60 and 100 percent for all entries, but only 760 varieties produced seed. The remaining 240 varieties produced some flowers but did not set seed.

The following agronomic traits were scored for each entry: days to germination, days to flowering, days to maturity, habit of growth and disease reaction (rust, common blight, mosaic, and powdery mildew). Disease reaction was scored from 0 to 5, where 0 was the absence of disease symptoms, and 5 was complete susceptibility. Mosaic score was made without identifying the type of virus causing it. Habit of growth was classified as bush, viny or semi-viny.

More than 80 percent of the entries exhibited a disease reaction greater than 3, which means that more than 800 varieties showed susceptibility to one or more diseases.

If the range of 0 to 1.5 is regarded as the range of resistance, the percentage of disease resistance was as follows: rust, 17 percent; common blight, 10 percent; mosaic, 12 percent; and powdery mildew, 18 percent.

TRAINING AND COMMUNICATION

Training and communication is one of the professional groups of CIAT and consists of the following activities: Training, Information Services, Field Projects and Demonstrations, Library, Statistics, and Housing and Food Services.

The Training and Communication Program encompasses activities designed to achieve three primary goals considered instrumental to the development process:

1. To **mobilize** — the identifying of institutions and individuals whose roles in the various countries involved are highly relevant to the development process.
2. To **energize** — the bringing together of these institutions and individuals in meaningful ways and with a catalytic-type action. This includes information dissemination, as well as conferences, symposia and other exchange activities.
3. To **qualify** — the training of individuals so that they can effectively function in their own institutions and thus enable those organizations to contribute significantly to the development process.

These activities involve a basic philosophy of development which underlies CIAT's educational programs. It is considered that the central element of the development process is man himself, and therefore the behavioral changes that can be effected in order to improve the decision-making abilities of individuals will bear upon the speed

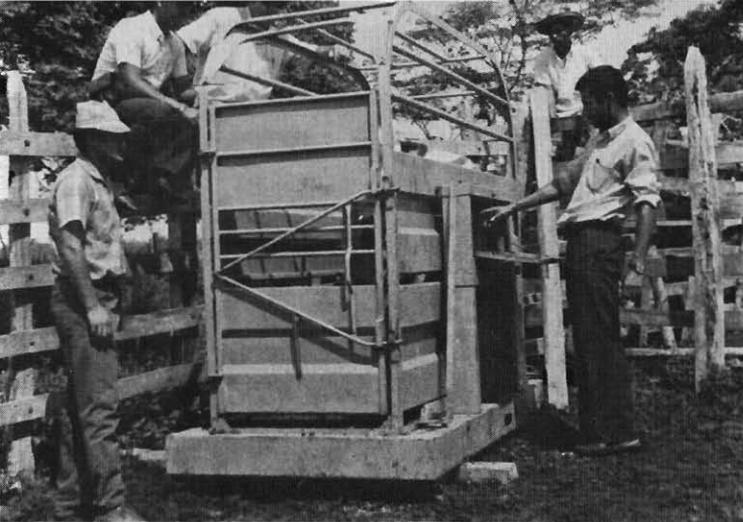
with which the development process takes place.

More specifically, this task involves:

1. Helping people to **know and understand the alternatives** for action when faced with a problem;
2. Helping people to **develop criteria** for choosing among alternate courses of action; and
3. Helping people to acquire the capacity to **anticipate the probable consequences** of the various alternatives, and to **use them as criteria** for evaluating the appropriateness of the action taken in solving a particular problem.

In addition, a prime consideration in all of CIAT's training activities is to inculcate in participating individuals a sense of urgency and dedication to work for the development of their countries.

The training programs begin with a clear definition of objectives in behavioral change and level of performance. The type of professional CIAT aims to produce is one with five major competencies. In addition to acquiring practical experience and applied training in **farming** within the context of the humid tropics ecology, this professional should also obtain from CIAT's program a familiarity with and ability to handle the **economic, scientific, technical, and communication** aspects of modern agricultural production and diffusion of technology. The training emphasizes problem-solving and production-related objectives which are taught through a learn-by-doing methodology.



