CATIE 1983
ANNUAL REPORT

(IFAD TA 38B GRANT)

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CATIE 1983
ANNUAL REPORT
(IFAD TA 38B GRANT)

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA
Departamento de Producción Vegetal

Turrialba, Costa Rica, 1984

CATIE is a civil, nonprofit, autonomous association, scientific and educational in nature. It carries out, promotes and stimulates research, training and technical cooperation in agricultural, animal and forestry production in order to offer alternatives to the needs of the American Tropics, particularly in the countries of the Central American Isthmus and the Antilles. The Center was created in 1973 by the Government of Costa Rica and IICA. Accompanying Costa Rica as a founding member, Panama joined in 1975, Nicaragua in 1978, and Honduras and Guatemala in 1979.

IFAD (International Fund for Agricultural Development) was stablished in 1977 as a specialized body within the United Nations Organization. It is formed by 136 member countries, who's contributions create an economic fund. This fund is destined to finance projects designed to contribute to the solution of the world's food problem and rural poverty. These projects include: loans for integrated rural development; development of infrastructure and institutions of support to agricultural production; grants in direct support of agricultural research, extension and credit destined to small farmers; training and other support needed to develop agricultural cooperatives and other farmer organizations for production and marketing.

PREFACE

This report is on the progress made by CATIE during 1983, under the TA Grant 38C-CATIE from IFAD. These efforts were directed to improve the technical and economic performance of important cropping systems, thus benefiting the small farmers who practice them in areas selected by their priority for development in different countries of the Central American region. The activities include: research on production systems for annual crops, training of nationals of CATIE's member countries in agricultural research and production techniques, and technical assistance to national agricultural research and extension programs. Furthermore, most research activities were conducted through interaction with personnel from the national programs and farmers, which reinforces training, extension and technical cooperation.

Contributors to this document include the personnel from the Plant Production Department of CATIE directly involved in the reported activities and other, particularly Margaret Smith, Raúl Moreno, Carlos Burgos and Joseph Saunders.

Other contributors include: Susan Shannon in edition, Maricela Chaves in typing and Hector Chavarría and Andrés Núñez in the final production of the report.

Thanks are also given to the many national colleagues and farmers who participated and contributed to the progress made during the year.

Finally, a recognition is due to IFAD for providing timely and needed support to the activities of CATIE in the Central American region.

Luis A. Navarro
Technical Coordinator

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ACRONYMS

CATIE	Tropical Agricultural Research and Training Center
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CLAIS	Latin American Commission for Sorghum Researchers
DGTA	General Direction of Farming Techniques, Nicaragua
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IDA	Institute of Agricultural Development, Costa Rica
IDIAP	Agricultural Research Institute of Panama, Panama
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INTSORMIL	International Sorghum and Millet Program
ITCR	Technological Institute of Costa Rica
LHT	Lowland Humid Tropics
MAG	Ministry of Agriculture and Livestock
MIDINRA	Ministry of Integrated Development and Agrarian Reform
PCCMCA	Central American Cooperative Program for the Improvement of Food Crops
PPD	Plant Production Department (CATIE)
SAT	Semi-arid Tropics
UCR	University of Costa Rica

INTRODUCTION

The IFAD TA 38 Grant to CATIE is for the financing and support of activities related to research and technology development in food crop production, as part of CATIE's work in the Central American Isthmus.

The Project designed under the Grant is being implemented by the Plant Production Department (PPD) of CATIE in the six countries of the Isthmus. Due to the nature of the Grant, the components of the Project constitute key elements within the present structure and organization of the PPD. These are: "Prototype Teams" for research and technology development in selected areas; "Support Team" for research, training and technical cooperation; "Training Officer", to help coordinate the training activities of the PPD; "Outreach Coordinator", to communicate with and permanently link the PPD with the national counterpart institutions and teams; and "Operational Support Unit" to reinforce the administrative and logistical capability of the PPD.

The IFAD TA 38 Grant to CATIE began in 1981; after progress reviews, the Grant was continued as TA-38A during 1982 and TA-38B during 1983. This year (1983) a mid-term review was carried out by a team of four experts selected by IFAD: Dr. Hubert Zandstra (leader), Dr. Luis Marcano, Dr. Ciro Villamizar and Dr. Edgardo Moscardi[1/]. Dr. Hubert Zandstra has also acted as permanent advisor for the Project on behalf of IFAD, since the beginning of TA-38A. A proposal for the use of the Grant during 1984 was sent to

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1/ Zandstra, H. et al. Evaluación de mitad de período del Convenio de Asistencia Técnica TA Grant No. 38-A y 38-B. CATIE/FIDA. CATIE, 1983. 65 p.

IFAD by CATIE in 1983. Financial and technical reports have been forwarded to IFAD as required. The last technical report corresponded to TA-38A.

Most progress reported here relates to the reviewed objectives and plans for the use of the Grant as proposed to IFAD by CATIE in 1981 and 1982.

Most of the personnel to be initially financed under the Grant were hired during the first semester of 1982. The outreach coordinator, however, was hired during the second semester. A total of 50 persons have been hired under the Grant since its initiation; 10 of them have left, including three consultants and four professionals. Recently a weed management specialist was hired as part of the Support Team. At present, progress is being made in the recruitment of replacements for the following professionals who resigned their positions during the last part of 1982 and 1983: Cropping Systems Specialist withing the Support Team; Agricultural Economist for the Prototype Team in Nicaragua, and the Training Officer in Turrialba.

The Project made progress in all components without major problems during 1983. An additional Prototype Team was installed in Los Santos (Panama) and all three teams have increased their interaction with the national institutions. Most of the monitoring, demonstrations and training objectives in relation to these teams are being accomplished. Interest has been shown in installing other similar teams in El Salvador and Panama; Honduras is already installing one. The Project's Support Team strengthened ties with the Prototype Teams, with National Programs and with other international groups and institutions. The Weed Specialist, recently recruited began his work in research and training. The Training Officer resigned on June 30, 1983; however, most of the planned activities were on schedule. One of the most important training activities was a three-month intensive course in cropping systems research and technology development offered in Turrialba for professionals from national institutions of the region. All the personnel financed under the Grant participated in this course. The Outreach Coordinador intensified his contact with officers and staff from the different counterpart national institutions across the Isthmus. An important part of this efforts were to motivate and begin the formation of a regional network and a working group in cropping systems research and technology development. This included the organization and coordination of the first consultation meeting with the working group comprised of selected professionals from the region. This meeting was held in Turrialba during September 21 and 22, 1983 and resulted in a series of suggestions which will be summarized later in this report. The Operational Support Unit has continued its administrative and logistical support for the implementation of the different projects and activities of the PPD.

For most of the year the general coordination of the Project financed under the Grant was the direct responsibility of the Head of the PPD. Beginning in October, however, the PPD appointed a senior professional as Technical Coordinator of the Project.

After a brief review of the nature and objectives of the Grant, this report reviews the progress in each component of the Project financed by it.

IFAD/CATIE GRANT BACKGROUND

The IFAD TA 38-B Grant to CATIE (the Project) supports CATIE's core budget activities in research and technology development in food crops. It is implemented by the Plant Production Department (PPD) and strengthens the major work of the Department. This work serves as a basis for the design and implementation of other research and technology development projects particularly on food crops and usually with separate funding, in the countries of the Central American Isthmus.

Because of the nature of the project, its components constitute key elements within the present structure and organization of the PPD. These components and their purposes are:

"Prototype Teams" for research and technology development at area level. These teams, composed of three professionals (crop production, crop protection and agricultural economics), were formed to utilize the methodology for research and technology development, as proposed by the PPD, in selected geographical areas of the Isthmus. Their purpose is to give the PPD the opportunity to study the training, resources, general management and other support required for the functioning of such teams and the operation of proposed research approach. They also allow demonstration of the feasibility and effectiveness of the methodology to national institutions, as well as training personnel in its use. As part of the Project, there are Prototype Teams in Nicaragua, Costa Rica and Panama.

"Support Team". This component of the Project includes personnel and activities which reinforce the capability of the PPD to provide support to the multidisciplinary teams working in technology development at farm level in the different countries. This support is in the form of "Support Research" direct and specialized "scientific support" and "training". In "Support Research" the problems addressed and the research methods used require more control or time than it is possible to provide in the adaptive type of on-farm research. A researchable subject is justified when it is considered to be of priority for the work of at least one multidisciplinary team working in technology development at area level; this will ensure an immediate application of results. However, it is also expected that those results will have a wider application in terms of area or as a disciplinary contribution. Within the Project the principal responsibility of the "Support Team" is to the "Prototype Teams". The team includes specialists in: crop physiology, weed management, soil management, cropping systems, agricultural economics and genotype evaluation.

"Training Officer". This professional provides leadership of the unit responsible for synchronizing the capabilities, plans and activities of the PPD in training with the corresponding national needs and priorities, particularly those of teams working in technology development at area level. It is also expected that a better strategy for training personnel in the use of the research and technology development approach will be developed based on the experience gained through the Prototype Teams.

"Outreach Coordinator". This key position did not exist in the PPD prior to the Project financed by IFAD. Its purpose is to create a permanent linkage and communication mechanism between the PPD and the counterpart national institutions, particularly their national teams, working in technology development in priority areas. Furthermore, the Outreach Coordinator encourages the establishment of links between national institutions and their teams working in technology development and between those teams within each country and other countries in CATIE's mandate region. This mechanism is expected to improve the synchronization of the PPD's capability and plans to provide support with the national needs and priorities in the field of agricultural research, training and technical cooperation. Within the Project, the Outreach Coordinator pays particular attention to the Prototype Teams.

"Operational Support Unit". This component includes personnel and other resources which directly reinforce the administrative and logistical support capability of the PPD. Its purpose it to free as much as possible the technical personnel from administrative details.

By nature, each component of the Project also interacts with other elements and projects within the PPD. The general coordination of the activities planned under the project, has been the direct responsibility of the Head of the PPD. Beginning in October however, the PPD appointed a senior professional to provide technical coordination of the work developed under IFAD financing.

The activities of and progress made by each of the components of the Project during 1983 is presented in the following sections of this report.

PROTOTYPE TEAMS

The Prototype Teams installed in Estelí, Nicaragúa and San Carlos, Costa Rica in January 1982 are completing their second year of field work. This work was mostly on testing and evaluation of certain technical changes designed to improve the main cropping systems identified during the target area characterization reported in 1982.

A third team was installed in January 1983 to work in Los Santos, Panama. One of its professionals belongs to and is financed by IDIAP, the national research institute. This complies with the objective of making these teams part of the national institutions and promoting the use of the on-farm technology development approach as presented in the 1982 technical report. This team has characterized its target area and is now completing the first year of field research on the principal crop production systems based on maize, rice, tomatoes and other vegetable crops. Some of the interactions of these cropping systems with the animal component of local small farms are also being considered.

Discussions with national institutions about the installation of additional teams under direct national financing are being conducted by the outreach coordinator in Panama, Costa Rica, El Salvador and Honduras.

The operation of the Prototype Teams had no major logistical problems during 1983 except in Nicaragua. There, the guerilla problems around the target area have occasionally jeopardized the completion of some field experiments. Also in Nicaragua, because of the lack of appropriate personnel, it has not been possible to substitute the agricultural economist who resigned from the team in November 1982. Those responsibilities have been partially met by means of short-time consultancies. Similarly, in Costa Rica, the agricultural economist resigned his position in March 7, 1983; however, his replacement started working on August 1, 1983.

The general supervision of the Prototype Teams and their Coordination with the Support Teams of the PPD, was for most of the year, the responsibility of the Agricultural Economist of the Project. However, these responsibilities are being transferred to the Outreach Coordinator and the recently appointed Technical Coordinator for the Project.

Each team has the responsibility of coordinating its activities with the respective national institutions with support from the Outreach Coordinator. These institutions include: MIDINRA and DGTA in Nicaragua; MAG, ITCR and IDA in Costa Rica; IDIAP and MIDA in Panama plus the respective Schools of Agriculture at university level.

The activities of the Teams during 1983 and their main results can be grouped as follows:

RESEARCH ACTIVITIES

These include different types of characterizations at area level, the design of technical innovations to improve the principal cropping systems and field work to test and evaluate them, mostly at farm level in the target areas.

Activities in characterization

The principal characterization was of the target area in Los Santos, which was the first work phase of the recently installed Panamanian team. The area was chosen for the team by IDIAP and CATIE, based on a previous survey of 13 areas with priority for development[1/].

This target area comprised the districts of Los Santos and Guararé in the province of Los Santos, Panama. The province lies below 100 m.a.s.l. within the quadrant 7°15' to 8°15'N and 79°45' to 81°41'W. Yearly rainfall fluctuates between 1000 and 1500 mm. The highest monthly precipitation is 250 mm and occurs during September, October and November and there is a long "dry season" beginning in late December - early January until May-June. Most soils in the area correspond to Tropepts within the Inceptisols.

The 35,059 ha dedicated to agriculture in Los Santos are under annual crops (13.95%), perennial crops (1.46%) improved pastures (68.99%) and natural pastures (7.52%). The corresponding percentages for the 18,340 ha of Guararé are: 12.35, 2.31, 66.19 and 8.69 percent respectively. Half the land in the area is considered suitable for agriculture and half for pastures and forest. Tha main crops in the area are maize, sorghum, industrial tomato and onions. The main prospects for the area are vegetable productions under irrigation; however, the irrigation and marketing infrastructure is not well developed.

A total of 1531 farms in Guararé and 3241 in Los Santos are listed in official records.

1/ Bejarano, W. Selección de áreas geográficas en Panamá para investigación agrícola aplicada. Presented during "Curso de Investigación y Desarrollo de Tecnología para Sistemas de Producción de Cultivos". Turrialba, Costa Rica, 1983. 29 p.

The characterizacion of the target area was mostly based on two surveys previously done by IDIAP and MIDA, which were complemented, by the team, with a "sondeo" of a sample of 39 small farmers.

The information provided by the farmers sampled allowed the identification of 18 different cropping patterns in use. The farmers justify their use in terms of land and water restrictions, marketing facilities and credit availability. The tendency is to work small plots in a very intensive and diversified manner. Successions of at leat two crops a year are practiced by 64.2 percent of the farmers.