A portable scale used to weigh steers in the evaluation of cattle management systems in a cooperating ranch on the north coast of Colombia.

Finally, follow-up and support programs are designed to keep in close contact with alumni so as to enable CIAT staff to assist above and beyond the training *per se* in the trainees' respective institutions and countries.

PROGRAM DEVELOPMENT

An important development in the Training and Communication program has been the increase of funds for trainee support. In addition to the fellowships made available in the Kellogg grant, AID supported 34 trainees in 1970. Some of the core budget also has been allocated to support research fellows obtaining advanced degrees and additional post-graduate interns.

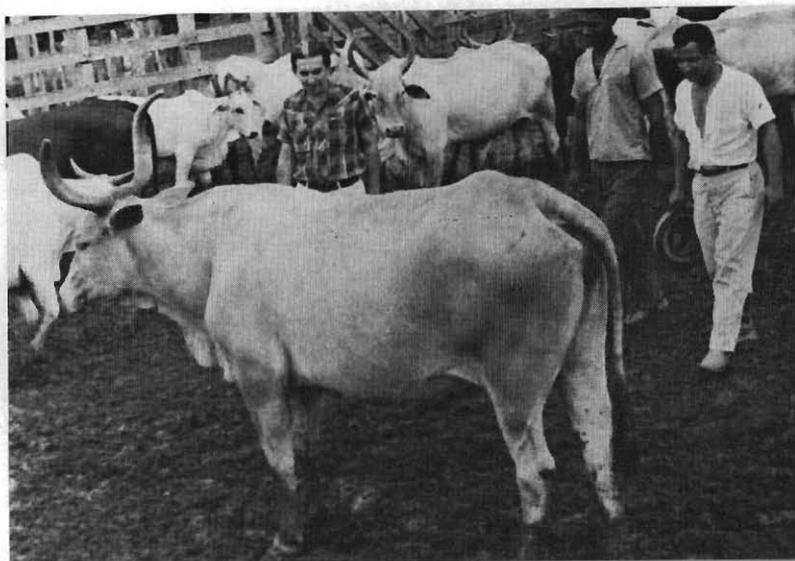
A contract was signed with the Inter-American Development Bank (IDB) for a grant of \$300,000 to carry out a series of production specialist training courses — some in tropical crop production, and others in livestock production over the two-three year period beginning in January, 1971.

TRAINING

As CIAT gains experience in training within the socio-ecological context of the lowland tropics, a categorization of training activities and consequently of trainees themselves becomes feasible.

Faced with the need to provide practical experience for young graduates, CIAT created a category of trainee call-

At the very site of the cattle ranches a CIAT trainee (left) had an opportunity to discuss, share experiences and take decisions with ranch owner (right) and farm manager (center).



ed post-graduate intern. Included in this category are in-service training and what has been termed production specialist training. In-service trainees spend varying periods of time applying academic training obtained throughout their university careers in CIAT research and development projects, directly supervised by a senior staff member.

Production specialists are treated as a group specializing in the various aspects of efficiently producing a particular commodity. Major emphasis is placed on the applied aspects of production, although some classroom training is also provided.

While the training activities mentioned above emphasize research and production techniques and abilities, CIAT also has collaborative arrangements with various academic institutions for graduate studies leading to advanced degrees. The thesis work is performed under the supervision of CIAT staff and concentrates on a problem related to the humid tropics. The degree is granted by the collaborating institutions.

During 1970, a total of 69 trainees participated in the various training programs of CIAT. This total included 29 production specialists, 25 in-service trainees, 2 research fellows, 7 research scholars and 6 special trainees. These trainees represented the following countries: Colombia (53), Peru (2), Dominican Republic (2), Ecuador (5), Brazil (2), Argentina (1), the Netherlands (1), and the United States (3).