Cropping systems are management intensive for producing vegetables and less intensive for producing rice, maize and sorghum.

Considering the technical and socioeconomic circumstances prevailing in the area, as well as the research policies and priorities of IDIAP, the team selected 6 of the principal cropping patterns on which to focus their research activities. They are: 1) maize for fresh consumption planted at the beginning of the rainy season, followed by a short period of cattle grazing once the corn ears are harvested. This is followed by a sowing of in dustrial tomato, partially under irrigation, followed again by a period of cattle grazing with the alternative of leaving the plot in fallow until the onset of the rainy season; 2) rice during the rainy season followed first by industrial tomato, partially under irrigation and later by grazing or fallow until the next cropping season; 3) fallow during the rainy season (or cattle grazing) followed first by industrial tomato, and later by cattle grazing or fallow; 4) corn for grain during the rainy season followed by a long period of cattle grazing; 5) rice during the rainy season followed by onions; 6) corn for grain followed by cattle grazing and then by onions during the dry season.

The major limiting factors for agricultural production, in the opinion of the farmers, are associated with the long dry season and the irregularity of the rains, particularly at the beginning of the cropping season. Another problem highlighted by farmers is diseases and pests particularly those affecting vegetables which have higher control costs. The farmers' concern about these problems is such that they buy and apply pesticides even when not needed. Weed problems and their control present a similar situation, especially because of the scarcity of labor in the area. Furthermore, almost 40% of the farmers included in the survey applied excessive or insufficient fertilizer to their vegetable production systems with consequent excessive costs or low productivity. Complementing the initial characterization of the target area, the Panama team began monitoring some of the principal cropping systems in order to describe and evaluate their present management and use of technology.

Similar work for monitoring the traditional maize-beans cropping systems in Estelí was planned for 1983 by the Nicaraguan team. However, the government initiated a very aggressive program of agrarian reform to introduce fertilizers, other inputs, machinery and irrigation to the area, as well the formation of cooperatives. This fact, plus the problems of political tension in the area have changed the expectations of local farmers. The monitoring work planned was therefore postponed. Instead, the team in

Nicaragua provided technical assistance in characterization to INRA, the Agrarian Reform Institute. This consisted of helping to plan the field work and preparation of material for a survey of farmers in Region I of Nicaragua for inventory and planning purposes.

In Costa Rica, the team began monitoring the traditional pineapple production systems of San Carlos, which will be completed in 1984. The team also finished the field characterization of the cassava-maize cropping systems with a survey of 27 farmers in the communities of Pital and La Fortuna which form the target area. The purpose of the study, carried out by a student and in agreement with the Costa Rican Technological Institute, was to describe and evaluate in detail the management, technology and costs of the system at farm level. The Costa Rican team has also participated in two characterizations carried out as part of the support research in agricultural economics. One is the study of credit availability and cost for small farmers and another of the cassava monocrop as a production system. Results from these studies are presented under the support group report.

Design and field testing of technology alternatives for improving selected cropping systems

The Costa Rican team has concentrated on the design and field testing of technology alternatives for the improvement of two important cropping systems in the area, cassava associated with maize (cassava+maize) and cassava associated with beans (cassava+beans). A "Central Experiment", designed to generate the first approximation to a technical recommendation, based on selected levels of fertilization, plant densities and weed management, has been planted for each system. Other trials are being carried out to study adjustments in the components of the recommendations. Some connected back-up research also has been planned in coordination with the Support Group in Turrialba and San Carlos; their results are presented later.

The field research is being developed in collaboration with farmers in trials replicated on several farms in La Fortuna and Pital. An inventory of these trials is shown in Table 1.

All trials planted in 1983 which include cassava as a component are still under way because of the long cycle of cassava.

Most trials of the 82-83 field campaign in Costa Rica were lost due to unfavorable weather conditions and the team's lack of experience in the area. Some results were obtained and used in the design of the 83-84 research.

In Nicaragua the team has focused most of its attention on the maize/bean and maize/sorghum relay cropping systems which are the most important for the small farmers in Estelí. The team has been conducting most of the field trials in collaboration with farmers who belong to the cooperatives formed in the area and in response to suggestions made by the Nicaraguan institutions.

An inventory of the trials sown during the 82/83 and 83/84 campaigns and some results are presented in Table 2.

The team in Panama has concentrated on the cropping systems based on the maize-vegetable, crop-grazing or fallow chronological pattern. These are planted at the beginning of the rainy season (late May-early June) in the target area. The vegetable crops included are tomato and onion,

Table 1. Inventory of field trials carried out by the Prototype Team of San Carlos, Costa Rica, 1983/84 campaign.

Focal cropping systems, type of trial and date of implementation	Location[3/]	Progress
1. Cassava + Maize[4/]		
1.1 "Central" trial[1/] (May 1983)	3 farms in La Fortuna, 1 in Pital	Yields of 1518 kg ha^{-1} in maize, superior to local averages when 2 and 4 plants per m^{-2} of maize and cassava respectively and 75, 80 and 75 kg ha^{-1} of N, P_2O_5 and K, respectively; plus herbicide are used; the cassava has not been harvested
1.2 Complementary trials		
a) Plant density (May 1983)	3 farms in La Fortuna, 1 in Pital	Maize density could be increased with advantages up to 3 plants m^{-2} maintaining those of cassava constant
b) Fertility levels (May 1983)	2 farms in La Fortuna, 2 in Pital	Shows the advantage for maize of the treatment included in the Central Experiment; cassava is still on the ground
c) Hercibide treatments (May 1983)	1 farm in La Fortuna, 1 in Pital	Some maize yields responses to chemical weed control as opposed to manual control have been demonstrated
d) Maize varieties	"Centro Agrícola Cantonal"[2/] Experiment field	Several varieties yielded more than 4 ton ha^{-1} as monocrop
2. Cassava + Beans[5/]		
2.1 "Central" trial		To be installed during December 1983
2.2 Complementary trials		

Table 1 (cont./)

Focal cropping systems, type of trial and date of implementation	Location[3/]	Progress
a) Plant density and fertilization (December 1982)	2 farms in La Fortuna	Bean yields responded clearly to plant density but not to fertilization
b) Fertilization (December 1982 - January 1983)	2 farms in La Fortuna, 1 in Pital	Beans with fertilizer applied produced more than those without
3. "Tiquisque" (*Xanthosoma sagittifolium*) as monocrop		
3.1 Form of propagation and fertilization (May 1983)	1 farm in La Fortuna	Not harvested
3.2 Plant density (May 1983)	1 farm in La Fortuna	Not harvested

1/ The "Central" trial is based on a first approximation to a recommendation including selected level of fertilizer, plant density and weed control.

2/ Local government agricultural center and experimental fields.

3/ Most farms belong to farmer settlements formed under the supervision of IDA.

4/ Cassava + Maize; both crops are in association until maize is harvested.

5/ Cassava + Beans; both crops are in association until beans are harvested.

Table 2. Inventory of field trials carried out by the Prototype Team in Estelí, Nicaragua, 1982/83 and 1983/84 campaigns.

Focal cropping systems, type of trial and date of implementation	Location[1/]	Progress
1. Maize/Beans in relay cropping		
a) Fertilization of maize plus herbicide and fungicide to beans (April 1982)	4 cooperatives in Los Calpules, San Antonio, Santa Ana and El Rosario	Best fertilization was 70, 30 and 13 kg ha^{-1} of NPK, respectively; no residual effect on beans was recorded
b) Fertilization of varieties of maize (April 1982)	3 cooperatives in Santa Ana, San Antonio and Paso Hondo	NB-3 appears as the most promising maize variety
c) Fertilization and chemical weed control (April 1983)	4 cooperatives in San Antonio Santa Ana, EL Rosario, Los Horcones	Data being processed
d) Soil conservation practices (April 1983)	3 cooperatives in Los Hatillos, El Motolín, Los Calpules	Trials unattended since guerrilla problems started
e) Cropping pattern changes based on combinations of maize, beans and cowpea (<u>Vigna unguiculata</u>) (April 1982)	2 cooperatives in El Rodeo and Guasuyuca	No differences were noticed except a tendency to better economic performance of those patterns including cowpea
2. Beans as monocrop		
a) Slug control (April 1982)	1 cooperative in Los Hatillos	No slug attack
b) Slug control (September 1982)	2 cooperatives in Los Hatillos and Los Horcones	No slug attack
c) Fertilization of beans planted in September (September 1982)	3 cooperatives in El Rodeo, Los Hatillos, El Matapalo	Two repetitions lost to drought. The third showed best economic response to application of 60, 30 and 0 kg ha^{-1} of NPK

Table 2 (cont/.)

Focal cropping systems, type of trial and date of implementation	Location[1/]	Progress
d) Fertilization of beans planted in April and possible residual effects on bean planted in September (April 1983)	4 cooperatives in San Antonio Santa Ana, El Rosario and Los Horcones	Data being collected
3. Maize/Beans and Beans as monocrop		
a) Disease control in beans (April 1982)	2 cooperatives in Los Horcones	Partly harvested, data not analyzed
4. Maize/Local Sorghum		
a) Change of sorghum variety and fertilization of maize (April 1983)	3 cooperatives in Los Hatillos, El Matapalo and El Rodeo	Partly harvested, data being processed
5. Sorghum as monocrop		
a) Fertilization, exploratory (September 1982)	2 cooperatives in Los Horcones and Santa Ana	No best treatment was found. Tendencies favor 30, 60, 90 kg ha^{-1} of NPK

1/ Most work done in plots lent by the "Cooperativas de Crédito y Servicio" or "Cooperativas Agrícolas Sandinistas".

selected because of their importance to farmers and their priority for IDIAP. The rice-tomato cropping pattern is also under study. Most of the trials are being carried out on farms in collaboration with small farmers throughout the target area. An inventory of those trials set up for the 83/84 campaign is given in Table 3.

OUTREACH ACTIVITIES

A major purpose of the project is to demonstrate the feasibility and effectiveness of the technology development approach used and to promote its adoption by multidisciplinary teams within national institutions. To this end, the project makes available to the national counterpart institutions, all details of the prototype team's objectives, methodology and results. This permits their full participation in the project activities and evaluation of the results obtained. To achieve this purpose, the Prototype Teams have developed a series of activities which include elements of training, diffusion, technical cooperation and coordination. A list of these activities in Costa Rica, Nicaragua and Panama is presented in Tables 4, 5 and 6, respectively.

TRAINING AND SUPPORT RECEIVED

To achieve their aim of developing crop production technology, the Prototype Teams at time need to seek external support. This is implicit in their mandate to clearly identify the demand for technical knolwedge on the part of a group of well defined and located farmers and to rapidly obtain

Table 3. Inventory of field trials carried out by the Prototype Team in Los Santos, Panama; 1983/84 campaign.

Focal cropping systems[1/], type of trial and date of implementation	Location[2/]	Progress
1. Corn-vegetable crop-grazing or fallow		
1.1 Fresh corn-onion		
a) Plant density, variety and fertilization of maize	1 farm in Sabana Grande	Data being processed
1.2 Fresh corn-tomato		
a) Plant density, variety and maize fertilization under minimum tillage conditions (May 1983)	2 farms in Sabana Grande	Data being processed
b) Plant density and maize fertilization under tillage (June 1983)	1 farm in Tres Quebradas	Data being processed
1.3 Grain corn-tomato		
a) Fertilization and maize varieties; maize under minimum tillage conditions	1 farm in Tres Quebradas and 1 in Guararé Arriba	Data being processed
b) Fertilization and varieties. Maize under tillage (June 1983)	1 farm in Tres Quebradas	Data being processed
c) Fertilization and variety of maize after industrial tomato and fallow during three fourths of the year (September 1983)	1 farm in Los Angeles	Not harvested

Table 3 (cont/.)

Focal cropping systems[1/], type of trial and date of implementation	Location[2/]	Progress
d) Fertilization, weed control and pesticide used in tomato (October 1983)	2 farms in Tres Quebradas	Trial in the field
e) Fertilization levels in tomato (October 1983)	1 farm in Sabana Grande	Trial in the field
f) Fractional application of fertilizer in tomato (October 1983)	1 farm in Tres Quebradas and 1 in Los Angeles	Trial in the field
g) Herbicide and cultural practices for controlling _Cyperus_ sp. in tomato	1 farm in Tres Quebradas	Trial in the field
2. Corn-grazing or fallow		
2.1 Grain corn-grazing		
a) Confirmation of fertilization for the promising maize variety "Across 7728" in second cropping season (September 1983)	2 farms in Sabana Grande, 1 in Los Angeles and 1 in La Espigadilla	Trial in the field
b) Dates for urea application to maize in the second cropping season (September 1983)	2 farms in Sabana Grande and 1 in La Espigadilla	Trial in the field
3. Rice-tomato		
3.1 Plant density and irrigation in rice (July 1983)	2 farms in Tres Quebradas	Data under processing

Table 3 (cont/.)

Focal cropping systems, type of trial and date of implementation	Location[2/]	Progress
3.2 Rice fertilization (July 1983)	1 farm in Guararé Arriba and 1 in Sabana Grande	Data under processing
4. Variety trials		
4.1 Onions for the rainy season (June 1983)	1 farm in Llano Largo and 1 in Tres Quebradas	Data under processing
4.2 Up-land rice (June 1983)	"Instituto Coronel de Villa-real" (Experimental farm)	Data being processed

1/ Most cropping systems are planted at the onset of the rainy season (late May - early June).

2/ Most trials are carried out on cooperating farmers' plots.

Table 4. Inventory of the outreach activities[1/] developed by the Prototype Team in San Carlos, Costa Rica from October 1982 to November 1983.

Type of activities and main purposes	Number of Events	Number of Total Participants	Type of participants and Institutions represented	Place in Costa Rica and date
1. Lectures for professionals publicizing the work and technical cooperation	5	68	Research, extension, professional and other staff from: University of Costa Rica (UCR), University of Cornell, "Marketing House", Ministry of Agriculture of Costa Rica (MAG), visitors from different institutions of the Philippines	San Carlos and San José October 1982 to July 1983
2. Technical meetings with personnel from national institutions				
a) Planning and coordination of joint activities	14	77	Research, extension, professional and other staff from: Instituto Tecnológico de Costa Rica (ITCR) UCR, MAG, Estación Experimental Fabio Baudrit de Alajuela (EEFB), Ministerio de Planificación de Costa Rica (MIDEPLAN), Consejo Nacional de Producción (CNP), Instituto de Desarrollo Agropecuario (IDA), Graduate Program UCR/CATIE	San Carlos, San José, Alajuela. March-November 1983
b) Participation in working group	2	45	Research, extension and professional staff from different institutions in Latin America participating in a) a workshop on Cropping Systems Research, sponsored by CATIE and IDRC from Canada and b) a course of the M.Sc. Graduate Program UCR/CATIE	San Carlos, November 1982-November 1983

Table 4 (cont/.)

Type of activities and main purposes	Number of Events	Number of Total Participants	Type of participants and Institutions represented	Place in Costa Rica and date
3. Field days and meetings with farmers to demonstrate work done and results obtained				
a) With technical personnel	3	19	Research, extension, professional and other staff from MAG, ITCR, IDA, MIDEPLAN, "Coop. San Carlos", "Cámara de Cañeros"	San Carlos, March-September 1983
b) With farmers	3	40	Farmers within the target area	San Carlos, June-September 1983
4. Training activities for students				
a) Lectures on the methodology, its components and results obtained	9	92	Students from the ITCR, UCR and professionals attending the CATIE/IFAD intensive course in Cropping Systems Research 1983	San Carlos, Turrialba June-November 1983
b) Student advice and thesis guidance	8	8	Students from the ITCR	San Carlos, 1983
c) In-service training	2	11	Students from the UCR and ITCR	San Carlos, May-August, 1983

1/ For some of these activities the Prototype Team has coparticipated with personnel from the PPD of CATIE.

Table 5. Inventory of the outreach activities developed by the Prototype Team in Estelí, Nicaragua, 1983.

Type of activities and main purposes	Number of Events	Number of Total Participants	Type of participants and Institutions represented	Place in Nicaragua and date
1. Technical meeting with personnel from national institutions				
a) Technical assistance in survey preparation and execution	1	12	Planning, research and extension staff from different offices of the Ministry of Agrarian Reform and Development (MIDINRA)	Estelí, July-August 1983
b) Planning and coordination of joint activities	3	94	Research and extension staff as well as directors of the "Dirección General de Tecnología Agropecuaria" (DGTA) MIDINRA, Dirección General de Reforma Agraria (DGRA), Centro de Investigaciones Económicas de la Reforma Agraria (CIERA) and CATIE	Estelí, Managua, Matagalpa, March-April 1983
2. Field days and meetings with farmers to demonstrate the work done and results obtained				
a) With technical personnel	2	3	Regional directors of DGTA and Resident Agronomist of CATIE	Estelí, June 1983
b) With farmers	1	25	Farmers belonging to Cooperatives in Los Horcones	

Table 6. Inventory of the outreach activities developed by the Prototype Team in Los Santos, Panama, 1983.

Type of activities and main purposes	Number of Events	Number of Total Participants	Type of participants and Institutions represented	Place in Panama and date
1. Technical meeting with personnel from national institutions				
a) Planning and coordination of activities	1	11	National and regional director as well as researchers from the Instituto de Investigaciones Agropecuarias de Panama (IDIAP). Included monthly meetings with officials of IDIAP	Santiago de Veraguas, Los Santos and David; during the year
b) Working groups	3	38	Researchers, directors and administrators of IDIAP	Panama City and Santiago de Veraguas, March-November 1983
c) Technical assistance in specific methodological or disciplinary methods	1	Several	Research personnel from IDIAP	Los Santos, during the year
d) Participation in technical professional meetings presenting the methods used and results obtained	5	80	Directors, administrators, researchers, extensionists and farmers from IDIAP, Ministerio de Desarrollo Agropecuario (MIDA) Asociación de Productores de Maíz de Los Santos, Banco de Desarrollo Agropecuario (BDA), IMA, PIONEER, ENASEM, etc.	Los Santos, Las Tablas, Chitré, Santiago de Veraguas May-October 1982

Table 6 (cont/.)

Type of activities and main purposes	Number of Events	Number of Total Participants	Type of participants and Institutions represented	Place in Panama and date
2. Field days and meetings				
a) With technical personnel	8	76	Regional directors and subdirectors as well as researchers from CATIE and evaluation from IFAD	Los Santos, March - November 1983
b) With farmers	1	15	Local farmers working independently or in cooperatives in the target area	Los Santos, October 1983
3. Training				
a) Methodology and field experimentation	2	9	Students of the "Colegio Coronel Segundo de Villareal" and field assistants of IDIAP	Los Santos, October 1983

such knowledge from the appropriate sources. Many of the team's activities have been a direct result of this mandate including the outreach activities previously reviewed. This includes the time spent receiving training and other types of direct support. Most of the training and support has been provided by CATIE, particularly by personnel financed under the Project. A list of these activities for the teams in Costa Rica, Nicaragua and Panama is presented in Tables 7, 8 and 9, respectively.

SUPPORT TEAM

During 1983 the Support Team has continued to consolidate its work in research, training and technical cooperation both in Turrialba and at country level. This includes a greater interaction with the Prototype Teams and other projects within the PPD. It also includes an increased contact and interaction with national programs, and other international group working in crop production technology R & D in the area, plus CIMMYT, CIAT and ICRISAT.

A major problem during the year was the selection of appropriate candidates to replace the Cropping Systems Specialist in Nicaragua who resigned, Three are presently being considered for selection. The last position waiting to be filled, that of weed specialist, was finally filled on October 28, 1983.

There follows a summary of the progress achieved in research conducted by the "Support Team". The team's general structure and objectives have been described as part of the background for the Project. The training and outreach activities, other than research, in which personnel from the team participated are included in another section of this report.

Table 7. Inventory of the training and other support received by the Prototype Team in San Carlos, Costa Rica, 1983.

Type of support and main purpose	Number of events	Providers, place and date	Type and number of coparticipants if any, and institutions represented
1. Meetings to discuss specific subjects. In response to specific request by the team	6	CATIE and IICA en San Carlos, San José and Turrialba; November 1982 - August 1983	The team only
2. Evaluation and programming of activities	2	CATIE particularly PPD IFAD in San Carlos, April - June	The team only
3. Other technical meetings. Some already mentioned as part of outreach activities	Several	CATIE, MAG, ITCR, UCR	Includes participation in seminars and workshop in which the team also participated as lecturers

Table 8. Inventory of the training and other support received by the Prototype Team in Estelí, Nicaragua, 1983.

Type of support and main purpose	Number of events	Providers, place and date	Type and number of coparticipants if any, and institutions represented
1. Evaluation and programming of activities	6	CATIE, DGTA, IFAD, Estelí Managua, Turrialba; February - September 1983	The team only
2. Supervision and evaluation of field work	4	CATIE, particularly support group by the PPD and national personnel from DGTA; January - October 1983	The team only
3. Support in specific subject matter, including statistical analysis	3	CATIE, particularly the support group; February-June 1983	The team only

Table 9. Inventory of the training and other support received by the Prototype Team in Los Santos, Panama, 1983.

Type of support and main purpose	Number of events	Providers, place and date	Type and number of coparticipants if any, and institutions represented
1. Initial training in the use of the methodology and team operation	1	Staff from the PPD of CATIE, Turrialba. January 31 to February 4, 1983	The team only
2. Participation in specific subject matter seminars or workshops	2	CATIE, IDIAP, in David and Chitré, February - October 1983	Researchers, extensionists and farmers from IDIAP, MIDA, BDA, ISA, CPA, tomato growers cooperative in Coclé and Azuero
3. Evaluation and programming of activities	5	CATIE, particularly the support group and IDIAP Los Santos, Panama and Turrialba; April-October 1983	The team only

SOIL MANAGEMENT

Lowland Humid Tropics

- Liming Requirements of Different Soils

Soil management recommendations for the tropics are frequently based on the results of research carried out in temperate areas. For instance, liming was recommended for San Carlos soils given their generally low pH values. However, soils of the Central American LHT differ somewhat from the acid soils typical of this ecological zone (Oxisols and Ultisols), due to their varying content of volcanic ash. This soils with problems characteristic of Oxisols or Ultisols (high aluminium saturation and low levels of based and organic matter) can be found adjacent to soils without these problems. Most San Carlos soils have less than 10% aluminium saturation. At such low aluminium saturation, liming does not necessarily improve the soils and may even reduce the availability of certain elements.

To study the effect of liming on soils with different levels of aluminium saturation, and to obtain information on micronutrient availability in soils of the work area, an incubation study using calcium, phosphorus and zinc was done with 2 soils from San Carlos and 2 from Turrialba. All of these soils were low in pH yet also relatively low in aluminium saturation.

The effect of liming in all soils was to increase pH, exchangeable calcium and sulfur, and to reduce levels of aluminium, cooper, zinc, manganese and iron. The original levels of these elements, however, were considered non-critical with the sole exception of manganese (in excess of 100 ppm) in one soil. In this case 2 Mg ha^{-1} of lime*was sufficient to correct the critical condition. Changes in magnesium, potassium, and phosphorus with liming were minor and agriculturally insignificant.

For the soil which adsorbed the most phosphorus, application rates necessary to satisfy the soils adsorption capacity were determined, both with and without liming. The basic phosphorus requirement of most crops (0.2 ppm in the soil solution) was met with application of 530 mg P kg^{-1} soil without lime, or 650 Mg P kg^{-1} soil with 10 Mg ha^{-1} of lime. The lime treatment increased soil pH from 4.47 to 6.58 and reduce extractable aliminium from 0.60 to 0.10 me 100^{-1} g soil, but clearly did not increase phosphorus availability as might have been expected. Thus phosphorus fixation in these soils is not due to formation of insoluble aluminium phosphates, and liming cannot improve phosphorus availability.

Results of this study can be used to predict liming rates necessary to obtain desired pH and per cent aluminium and manganese saturation levels. Prediction equation for the four soils are given in Table 10. These equations accompanied by economic analyses, can be used in designing promising soil management alternatives.

Currently, field studies to investigate the liming needs of diverse San Carlos soils are underway in Pital. These include a study of liming rates and fertilizer combinations for cassava production, and for production of beans (aluminium-susceptible) and peanuts (aluminium-tolerant). Soils in the Pital area of San Carlos tend to have higher levels of aluminium saturation

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* Mg = Megagram = 10^3 kg (SI unit)

Table 10. Prediction equation for the effects of liming on four sites from Turrialba and San Carlos, Costa Rica

Soil	Source	Prediction Equations*		
		pH	Aluminium saturation, %	Manganese concentration, ppm
1	Turrialba	5.05 + 0.28X (r^2 = 0.941)	6.68 - 1.60X (r^2 = 0.743)	20.78 - 2.63X (r^2 = 0.596)
2	Turrialba	5.09 + 0.27X (r^2 = 0.969)	0.06 - 0.008X (r^2 = 0.734)	35.16 - 5.40X (r^2 = 0.702)
3	San Carlos (Fortuna)	5.73 + 0.21X (r^2 = 0.958)	0.03 - 0.0018X (r^2 = 0.230)	22.14 - 2.68X (r^2 = 0.555)
4	San Carlos (Pital)	4.69 + 0.16X (r^2 = 0.704)	4.11 - 0.39X (r^2 = 0.554)	121.65 - 8.07X (r^2 = 693)

* X = lime applied, Mg ha^{-1}**

** Mg = Megagram = 10^3 kg (SI unit)

than those used in the incubation study. These studies should be of use to the prototype team both for establishing fertilizer recommendations for the principal crops in the area and for evaluating the potential of peanuts, a new crop.

- Tolerance to Flooding

According to a FAO map, the Atlantic Zone of Central America includes over 4 million ha of soils where excess water is limiting (about 25% of its area). These soils are mapped as Aquents, Aquepts, or Aquic suborders in the USDA classification. While artificial drainage has been used on large plantations established on these soil types, small farmers rarely have access to the capital needed for artificial drainage. Finding crops suitable to soils which flood at some time during the growing period was considered to be a viable alternative for these growers. In addition to rice, taro and other aroids known to tolerate flooding, other tropical crops such as soybeans, sorghum and swordbean (Canavalia ensiformes) reportedly have a certain degree of flooding tolerance. During 1983, studies were developed on resistance of soybean and sorghum germplasm to flooding under greenhouse conditions, and a field study was carried out integrating results of the greenhouse work.

Sorghum, although generally considered a dryland crop, is reported to have better root zone oxidizing properties and to be more tolerant of temporary flooding than maize. In Panama, it is grown in relay after rice, where excess water is likely to be a problem at the beginning of the sorghum growth cycle. Excess water is also suspected to be a problem in semi-arid areas where sorghum, is grown, due to the high intensity and erratic distribution of rainfall. Ten sorghum genotypes were studied in the greenhouse, to observe their responses to flooding. One genotype was found to show considerable tolerance to the low oxygen levels and high manganese levels which prevail in flooded soils. In saturated soil, its grain yield was 23% less than in soil at field capacity. In less tolerant material yield reductions of up to 71% were observed. Manganese accumulation in the leaf tissue was greater in less tolerant material than in the resistant genotype, which appeared to be responsible for the reduced yields and poor growth observed in the former.