Beginning in June, 1970, seven trainees were selected from various universities in Colombia to participate in a crop production specialist training course. After 15 days of intensive training in interviewing techniques and diagnosis of maize production problems, they participated in a study to identify some of the factors associated with low maize yields observed among small farmers in Colombia. These trainees learned to interact effectively with the small farmer as they interviewed some

300 maize producers, both on the agronomic as well as the socio-economic aspects of their operations. The training program for these crop production specialists is continuing through June, 1971, with instruction in the production techniques of other crops grown under tropical conditions.

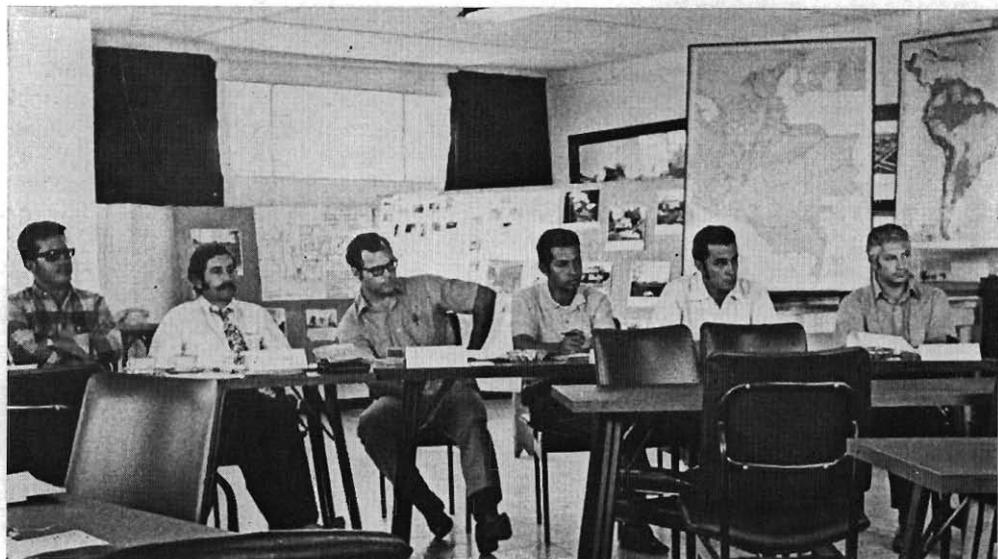
Involvement of these production specialists (whose background is mainly of a technical nature) in socio-economic research, as in the case of the study mentioned above, has proven to be an efficient mechanism both for instruction and for motivation of the trainee. He becomes, through this type of on-the-job training, directly involved with farmers and learns to analyze their problems from more than just a technical standpoint. The trainee thus acquires an understanding of the social context within which these problems occur and comes in contact with the complexity involved in finding appropriate solutions.

In-service postgraduate interns

In-service training is predicated on direct supervision by one or more staff members. Areas of study covered in 1970 included a broad range of specializations. Beef production, swine production, and animal health were grouped under animal science; and crop production, food legumes, plant pathology, opaque-2 maize production, rice production and cassava production within plant science. The 25 trainees within this category were distributed as follows: animal science, 5; plant science, 15; agricultural economics, 3; and agricultural engineering, 2.

Research scholars

Three research scholars are nearing completion of their training in communication under CIAT auspices at the graduate school in Chapingo, Mexico. In addition, four trainees at ICA's graduate school in Tibaitata are continuing their work for the master's degree. Two



At the final stage of the Livestock Production Specialist Training Project a one-week seminar was held to discuss the trainees' experiences on the north coast ranches with CIAT staff members and officials of the major Colombian agricultural institutions.

of these are in animal health, one in plant pathology, and one in swine production.

Research fellows

Research fellows already possess an advanced degree. They are appointed for one year to carry on research in a specific problem area. During 1970, two research fellows completed their appointments — one in swine production and one in plant protection.

INFORMATION SERVICES

The equipment for the small offset reproduction plant was installed at CIAT headquarters in 1970 and most of the printing work is now being handled in CIAT's shop, although large jobs are done commercially.