Reports in the literature indicate that soybeans can form oxygen conducting tissues similar to those found in rice, when subjected to flooding. In order to verify this information and to evaluate varietal responses to flooding, nine varieties were subjected to four flooding schemes: field capacity, continuous flooding 15 days after germination, gradual flooding during the second month after germination, and flooding 60 days after germination. Performance was much better than in the case of sorghum, with six of the varieties producing more grain when flooded 15 days after germination than when kept at field capacity. Flooding later in the cycle, however, proved detrimental to most varieties (Figure 1). At harvest, negative redox potential and higher levels of exchangeable aluminium, manganese, and iron, were found in all flooded plots, but the difference from the check (field capacity) was least for the treatment flooded 15 days after germination

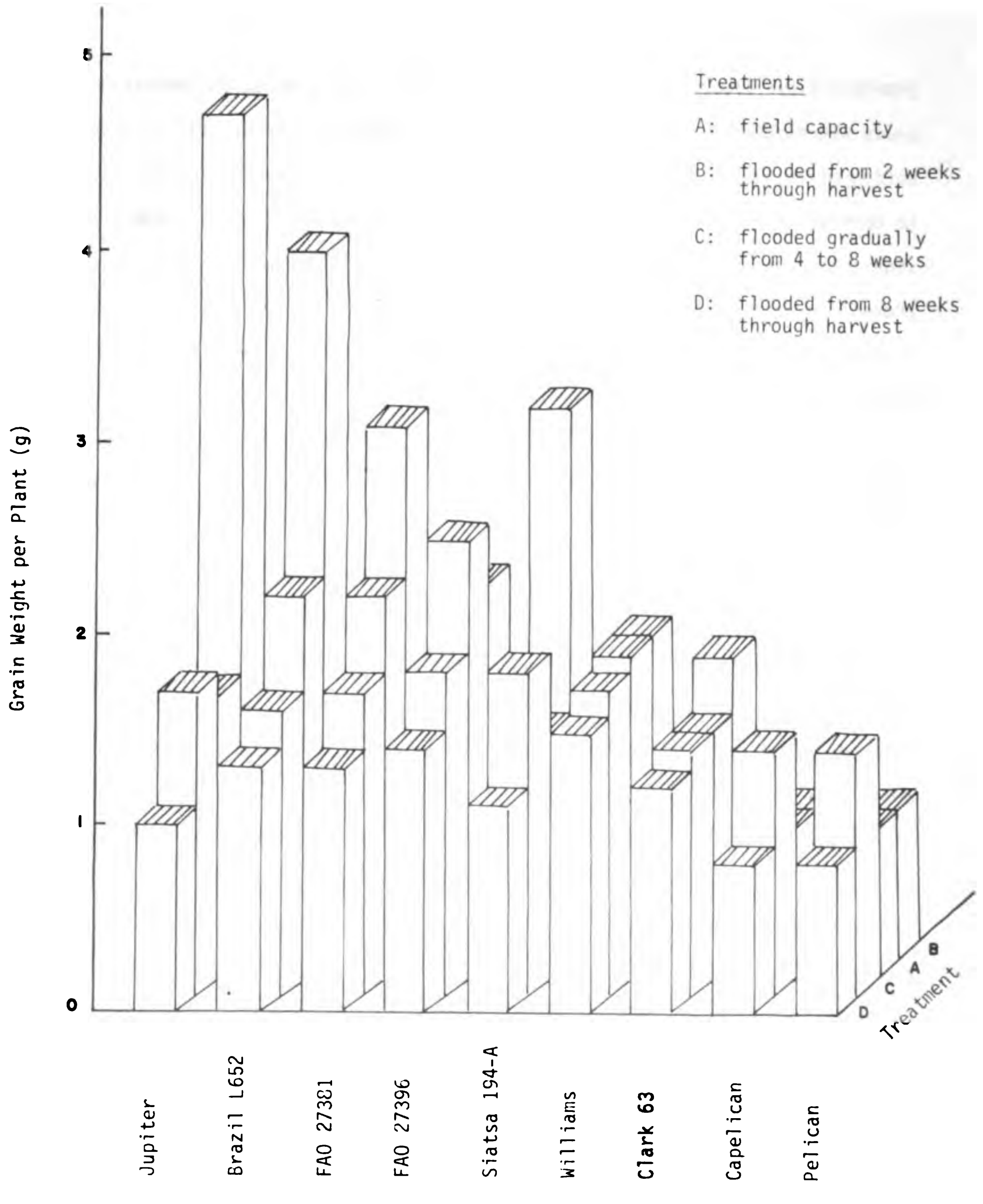

Figure 1. Production in grain weight per plant of 9 soybean varieties under different artificial flooding treatments.

(Table 11). Flooded treatments showed abundant root development in the water and, surprisingly, more nodules (apparently functional) than the field capacity treatment. Tissue analyses indicated that the varieties most tolerant to flooding showed the lowest accumulation of manganese in the leaves. Thus, it appears that the same mechanism confers flooding tolerance in both soybean and sorghum, but it was more common in the soybean germplasm tested. In general, soybeans have a greater ability to adapt to flooded conditions when flooding occurs early in the growth cycle. At flowering or later, energy demands for reproduction are too great to redirect photosynthate and protein into the formation of adventitous roots and other adaptative structures.

In May 1983, a study was established to compare performance of some of these crops on a soil classified as a Fluventic Tropaquept and hence subject to flooding. Five species: purple tanier (Xanthosoma violaceum), taro (Colocasia esculenta var. esculenta), sorghum, soybean and swordbean (Canavalia ensiformes), were planted in four different management schemes: no liming, limed at Mg ha^{-1}, limed at 8 Mg ha^{-1}*, and associated with rice. Liming and association with rice were expected to reduce levels of manganese, which was relatively high in this soil even prior to flooding. Shortly after planting, the area did not flood, and the degree of inundation was characterized by determining redox potential at monthly intervals. Negative redox potentials were associated with reduced yields in sorghum, soybean and swordbean (Table 12), although sourghum seemed the most affected. Flooding reduced swordbean establishment but plants which survived seemed able to compensate for reduced populations. Surprisingly, negative redox potentials were not associated

* Mg = Megagram = 10^3 kg (SI unit)

Table 11. Soil chemical characteristics after four months of artificial flooding treatments applied to Soybeans.

Flooding Treatment	Uncorrected Eh, mv	Mn, ppm		Exchangeable Al, mmol/kg	Extracted Fe, ppm
		Water Soluble	Exchangeable		
Field capacity	+292 a*	1.14 c	5 c	6.1 c	567 c
Flooded at 2 weeks	- 49 b	2.50 b	155 b	20.3 b	1412 b
Flooded gradually (4 to 8 weeks)	- 99 c	3.35 ab	191 a	35.3 a	2849 a
Flooded at 8 weeks	-144 c	3.77 a	194 a	37.5 a	2652 a

* Within a column, means followed by the same letter do not differ significantly according to Duncan's Multiple Range Tests at the 0.05 probability level.

Table 12. Effect of water-logging, as indicated by redox potentials on yields and other characters of Soybeans, Sorghum, and Swordbeans on a Fluventic Tropaquept.

	Redox potential throughout the growth cycle	
	Positive	Negative
Sorghum yield (Mg ha^{-1}) at 15% moisture*	2.4	1.1
Soybean yield (Mg ha^{-1}) at 14% moisture	3.7	2.4
Swordbean yield (Mg ha^{-1}) at 14% moisture	0.7	0.6
Final density of swordbean (1000 plants/ha)	60	35
Iron concentration in soybean leaves (pp)	425	1048
Manganese concentration in soybean leaves (ppm)	293	250

* Mg = Megagram = 10^3 kg (SI unit)

with higher soil or soybean tissue levels of manganese, although they were associated with considerably higher soybean tissue levels of iron. This soil has very high levels of organic matter, which might have prevented major changes in the oxidation state of manganese. Liming also had little effect on soil manganese levels, although a slight effect on soybean leaf manganese content was noted. Similarly, association with rice brought about slight reduction of leaf manganese content in soybean but no in swordbean. Yield reductions due to association with rice were about 50% in soybean, 60% in sword bean under reduced soil conditions may be due to using the variety 'Jupiter' which had shown itself well adapted to reduced soil conditions in the greenhouse study.

A report on this work at the meetings of the American Society of Agronomy (August 1983) indicated that there was much interest in the adaptation of soybean to flooded soils and that researchers on other continents had obtained similar results. It would seem that some soybean varieties are capable of morphological adaptation to flooding if it occurs early enough in the growing period. Proper exploitation of this ability might require a rice-type cultivation system or seeding in permanently waterlogged environments. These studies will be continued on plots whose water levels can be more adequately controlled, to confirm results obtained to date and study the reaction of various crops to flooding in greater depth.

- Nutrient Cycling.

Difficulties in maintaing production of annual crops in the humid tropics without large inputs of mineral fertilizer, animal or green manures, or long period of forest fallow are the principal obstacles to the establishment of stable farming systems in this ecological zone. Use of mineral fertilizer means a large cash outflow, not only for the farmer but also for the nations of the humid tropics which generally lack the resources for fertilizer production. Use of green manures and forest fallows require farmers to take land out of production for considerable periods. Obtaining sufficient quantities of green manures to supply the nutritional needs of annual crops is another limitation. Recent work has shown that several woody legume species as capable of much higher rates of dry matter production than non-woody legumes traditionally used for green manures. Their erect habit and ability to resprout following pruning would allow planting in association with annual crops and pruning back when nutrient and light requirements of the annual crops have to be satisfied, a common practice with perennial crops in the humid tropics.

A long term experiment was set up in Turrialba in May 1982, to evaluate two leguminous trees for their ability to maintain yields and supply nitrogen in an annual cropping systems consisting of a maize-bean rotation associated with cassava. Crop yields for the first year as well as maize yields for the second year are given in Table 13. Nitrogen recovery for the different systems, based on the crop's tissue nitrogen content at the end of the first year in summarized in Table 14. Only a mulch of prunings of _Erythrina poeppigiana_ applied at the rate of 40 Mg ha^{-1} yr^{-1}* fresh weight (the approximate annual production of prunings from a Costa Rica coffee plantation) was able to counteract the decline

* Mg = Megagram = 10^3 kg (SI unit)

Table 13. Maize, Bean and Cassava yields under different organic and inorganic fertilization treatments.

Treatment		First Cropping Cycle			Second Cropping cycle
System	Mineral nitrogen applied	Maize yield Mg ha^{-1}*	Bean yield Mg ha^{-1}	Commercial cassava yield Mg ha^{-1}	Maize Yield Mg ha^{-1}
Control	0	2.4	0.7	12.9	2.2
	+	2.6	0.9	15.0	2.9
E. poeppigiana	0	2.6	1.3	13.4	3.3
mulch	+	2.9	1.1	15.2	2.8
Dairy manure	0	2.3	0.6	13.3	2.5
	+	2.4	0.9	16.8	2.8
Velvetbean	0	0.2	1.2	8.8	2.4
intercrop	+	0.3	1.5	7.4	2.8
Cowpea intercrop	0	1.7	0.5	14.1	2.0
	+	1.9	0.7	16.0	2.9
E. poeppigiana	0	1.6	0.3	12.7	2.1
alley crop	+	1.5	0.5	12.5	2.5
G. sepium alley	0	1.4	0.3	14.8	1.7
crop	+	1.7	0.4	16.6	1.6

* Mg = Megagram = 10^3 kg (SI unit)

Table 14. Partial nitrogen balances for maize, beans and cassava cropping systems under different organic and inorganic fertilization treatments.

Treatment		Total nitrogen applied	Tissue nitrogen recovery, kg ha^{-1}					
System	Mineral nitrogen applied	kg ha^{-1}**	Maize	Beans	Cassava	Alley or intercrop	Total	Net* kg ha^{-1}
Control	0	0	55	16	100	---	171	171
	+	150	59	26	113	---	198	48
E. poeppigiana mulch	0	328	66	42	105	---	213	-115
	+	478	77	48	117	---	242	-236
Dairy manure	0	113	47	15	113	---	175	62
	+	268	47	38	135	---	220	-48
Velvetbean intercrop	0	0	24	51	108	34	217	217
	+	150	39	57	90	28	214	64
Cowpea intercrop	0	0	45	15	91	74	225	225
	+	150	46	23	109	63	241	91
E. poeppigiana alley crop	0	0	31	10	102	101	244	244
	+	150	34	17	118	101	270	120
G. sepium alley crop	0	0	32	11	134	28	205	205
	+	150	47	22	113	28	210	60

* Total tissue nitrogen recovery - total nitrogen applied

** Mg = Megagram = 10^3 kg (SI unit)

in yields experienced when no nitrogen fertilizer was applied. In control plots of the second year maize crop where no nitrogen has been applied, the effect of the E. poeppigiana mulch was quite marked, and yields exceeded those of the plots to which a total of 250 kg/ha of nitrogen has been applied by almost 500 kg/ha of maize grain. Effect of the associated trees was not beneficial to crop yields in the first year; however, trees were not pruned until the end of the first year and the amount of prunings produced was less than would be expected from fully established trees. For the pruning following the second maize harvest, both Gliricidia sepium and E. poeppigiana produced over 20 Mg ha^{-1*} fresh weight of prunings in only six months, representing considerable potential contribution of nitrogen to the annual crops in subsequent years.

Three other studies have supplemented the data obtained in the experiment. In one, prunings of G. sepium were applied to a maize crop at different times following planting, and fertilizer and weed control treatments were also varied. Beneficial effects of the G. sepium mulch were always noted by the highest yields being obtained when the mulch was combined with chemical weed control and mineral nitrogen. The mulch decomposed rapidly, releasing more than half of the nitrogen it contained within three weeks of application.

A study in which E. poeppigiana mulch was compared with mineral nitrogen alone, mineral nitrogen combined with E. poeppigiana mulch, and mineral nitrogen combined with mulch of Gmelina spp. (a non-legume), at two different levels of total nitrogen, has shown that the E. poeppigiana

* Mg = Megagram = 10^3 kg (SI unit)

mulch was more effective than various combinations of mineral and organic nitrogen at the same nitrogen level. The E. poeppigiana mulch also decomposed rapidly, releasing most of the nitrogen it contained (3-4% on a dry weight basis or about 0.15 - 0.25% on a fresh weight basis) within a month after application.

The third study involves an attempt to establish one of these systems on a farmer's field. Prunings and interplanting of G. sepium are being used to supply nitrogen fertilizer to a maize-bean rotation in a humid sub-tropical zone of Costa Rica, characterized by soil exhaustion and erosion. It would be useful to establish a similar experiment in the area of San Carlos, where G. sepium is abundantly used as a living fence but has not been exploited in crop production systems.

Semi arid Tropics

Research in the SAT has concentrated on the areas of increased efficiency of water use, soil conservation and fertility problems. Cropping systems under study are maize-bean, bean-bean, maize+sorghum, and bean+sorghum, the former two, are found in the more humid areas and the latter two in drier areas. Estelí, Nicaragua, has been used as the study area.

- Water Use Efficiency in the Maize+Sorghum Systems

Because of its greater extent in the study area, as well as its greater importance in the drier areas of Central America, the maize+sorghum system has received research priority. Improving its water use efficiency has involved studies of various management practices, including planting densities, spatial configuration, fertilization, and genotypes of the component species. Studies in 1982 emphasized the effect of fertilizer and substitution of the traditional photoperiod-sensitive sorghum component with sorghum hybrids and pearl millet. It was found that increasing nitrogen fertilization of the traditional maize+sorghum association improved the water use efficiency of the system as measured by dry matter production. Application of 70 kg ha^{-1*} of nitrogen to only the maize component of this system, resulted in the highest total dry matter production, even when compared with higher fertilizer applied to the same systems or with systems in which traditional sorghum was replaced by hybrids or by pearl millet. In terms of grain production, however, substitution of the traditional sorghum by the hybrid led to as much as five times the grain production from the same amount of water. Pearl millet did not appear to be a very promising alternative to either the traditional or hybrid sorghum but a better adapted variety should be tested.

Continuity of this work in 1983 was threatened by the departure of the cropping systems agronomist and difficulties encountered in finding qualified personnel willing to work in Nicaragua. However, a series of experiments was designed and planted under the supervision of his assistant in 1983. Part of this work was developed in coordination with CLAIS and involved one crop arrangement x sorghum variety trial and two density x fertility x sorghum variety trials for the maize+sorghum systems. In addition, a total of five fertility experiments with this systems were planted in the department of Estelí. Two compared different levels of nitrogen,

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* Mg = Megagram = 10^3 kg (SI unit)

potassium, and phosphorus fertilization, while three consisted of 2^4 complete factorials for the factors phosphorus, potassium and sulfur; plant samples taken in 1982 had given an indication of a potassium-sulfur interaction in maize and sorghum. Another experiment involved planting dates for photoperiod sensitive and insensitive sorghums relative to maize planting dates. Systems consisting of two maize or two sorghum crops in relay were included for comparison.

- Crop arrangements in the Bean+Sorghum System

Research was also initiated on the bean-sorghum system, which is often favored by farmers in areas where rainfall is insufficient for a maize crop. In a single experiment different crop arrangements of both photoperiod sensitive and insensitive sorghum with beans, as well as sequential monocultures of the sorghums and beans are being compared.

- Soil Conservation Studies

Soils at the SAT are highly susceptible to erosion, due to the sparse vegetation present at the end of the dry season, which leaves very little protection from rainfall erosion at the onset of the rainy season. In order to develop management techniques which could contribute to controling erosion, soil erosion research was initiated in 1982 and has continued through 1983. Two sites were made available for this research: one with a cooperative of ten farmers and another in the Center for Research in Appropiate Technology maintained by the Land Reform Agency, both near Estelí. Different forms of barriers were tested including stone walls, pigeon peas, leucaena, Gliricidia sepium, pineapple, sisal and napier grass. Beans and sorghum were grown at the cooperative and maize at the Center for Appropriate Technology. Crop yields were measured, and soil samples were taken to measure soil loss by changes in texture and by phosphorus levels. In 1983, runoff plots were constructed but were completed too late in the season to be used. Response to the erosion control practices was enthusiastic, especially at the cooperative, which undertook to construct stone wall barriers on other parts of their holdings with technical help from CATIE/IFAD personnel. Yields of beans exceeded 2000 kg ha^{-1} in the first cropping period of 1983 even though the erosion control works occupied more than 10% of the experimental area. With the reestablishment of the CATIE/IFAD cropping systems specialist in Estelí, it is hoped that the soil conservation work in this area can be intensified, as the Land Reform Agency would like to extend this activity to at least 500 hectares in 1984.

CROP PHYSIOLOGY

Research in crop physiology has been carried out exclusively in the LHT, although results of some of the work (such as light availability under crop canopies and shading simulation studies) are applicable to other ecological zones. Much of the work reported has been carried out in collaboration with CATIE/UCR graduate students and UCR undergraduates. Research has concentrated on three basic areas: tropical root and tuber crops, weed control and live mulches, and light availability under different maize varieties and use of bio-indicator crops.

Tropical Root and Tuber Crops

- Propagation Methods in Purple Tanier

Purple tanier (Xanthosoma violaceum) is cultivated in the LHT as both a local market, and an export crop. Establishment of plants in the field, however, is extremely variable, causing problems for the producer in predicting labor demands (for weed control operations, for instance), in timing harvests appropriately, and thus in obtaining an acceptance product. The extreme variation in establishment has also been a major complicating factor in research studies with purple tanier. Thus, the effects of presence or absence of the terminal bud and size of seed pieces were studied to determine the influence of these factors on uniformity of crop establishment and on production. The study was carried out from June 1982 through August 1983, continuing through a dry spell occuring in February and March 1983 (200-270 days after planting). Five different seed piece sizes, ranging from 50 to 2500 g, were used.

Results show that both number and weight of corms produced are directly proportional to seed piece weight. Within the smaller seed pieces, production from those weighing 200-750 g did not vary significantly, but it was higher (both in terms of number and weight of corms produced) than that from seed pieces weighing 50-99 g (Figure 2). These results can be explained by the higher levels of emergence and vigor observed during the first 50 days with large seed pieces; smaller ones reached the same state at 100 days. Thus plants from large seed pieces attained maximum plant height and leaf area between 120 and 150 days, whereas for plants from

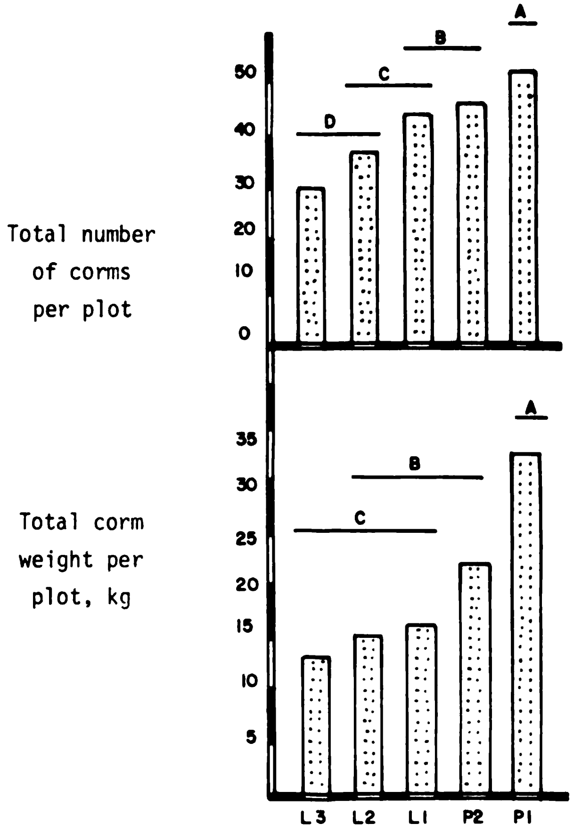

Figure 2. Total number of corms and total corm weight per plot for different seed piece sizes of purple tanier. L3 = lateral corm section, 50-99 g; L2 = lateral corm section, 200-400 g; L1 = lateral corm section, 700-800 g; P2 = primary corm section, 800 g; P1 = primary corm section, 2500 g. Horizontal lines indicate results of a Duncan's Multiple Range Test at the 0.05 probability level.

small seed pieces these maxima were lower and they occurred between 180 and 210 days.

Seed pieces without the terminal bud produced more corms per unit area than those with the terminal bud (450 vs. 400 corms/plot, respectively), thus showing apical dominance, but no difference was detected in total corm dry weight for these two treatments. Thus seed pieces with the terminal bud produced fewer but larger corms, and those without the terminal bud produced many smaller corms. This suggests the possibility of manipulating the type of corms produced to meet quality demands by varying the planting material used.

As this is a vegetatively propagated species, obviously some portion of the harvest must be used for seed pieces. Results show that the return in corm weight produced per unit weight of the seed pieces is less when large seed pieces are used. More specific economic and plant density studies are needed (such as using small seed pieces and a higher density) in order to improve crop management and maximize the saleable portion of the corms harvested.

The effects of using different sections of the corm (longitudinal, transverse and pieces produced by both longitudinal and transverse sectioning), with and without pre-sprouting were also investigated in purple tanier. Both number and total weight of corms were greater with seed pieces taken from primary corms as compared to those from lateral corms. Of the transverse sections, those with apical and sub-apical buds were most productive. Corms sectioned into various pieces showed the lowest yields, both in number and weight of corms (Figure 3).

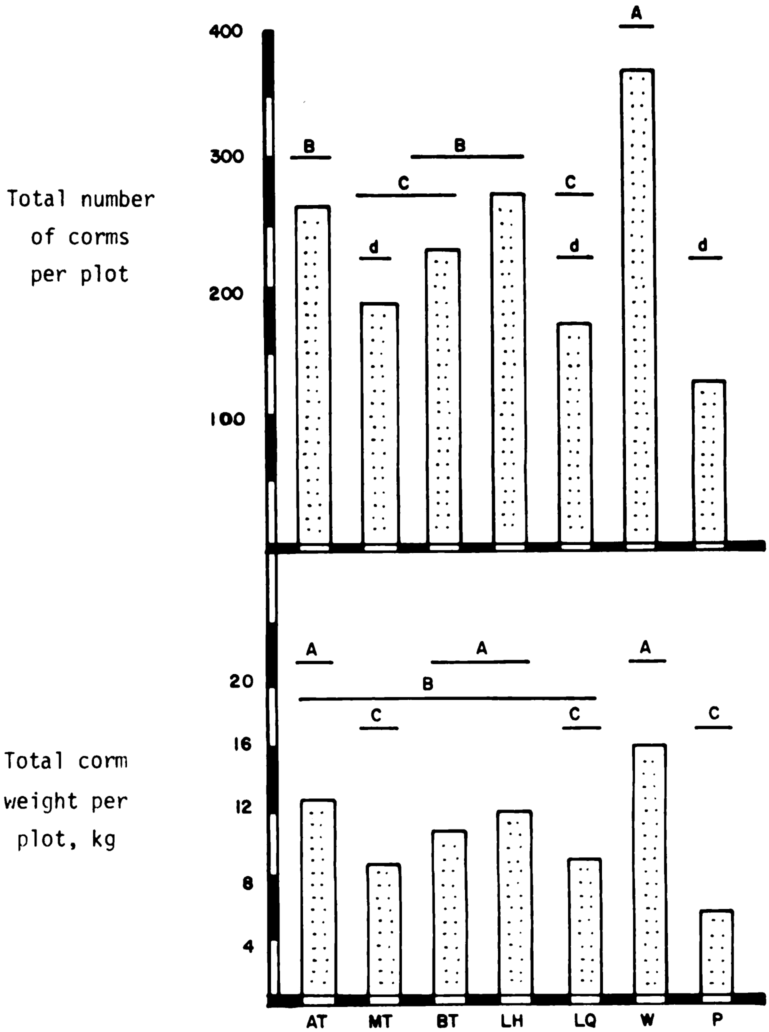

Figure 3. Total number of corms and total corm weioht per plot of purple tanier for different corm sections used as seed pieces. Sections: AT = apical transverse; MT = median transverse BT = basal transverse; LH = longitudinal halves, LQ = longitudinal quarters, W = whole corm, P = pieces produced by both longitudinal and transverse sectioning. Horizontal lines indicate results of a Duncan's Multiple Range Test at the 0.05 probability level.

It appears that pre-sprouting is important when seed pieces are cut from lateral corms, and it affects emergence, vigor, petiole length and leaf area. For these same variables, higher values were obtained when primary corms were used for seedpieces as opposed to lateral corms.

- Growth Analysis of Taro

Taro (Colocasia esculenta var. esculenta) is a potentially important root crop for the LHT of Central America. Little is known about its growth pattern, information which would be of use in designing alternative cropping systems for this ecological zone. In order to understand photosynthate partitioning to plant organs (leaves, petiols, and corms). a growth analysis was done for taro using 3 different seed piece sizes and 2 fertilizer levels.

Results show that larger seedpieces are more productive than small ones. Within size groups of seedpieces, corm dry matter accumulation fits a sigmoid curve, more closely for plants from large seedpieces (r^2=.90-.94) than those from small ones (r^2=.82-.86). In both cases, dry matter accumulation was greater with fertilizer than without, the difference becoming evident at about 118 days after planting. The effect of fertilizing was more marked in plants from large seed pieces (Figure 4).

The increase in leaf area for plants from large seed pieces is rapid until 72 days after planting. At this point it begins a rapid decline, and then stabilizes at about 103 days after planting. During the period

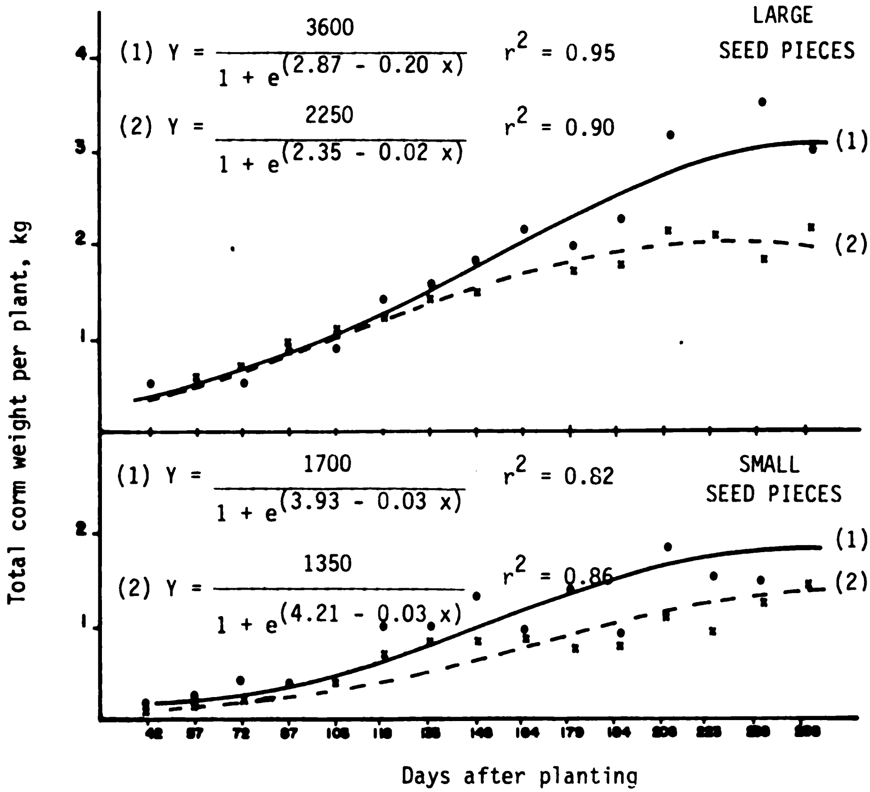

Figure 4. Total corm weight per plant as a function of days after planting for taro plants from large seed-pieces (upper figure) and small seedpieces (lower figure), both with (o) and without (x) fertilizer.

of maximum plant growth, leaf area of unfertilized plants was only 35% that of fertilized plants (Figure 5).