During 1970, the first CIAT Annual Report (English version), containing a narrative account of CIAT activities during 1969, was published. The Spanish edition is being published in 1971.

A descriptive brochure stating CIAT's objectives, philosophy, programs, and short and long term goals was printed in English and Spanish. A pamphlet describing CIAT's training programs and requirements was issued in Spanish.

CONFERENCES AND SYMPOSIA

Conferences and symposia help CIAT to establish closer contacts with key institutions and persons, and to disseminate information and influence policy decisions regarding important agricultural issues for the tropical countries.

Through its rice production program, CIAT has produced improved varieties with a higher-yielding capacity. These varieties are now ready to be released to rice-producing countries, and, as a related activity, a seminar on rice in Latin America is scheduled for October 10-14, 1971.

Simultaneous translation equipment has been purchased for immediate use

this year in CIAT's present facilities and for future permanent installation in the projected Continuing Education Center buildings.

In addition to international activities regarding conferences and symposia, an internal seminar series was begun at CIAT headquarters in September, 1970, for staff members and trainees. These seminars focus on agronomic and related economic problems within the lowland tropics and present staff members and trainees with the opportunity to exchange ideas on research problems and their possible solutions.

LIBRARY

At the end of its first full calendar year existence, the Library's collection stood at 3,546 volumes. The Library was receiving 455 journals by subscription, gift and exchange. The total number of titles cataloged during the year was 1,345.

A large collection of maps dealing with CIAT's areas of interest in Colombia and a collection of catalogs of manufacturers and dealers of equipment

and supplies suitable for CIAT's programs were obtained.

The Library had bound 475 volumes of journals and books on contract with binderies in Cali and Palmira.

To notify CIAT's staff of new acquisitions, the Library issues a monthly list of titles cataloged entitled **Ultimas Adquisiciones**. The list is also distributed to libraries and scientists in Colombia and other countries which express interest in receiving it.

STATISTICS

The statistics section of CIAT has been planned and budgeted to start operating in 1971. A consultant, Dr. Henry Tucker, professor of systems engineering, University of Arizona, made a brief visit to CIAT in October, 1970, and will come again for two weeks in March, 1971, to make a more detailed analysis of CIAT's statistical and computer needs. In anticipation of the final staffing and equipping of the statistics section, an informal survey of computer facilities was made in the four major cities of Colombia.

**Administration
and
Finance**

PRICE WATERHOUSE & CO.

APARTADO AEREO 190
CALI-COLOMBIA

March 25, 1971

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, 1970 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.

In our opinion, except for the understatement of the excess of expenses over income described in the following paragraph, the accompanying financial statements examined by us present fairly the financial position of Centro Internacional de Agricultura Tropical (CIAT) at December 31, 1970 and the results of its operations for the year, in conformity with generally accepted accounting principles.

We stated in our opinion dated May 8, 1970 that we regard the inclusion in the financial statements for the year 1969 of certain commitments for future expenses (mainly materials and supplies) as not being in accordance with generally accepted accounting principles. These expenses were incurred in 1970 and as a result the excess of expenses over income for the year is understated by \$88,275.

Price Waterhouse & Co.

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

BALANCE SHEET

DECEMBER 31, 1970

(Expressed in U.S. dollars — Note 1)

ASSETS (Note 2)

Cash and banks		925,374
Demand deposits		33,993
Funds on deposit with, or allocated by, The Rockefeller Foundation, New York (for purchases)		388,198
Receivable from Agency for International Development, Washington, D.C.		57,598
Advances to employees		16,399
Advances to contractors and others		62,216
Miscellaneous accounts receivable		23,295
Property and equipment (Note 3):		
Land	3,206	
Farm equipment	224,232	
Laboratory equipment	171,316	
Furniture, fixtures and office equipment	145,314	
Vehicles	248,313	
Construction in progress	<u>474,393</u>	1,266 774
Other assets:		
Experimental livestock	43,846	
Books and periodicals	41,778	85,624
Total assets		<u>2,859,471</u>