For plants from small seedpieces, fertilized plants followed a pattern of leaf area development similar to that discussed above. Unfertilized plants, however, reached maximum leaf area at 87 days after planting, and at this point had 66% the leaf area of fertilized plants (Figure 5). In all cases, large seedpieces gave rise to plants with more leaf area than small ones.

Similarly, petiole dry weight was greater in plants from large seed pieces. In this case, petiole biomass of fertilized plants increased rapidly until 72 days after planting, then very rapidly from 72 to 87 days. It then remained roughly constant until 113 days, at which point it began a rapid drop of until 133 days, followed by a continued slow decline. No stable period was observed in unfertilized plants, but rather a gradual increase in petiole biomass until 133 days (reaching a maximum of 40% that of fertilized plants), followed by a gradual decline (Figure 6).

Using small seedpieces, fertilized plants reached maximum petiole biomass at 102 days after planting, and unfertilized plants at 87 days. The maxima were similar in value (Figure 6).

Analysis of growth curves for taro showed that initially rapid leaf formation occurred, followed by a period when biomass accumulated in petioles and corms. Lastly there was a long period of photosynthate translocation from petioles to corms. Fertilizer effects and the influence of seedpiece size can be explained by increased efficiency during each of these periods and an appropriate balance among them.

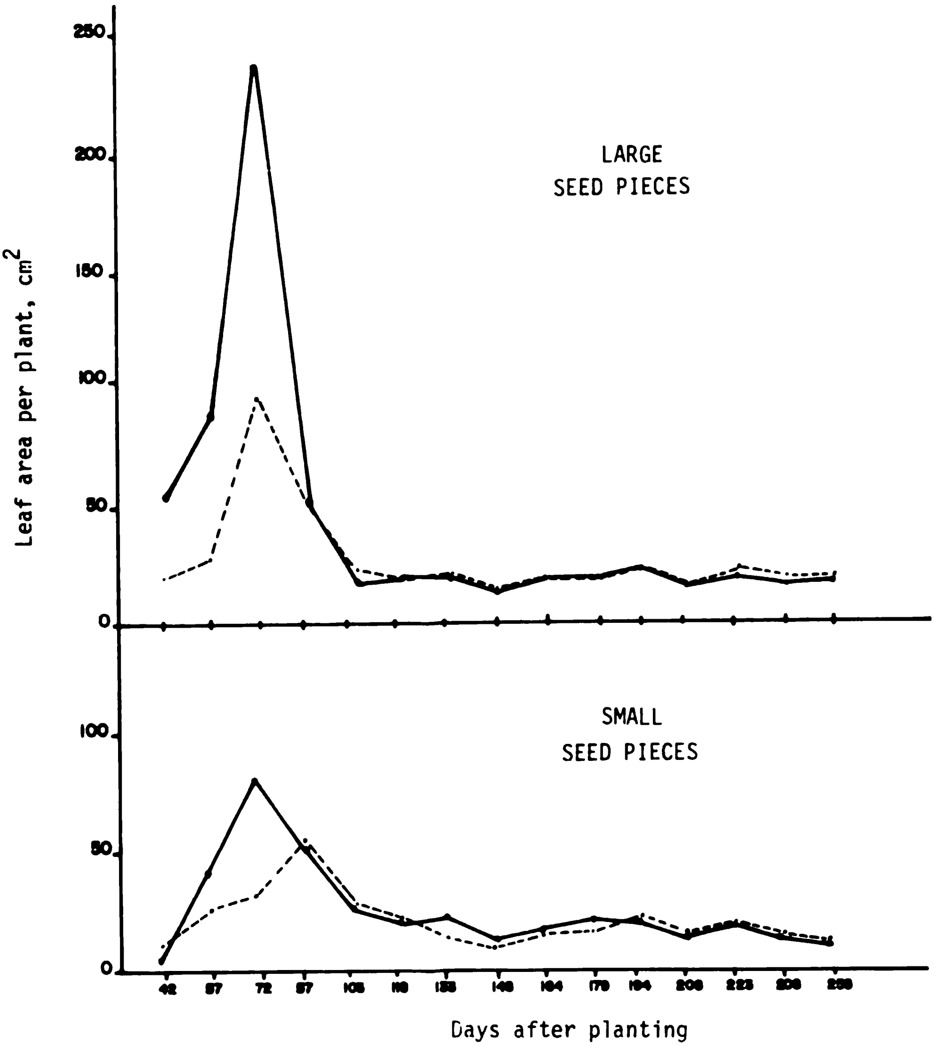

Figure 5. Leaf area per plant as a function of days after planting for taro plants from large seedpieces (upper figure) and small seedpieces (lower figure), both with (——) and without (---) fertilizer.

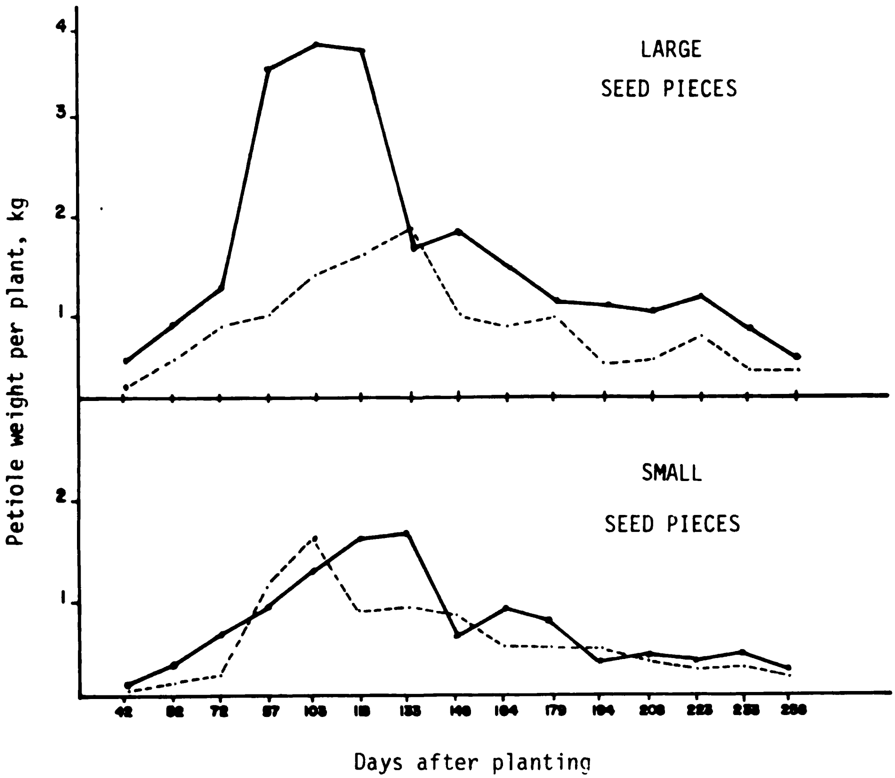

Figure 6. Petiole weight per plant as a function of days after planting for taro plants from large seed pieces upper figure) and small seed pieces (lower seed pieces), both with (——) and without (---) fertilizer.

- Other Studies

Several other physiology studies are currently in progress with tropical root crops, to provide information of use in designing alternative cropping systems involving these species. These include a growth analysis of white tanier (X. sagittifolium), a growth analysis of sweet potatoes (Ipomoea batatas), and a study of the effect of growth regulators on sprouting time in eddoe (C. esculenta var. antiquorum). Results of these studies are not yet available.

Weed Control and Living Mulches

- Growth Analysis of Gamalote

Gamalote (Paspalum fasciculatum) is a major weed species in the LHT, but little is known about its growth habits, information which would help desigr weed management methods. Using non-rooted stolon sections as planting material, a stand of gamalote was established in Turrialba for growth studies.

Total dry weight of the weed increased logistically (r^2 = .92). The growth rate was low during the first 6 weeks, despite an adequate water supply (Figure 7). Rapid growth began at 8 weeks, and the growth rate did not decrease until 18 weeks. The highest growth rate coincided with a dry spell (14 - 19 weeks). The growth patterns for stolons and for leaves were quite similar, both fit a sigmoid curve (r^2 = .92 and .76 for stolons and leaves, respectively). Leaf area index remained low, varying from 0.05 at 6 weeks to 0.12 at the end of the study. The stolon/leaf ratio

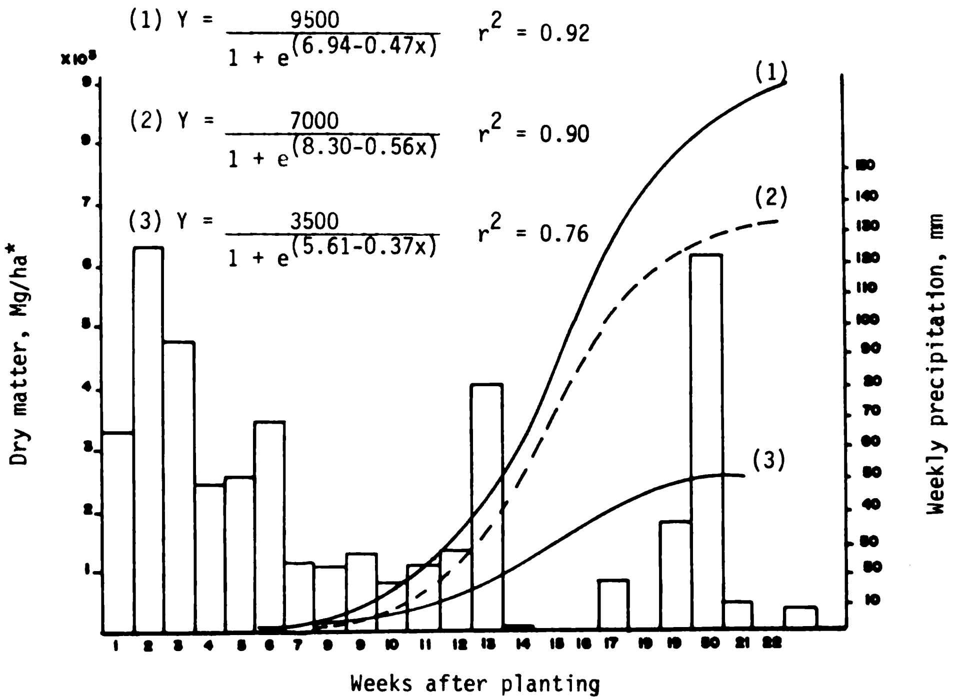

Figure 7. Dry matter production of gamalote as a function of weeks after planting, compared with weekly precipitation observed. (1) Total dry matter, (2) Stolons, (3) Leaves.

* Mg = Megagram = 10^3 kg (SI unit)

was less than 1.0 until 9 weeks, then increased to a maximum of 3.3 at 15 weeks.

It appears that the first 6 weeks after planting constituted an establishment phase, during which the new plant depended primarily on reserves stored in the stolon. Under natural conditions in an infested field, however, the stolon remains connected to the mother plant and new plants can draw on its reserves, resulting in a much more rapid initial growth rate. This also explains the more rapid reinfestation following tillage of fields with an established gamalote stand (where rooted stolon pieces are disseminated) compared to a recently infested field (where most stolon pieces still have no roots).

The stolon/leaf ratio indicated that gamalote is probably most aggressive after 9 weeks, when more rapid stolon formation occurs. As the plant has a generally small leaf area, herbicides should be applied with adjuvants (when these are compatible with the product used) and it would be useful to identify the phase of maximum leaf development for improved gamalote management.

If chemical control is to be used for gamalote a systemic herbicide would probably be highly efficient, as it would be translocated to the storage and propagation organs (stolons). During the first 9 weeks after establishment, a vigorous living mulch might be preferable to control the gamalote, as this is a critical period for the weed in which it is very susceptible to competition.

- Other Studies

In order to obtain further information on the growth habits of gamalote necessary for designing appropriate weed management strategies, a study is currently underway on its reinfestation capacity. In an effort to develop alternatives to costly chemical and manual weed control methods, two studies in living mulches are underway. One involves the use of sub-lethal doses of herbicide to regulate living mulches for weed control in maize, and the other is a study of controlled propagation of *Melampodium divaricatum*, a potential living mulch species. Results of these three studies are not yet available.

Light Availability under different Maize Varieties and use of Bio-Indicator Crops

- Light Availability under three Maize Phenotypes measured electronically and with Bio-Indicator Crops

Small-scale farmers throughout Central America plant maize, nornally associated directly or in relay with another crop. Neither the environmental conditions nor the competition which the maize imposes on associated crops have been investigated in sufficient detail. Light availability appears to be a limiting factor to crops associated with maize. An understanding of these factors would improve researchers' capacity to design technological alternatives.

A series of studies was initiated in July 1982 in order to investigate the light availability under the canopy of three maize varieties, selected to represent a wide variation in plant height and leaf area. The possibility of using some species as biological indicators of light availability, as an easy and inexpensive alternative to radiometers was also investigated.

Tall, intermediate and short maize varieties ('Eladio Hernández', 'Tuxpeño P.B. C-7' and 'Maicito' respectively) were planted at three densities (30,000; 45,000 and 60,000 plants ha^{-1}), in a factorial arrangement of treatment combinations. Two bio-indicators (mung bean and rice) were planted with each treatment. Photosynthetically active radiation under the maize canopy was measured periodically using a linear integrator, while measuring the biomass of the rice and mung beans.

Results showed that both maize varieties and planting densities significantly affected light availability. The tall and intermediate varieties did not differ significantly, with 49% and 51% non-intercepted light respectively. The short variety, with 78% was statistically different. Maximum light interception occurred between 50 and 90 days after planting for tall and intermediate varieties, and between 30 and 50 days for the short variety (Figure 8).

Differences in light availability due to maize planting density were also significant. Non-intercepted light was 48% of the total radiation with 30,000 plants ha^{-1}, 39% with 45,000 plants ha^{-1}, and 30% with 60,000 plants ha^{-1}. Variation in the light availability within the maize rows was also found; non-intercepted light was up to 30% higher between rows than at the base of the maize plants (Figure 8).

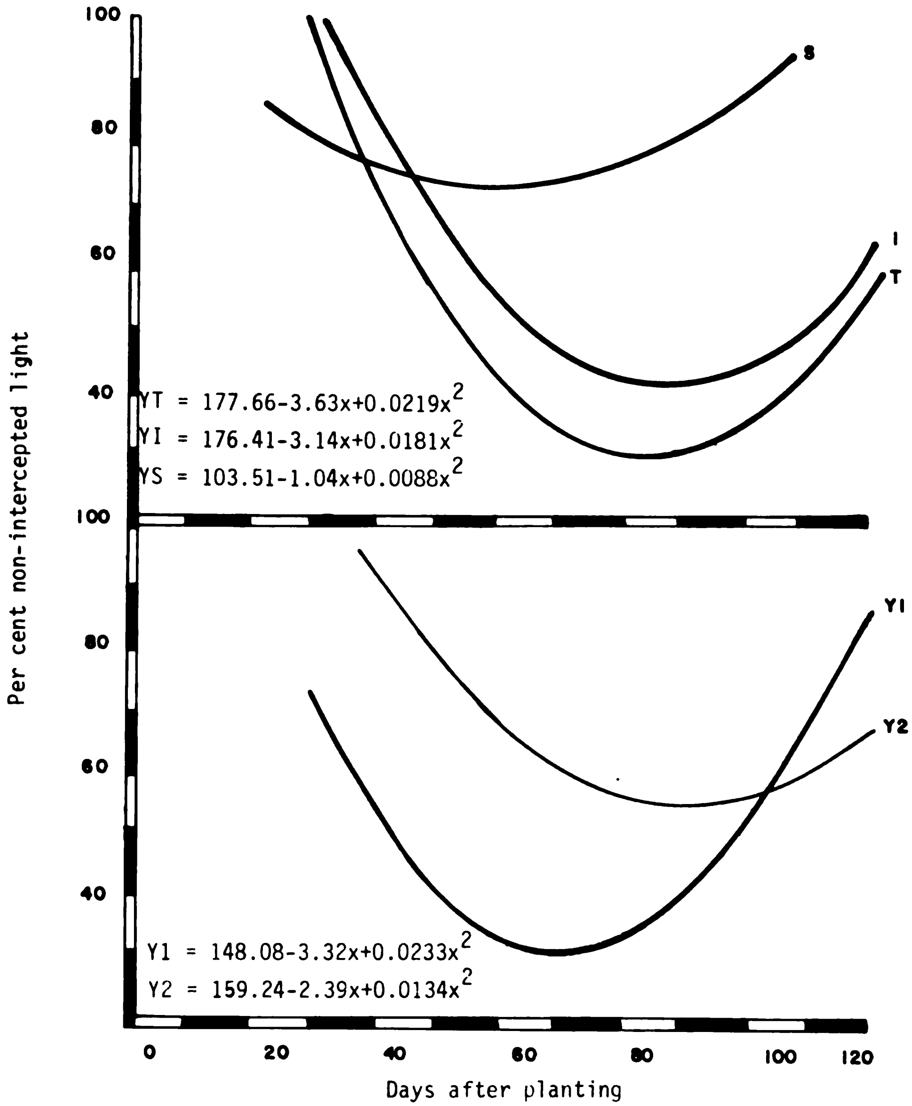

Figure 8. Per cent non-intercepted light over time for tall (T), intermediate (I) and short (S) maize varieties (upper figure), and for measurement at the base of the maize plants (Y1) vs. at the midpoint between maize rows (Y2) (lower figure).

The patterns of light availability under nine different variety x density combinations for maize should be of use in varietal selection of crops to be associated with maize, selecting for the appropriate degree of shade tolerance.

Information from the bio-indicator crops, it was hoped, would correlate with electronic measures of light availability. Figure 9, shows the relative biomass production of rice associated with maize (compared to biomass production of monoculture rice). The effects of maize varieties and densities are evident. Again the tall and intermediate varieties ('Eladio Hernández' and 'Tuxpeño') were not different from each other, but both were different from the short variety ('Maicito'). With increasing maize density the rice biomass decreased, although the magnitude of this decrease varied somewhat for different maize varieties.

Thus it appears possible to evaluate light availability indirectly, using bio-indicators, although care must be taken to minimize the effects of competition attributable to factors other than light.

- Other Studies

Work on light availability is being continued with an evaluation of the possibility of simulating maize canopy development using shade cloths of varying densities. If effective, the method could be used in varietal selection of crops to be associated with maize.

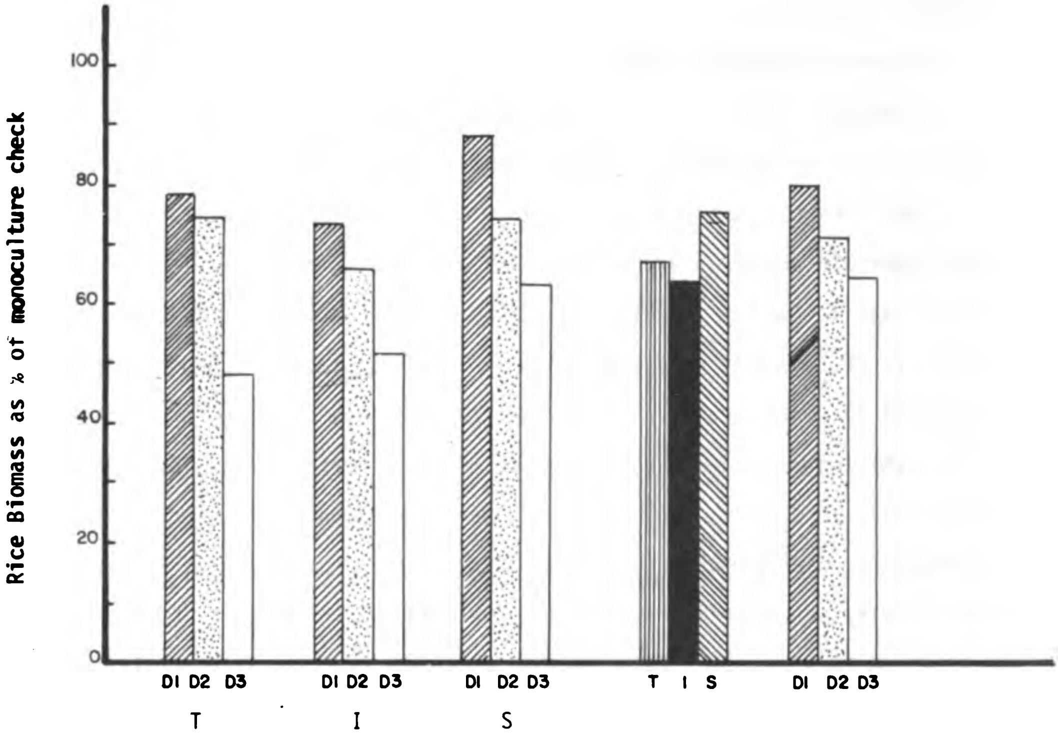

Figure 9. Biomass of rice produced in association with three maize varieties (T = tall, I = intermediate, S = short) planted at three different densities (D1 = 30,000 plants ha^{-1}, D2 = 45,000 plants ha^{-1}. D3 = 60,000 plants ha^{-1}).

GENOTYPE EVALUATION

Research concerning genotype evaluation is of two types: 1) evaluation of the adaptation and potential of a range of varieties of basic food crops under specific environmental conditions, and 2) study of the response of crop varieties to the conditions prevalent on small farms, specifically environmental stresses, varying levels of management, and polyculture cropping systems. The first activity is of an applied nature, and results should be of immediate practical value to teams working on technology development for small-scale farmers in Central America, by providing them with promising varieties and information on their performance. The second activity is more basic, and should provide information on the need (or lack thereof) for varieties bred specifically for certain environments, management levels, or crop mixtures. Specific experiments often contribute to both activities, so the role of each study in one or both of them will be discussed when it is presented.

To date, genotype evaluation research has been carried out in sites representative of two major ecological zones of Central America: the LHT and the SAT. Research results from these representative sites should be relevant to most of the regions comprised by the respective ecological zone. Work in other important ecological zones of Central America, such as the low altitude and high altitute wet-dry tropics, may be contemplated in the future.

Lowland Humid Tropics

The major annual food crops of the LHT are cassava, maize, common beans, and edible corms and roots. Work with the corms and roots has been left to a CATIE/IDRC project, which is dedicated specifically to varietal introduction and evaluation for these crops. IFAD-supported genotype evaluation research has concentrated on cassava, maize, common beans, and soybeans (a promising alternative to common beans in this zone). Turrialba and San Carlos, Costa Rica are being used as research sites. The following studies are underway:

- Evaluation of 38 Cassava Varieties in San Carlos

Previous studies in several sites, using a relatively limited range of cassava germplasm have turned up varieties with yields superior to those of local cassava varieties. However adoption of these varieties has been minimal, due (according to San Carlos farmers) to their inferior flavor, cooking quality and export quality. Thus a study was designed to evaluate a wide range of material (including local San Carlos varieties, local varieties from other areas in Central America, and improved varieties introduced from CIAT), for agronomic characteristics and, using the most promising materials, for market acceptability. The study was done together with the agricultural economist.

The agronomic characters observed for each variety included:

Tolerance to scab (*Elsinoe brasiliensis*) and cercospora leaf spot (two cassava diseases prevalent in the LHT)

- pubescence of new leaves (a mechanism of resistance to thrips, an insect suspected of affecting cassava yields in the area)

- foliage density, days and height to first branch, and plant height (all correlated with yield potential in cassava, and probably related to its suitability for intercropping)

- yield and yield components

The initital evaluation also included a visit to the trial, immediately prior to harvest, by 10 local farmers, who evaluated each variety for acceptability of the plant type and of the root shape, color, and size. Based on published information (primarily from CIAT) and the ideas of the farmers who evaluated the trial concerning the importance and optimal values of the various characteristics observed, a selection index was generated to rank the varieties and to choose those which were to be included in the market acceptability study.

Results showed that there was a significant variation among varieties for all the characters observed, indicating that genetic variability for any of these characters is available. Yields, of commercially acceptable, of roots ranged from 0.9 to 24.5 Mg ha^{-1}*. The highest yielding local variety (Mangf) produced 16.4 Mg ha^{-1}. It is of interest that the yield of non-commercial roots did not vary significantly, which suggests that regardless of total root yield of the variety, a relatively constant portion of the roots will be commercially unacceptable. Commercial and total root

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* Mg = Megagram = 10^3 kg (SI unit)

yields for the ten highest yielding varieties and the local varieties are presented in Table 15. Further discussion and results related to the selection index used are presented under Socioeconomic Studies. Several materials appear very promising agronomically and acceptable both to farmers and consumers.

It is anticipated that 4 - 5 of the best varieties from this study will be evaluated on farms by the San Carlos prototype team in 1984. The farmers' evaluation has provided valuable information on the plant type required for adequate crop management and on the most desirable root type. The study of acceptability for home consumption, for the local market, and for exportatior will provide guidelines for future cassava varietal selection in Costa Rica. Furthermore, the methodology used, combining a standard agronomic evaluation with an evaluation by farmers and a socio-economic evaluation of acceptability of the varieties, is a new one which hopefully will prove of value in varietial evaluation and selection in general.

- Evaluation of 19 Maize Varieties with two levels of Fertilization

Most farmers in the San Carlos area grow maize associated with cassava, both for home consumption and for the local market. The varieties used are tall late local materials with relatively low yield potential. Fertilizer usage in the maize+cassava association varies considerably among farmers in the region. As cassava is the main income-earning crop and maize is secondary in importance, it does not always receive optimal fertilization. This study was designed to evaluate the performance of 19 maize

Table 15. Sources and yield of highest yielding Cassava varieties and local checks from an evaluation of 38 Cassava varieties.

Variety	Source	Commercial yield (Mg ha^{-1})**	Total yield (Mg ha^{-1})
Vagana	CATIE*	24.5	31.4
CMC 323-375	MAG	23.8	28.9
P 77-14	CATIE	22.7	26.5
Brazil 14-47-40	CATIE	17.2	27.0
CMC 30 No. 88	CATIE	16.7	20.0
Mangí	San Carlos+	16.4	21.2
CM 523-7	CIAT	16.3	25.7
Tilarán - 1	CIAT	15.9	20.5
Camote Corriente	CATIE	15.7	23.2
Mata de Chile	CATIE	15.2	22.4
Algodón	San Carlos	12.6	20.9
Valencia	San Carlos	8.9	14.1
Brasileña	San Carlos	5.4	13.0

* Collections from the Genetic Resources Unit at CATIE.

+ Local varieties from San Carlos.

** Mg = Megagram = 10^3 kg (SI unit)

varieties (including local varieties, materials from the Costa Rica, maize breeding program, and materials introduced from CIMMYT), both with and without fertilization.

Yield data were lost due to very severe bird damage at maturity. (This trial was planted as a monoculture. It is interesting to note that association with cassava apparently reduced bird damage to maize, according to studies discussed later in this report). Data were obtained for a range of morphological and physiological characters, and light interception by each variety at flowering (a measure of its suitability for associations) was measured.