LIABILITIES AND FUND BALANCES

Liabilities:		
Accounts payable		53,082
Accrued employees' benefits		<u>20,854</u>
		73,936
Deferred income — advance from Interamerican Development Bank, Washington, D.C.		<u>25,000</u>
Fund balances (accompanying statement):		
Capital asset fund		2,828,883
Operating fund — deficit		<u>(68,348)</u>
		2,760,535
Total liabilities and fund balances		<u>2,859,471</u>

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)**STATEMENT OF INCOME AND EXPENSES****FOR THE YEAR ENDED DECEMBER 31, 1970**

(Expressed in U.S. dollars — Note 1)

Income:—

Operating grants (Note 4):	
The W. K. Kellogg Foundation, Battle Creek	69,956
The Rockefeller Foundation, New York	423,408
The Ford Foundation, New York	500,000
Agency for International Development, Washington, D.C.	240,107
	<hr/>
	1,233,471
Interest	12,897
Sale of farm produce and miscellaneous income	21,627
	<hr/>
	1,267,995

Expenses:

Salaries, wages and employees' benefits	881,746
Agricultural and other materials and supplies	167,324
Freights and miscellaneous shipping expenses	43,283
Travel	169,713
Trainees' allowances and expenses	150,573
Maintenance and repair of equipment	58,968
Insurance	20,773
Telephone, telegraph and postage	16,239
Rent	5,918
Light, power and water	2,198
Trustees' compensation and travel	11,097
Security services	7,108
Publicity and printing	6,313
Cafeteria — net	4,524
Consultants and professional fees	5,911
Conferences	1,609
Entertainment expenses	2,045
Exchange loss	2,389
Subscriptions and books	2,472
Contributions to local schools	1,366
Miscellaneous	17,232
	<hr/>
	1,578,801

Excess of expenses over income

310,806

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)
STATEMENT OF CHANGES IN FUND BALANCES
FOR THE YEAR ENDED DECEMBER 31, 1970

(Expressed in U.S. dollars — Note 1)

	Operating fund	Capital asset fund
Fund balances, December 31, 1969	356,719	1,886,685
Transfer of 1969 revenue of the capital asset fund credited to operating income of that year	(9,088)	9,088
Reimbursement of unexpended operating funds of 1969:		
The Rockefeller Foundation, New York	(4,563)	
The Ford Foundation, New York	(100,610)	
Capital grants (Note 4):		
The W. K. Kellogg Foundation, Battle Creek		45,029
The Rockefeller Foundation, New York — Cash and allocation of funds		776,247
Adjustment of excess of capital grant received in 1969		(6,819)
Agency for International Development, Washington, D.C.		18,717
Revenue of the capital asset fund in 1970		99,936
Excess of expenses over income in 1970 (accompanying statement)	<u>(310,806)</u>	
Fund balances, December 31, 1970	<u>(68,348)</u>	<u>2,828,883</u>

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

NOTES TO FINANCIAL STATEMENTS

DECEMBER 31, 1970

(Expressed in U. S. 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	Approximate	year-end	ex-
Peso balances included in cash and banks, deposits, advances, accounts receivable, other assets and liabilities	19.09	exchange rate		
Peso disbursements for property and equipment and expenses	18.52	Average monthly rate of exchange applicable to sales of dollars		
Peso income	18.34	Average monthly rate of exchange applicable to sales of dollars		

NOTE 2:

CIAT operates under an agreement signed with the Colombian government, the most important stipulations of which 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 provides land for CIAT's purposes under a rental contract for ten years, at a nominal rent. This contract may be extended by mutual agreement.

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 are generally designated as to purpose (acquisition of capital assets or payment of expenses). When no such specification is made the part of the funds received which is used to purchase capital assets is included in the capital asset fund and the remainder in income of the operating fund.

This report
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