Analysis of variation showed significant differences due to fertilizer levels of plant height, stalk diameter, and light interception at flowering. As might be expected, plant which received fertilizer were more vigorous. Varieties were a significant source of variation for all characters measured, but statistically significant interactions of varieties with fertilizer levels were not detected.

Varieties were characterized according to plant height and leaf area, the characters which would most affect their suitability for association with other crops. It is clear from Figure 10 that the two local varieties (no. 18 'Maicena' and no. 19 'Rocamex') are much taller than any of the improved materials, and 'Maicena' is also much leafier. Some interesting varieties, such 'Poza Rica 7543' (no. 7) which is very short but very leafy, and 'Poza Rica 7828' (no. 5) which is short with a low leaf area, can be identified and will be of use in studying the effect of plant morphology on maize performance in crop mixtures.

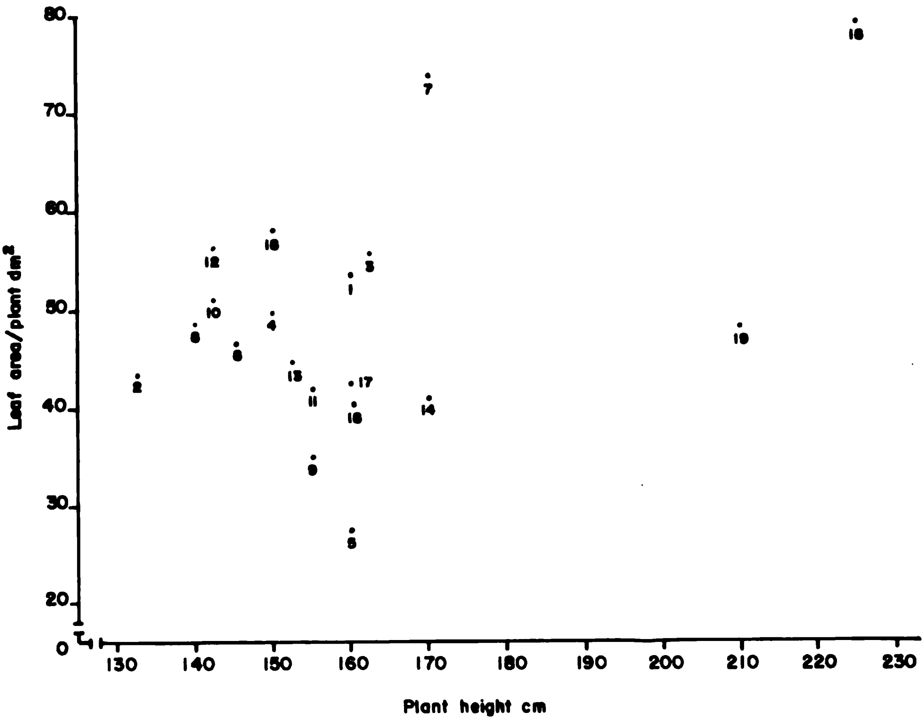

Figure 10. Leaf area / plant (dm^2) vs. plant height (cm) for 19 maize varieties.

Although variety by fertilizer level interactions were not significant, some idea of the stability of performance over the two levels of fertilizer can be obtained by examination of plant height, leaf area, and light interception data. These are presented in Table 16 for the varieties which appear most stable over fertilizer levels, and for the local varieties. These results will be checked by repeating this trial, hopefully obtaining yield data. Should they be upheld, the more stable varieties could be useful in areas where optimal fertilization is not used (due to insufficient purchasing power or to low economic return to its use). Yield data would also allow varieties which are good performers in humid conditions, such as those of San Carlos, to be identified.

- Evaluation of Different Cassava Plant Types in the Cassava+Maize Association

Little is known about competition in the maize + cassava association, and how it is influenced by the plant architecture of the two species involved. With the aim of defining which plant types are most compatible in this system and allow optimal productivity of both crops, two complementary studies were designed: one investigating the effect of cassava varieties differing in plant height and leafiness on the performance of the association, and a similar one using different types of maize (to be discussed in the following section).

Five cassava varieties were planted both in monoculture and associated with the maize variety 'Tuxpeño Planta Baja C-7', in Turrialba. Data for

Table 16. Reaction to different fertilizer levels of the most stable of 19 varieties and for local checks.

Variety	Fertilizer treatment	Plant height, cm	Leaf area, dm^2	% light not intercepted
7. Poza Rica 7543	+	170	74	92
	0	160	60	92
11. Tico V-6	+	155	42	92
	0	125	38	93
16. La Posta	+	160	41	89
	0	155	43	93
18. Maicena (local check)	+	225	79	88
	0	170	46	94
19. Rocamex (local check)	+	210	48	90
	0	185	63	89

those characteristics of the maize which varied depending on the cassava variety it was associated with, are presented in Table 17. Maize yield in monoculture was lower than that of any in association with cassava, a result which appears unlikely at first glance. However, bird damage to the ears was greatest in the monoculture treatment. Apparently, the cassava canopy conceals the maize ears from birds to some extent. Bird damage was lowest in the maize associated with cassava of intermediate plant height ('Criollo Zamorano' and 'M Col 22'), suggesting that there was more foliage at the height of the maize ear during maturity with these plant types than with taller or shorter ones.

Cassava appears to interfere with maize pollination somewhat, as the number of barren ears was higher in association than in monoculture. In this case, intermediate height and short cassava plant types apparently interfered more than tall types. As yet the reason for this is unclear, although it is probably related to the relative position of the cassava canopy and the maize ear shoot and tassel at flowering.

Maize plant height was generally lower in monoculture that in association. The increased plant height in association suggests that the cassava was competing with the maize, although in the field the maize appeared dominant throughout its growth cycle. Maize yields relative to the monoculture were highest when it was associated with a tall leafy cassava variety.

Cassava data indicated that planting systems (monoculture vs. association with maize) were a significant source of variation only for plant

Table 17. Maize data from study on cassava plant types in the Maize + Cassava association.

CASSAVA VARIETY			MAIZE DATA				
Name	Height*	Leaf area+	Yield Mg ha^{-1}**	Plant height cm	Approx. grain loss to birds g/plot	Number of barren ears per plot	Yield relative to monoculture
CMC 84	T	H	1.6 a°	168 b	124 ab	1.0 b	1.18 a
Criollo Zamorano	I	H	1.5 ab	171 ab	1 b	6.3 a	1.09 ab
Valencia	T	L	1.4 ab	180 a	288 ab	1.0 b	1.03 b
CM 342-180	I	L	1.4 ab	173 ab	70 ab	4.7 ab	1.03 b
M Col 22	S	I	1.4 ab	169 b	55 b	2.3 ab	1.02 b
Maize monoculture	-	-	1.3 b	164 b	378 a	0 b	--
Mean			1408	171	155	2.6	1.07
F Value			1.58	2.46	2.08	2.40	2.62
Probability F			0.24	0.09	0.13	0.09	0.11

* T = Tall; I = Intermediate; S = Short

+ H = High; I = Intermediate; L = Low

° Means within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

height; neither yield nor its components were affected significantly. All characters measured except for total number of roots varied significantly over cassava varieties, but plant height was the only character which showed significant variety x systems interaction. Tables 18 and 19 presented data for systems, varieties, and their interaction for cassava final plant height and commercial root yield, respectively. For both variables, the efforts of competition with maize are evident in the associated system: plants were generally taller and yielded less. Both of these effects were very pronounced with the variety 'Criollo Zamorano', suggesting that it is quite susceptible to competition. Despite this fact, it yielded more even under association than any of the other varieties in either system. 'CMC 84' a tall leafy cultivar, maintained fairly stable yield over the two systems, whereas 'Valencia', a tall cultivar with little foliage, suffered an intermediate level of yield reduction when associated with maize. The intermediate height, low leaf area cultivar'CM 342-180' showed almost no change in plant height upon association, but suffered a yield reduction similar to that of 'Valencia'. The short cultivar, 'M Col 22', showed a marked reduction in both plant height and yield under association.

Combined analysis of maize and cassava data using relative yields showed no significant differences in productivity of the systems for the different cassava varieties. The highest relative yield value was obtained for maize associated with 'CMC 84', the cassava variety which allowed the highest maize yield and itself yielded second highest. Interestingly, maize yield was highly significant positively correlated with yield of non-

Table 18. Variety, system and interaction mean values for cassava final plant height (cm).

Planting System	Cassava Variety					System Mean
	CMC 84	Valencia	Criollo Zamorano	CM 342-180	M Col 22	
Associated with maize	277	260	288	188	165	224 a*
Monoculture	248	238	167	182	117	190 b
Variety mean	263 a*	249 a	198 b	185 b	141 c	

* Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 0.05 probability level.

Table 19. Variety, system and interaction mean values for commercial root yield of cassava ($Mg\ ha^{-1}$)**

Planting System	Cassava Variety					System mean
	Criollo Zamorano	CMC 84	Valencia	M Col 22	CM 342-180	
Monoculture	37.8	28.4	22.6	18.3	15.2	24.5
Associated with maize	30.3	26.2	18.7	15.1	12.2	20.5
Variety mean	34.0 a*	27.3 b	20.6 c	16.7 cd	13.7 d	

* Means followed by the same letter do not differ significantly according to Duncan's Multiple Range Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

commercial roots in cassava (r = 0.67**), suggesting that more vigorous maize plants may compete with cassava in the root zone, limiting the size to which cassava roots develop.

This study is currently being repeated, with special attention to observations concerning the possible interactions between the two crops which are mentioned in the preceeding discussion. Such data will ultimately provide information on the advantages and limitation of growing the two crops together in terms of specific characters in the cassava which are desirable if it is to be grown in association with maize.

- Evaluation of different maize plant types in Cassava+Maize Association

As mentioned previously, this study was designed as a complement to the one discussed above, in order to study competition in the maize+ cassava association and define plant types of maize most suitable for this system. As most farmers in the San Carlos area plant maize 15 days after the cassava, this arrangement was included as well as simultaneous planting and monoculture. The trial was done both in San Carlos and in Turrialba. At present the cassava data are being analyzed, however data for the maize varieties are presented below, using only the San Carlos site for the sake of brevity (results were quite similar at the two sites).

Cropping systems were a significant source of variation for number of bird-damaged ears, weight of clean grain per ear, number of ears incompletely filled and estimated grain loss to birds. Means for these and other key variables for the different systems are presented in Table 20. The monoculture outyielded both association, although the difference was only significant at the 0.15 probability level. Plant height data suggests that competition with the maize was highest with planting 15 days after cassava, as might be expected. As seen in the previous study, bird damage to maize was reduced when it was associated with cassava, and the damage was lowest with planting 15 days after cassava. Other factors appeared to outweigh this in determining yield, however. The weight of clean grain per ear was highest in the monoculture, followed by the simultaneous association, and the number of ears incompletely filled was least in the monoculture, followed by the simultaneous association. Thus, as seen in the previous study, it appears that association with cassava interfered with maize pollination, and this effect was most marked with planting 15 days after cassava.

Data for each of the maize varieties is presented in Table 21. Plant height and leaf area data confirmed the classifications used in selecting the varieties for the study. 'Tico V-5', the intermediate height, intermediate leaf area variety yielded most, while the extremely tall variety ('Eladio Hernández') and the extremely short one ('Tuxpeño PB C-17') yielded least. Tall leafy varieties had more bird damage and more ears not completely filled, while the short early materials had more grain loss to rots and less clear grain per ear. Variety x systems interactions were observed for maize plant height and grain loss to rots. Further analysis is required to understand the nature of these interactions.

Table 20. Data for planting systems from a study on maize plant types in the Maize + Cassava Association

Planting System	MAIZE DATA					
	Yield $Mg\ ha^{-1}$**	Plant height cm	Weight of clean grain per ear, g	Number of bird-damaged ears	No. of ears incompletely filled	Estimated grain loss to birds, $Mg\ ha^{-1}$
Maize monoculture	1.8 a*	171 b	82 a	4.5 a	5.0 b	126 a
Maize + Cassava with simultaneous planting	1.4 b	178 b	64 b	2.4 ab	6.1 ab	32 b
Maize planted 15 days after cassava	1.3 b	189 a	55 c	0.9 b	7.4 a	15 b
Mean	1.5	179	67	2.6	6.1	58
F Value	2.59	3.79	12.05	11.19	6.87	6.10
Probability F	0.15	0.09	0.0008	0.01	0.03	0.04

* Within a column, means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

Table 21. Data for varieties from a study on maize plant types in the Maize + Cassava association.

Maize Variety	Height*	Leaf area+	MAIZE DATA						
			Yield Mg ha^{-1}**	Plant height, cm	Leaf area per plant dm^2	Weight of clean grain per ear, g	Number of bird-damaged ears	Number of ears incompletely filled	Estimated grain loss to rots Mg ha^{-1}
Tico V-5	I	I	1.8 a°	180 b	54 d	68 b	2.7 ab	6.1 ab	66 b
Tuxpeño Planta Baja C-12	I	H	1.6 ab	178 b	70 a	73 b	1.6 b	8.3 a	131 ab
Blanco Cristalino	S	L	1.5 ab	165 c	40 c	57 c	2.9 ab	4.8 bc	125 ab
Eladio Hernández	T	H	1.3 b	241 a	74 a	85 a	5.3 a	8.0 a	112 b
Tuxpeño Planta Baja C-17	S	I	1.3 b	132 d	50 b	51 c	0.7 b	3.4 c	189 a
Mean	...	...	1.5	178	58	67	2.6	6.1	125
F Value	...	...	3.4	158	45.9	22.4	3.1	6.5	3.8
Probability F	...	...	0.02	0.0001	0.0001	0.0001	0.03	0.005	0.01

* T = Tall; I = Intermediate; S = Short

\+ H = High; I = Intermediate; L = Low

° Within a column, means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

Once completed and analyzed, the data from this study will serve as a complement to that of the previous one, both to help understand the interaction between species in the systems and to identify the most compatible plant types for it.

- Evaluation of 14 Soybean varieties for tolerance to flooded soils

Conditions in much of the LHT are very marginal for common beans, due to excessive soil moisture and high humidity. Soybeans are reputed to be a promising alternative in such areas, as they theoretically can adapt to flooding by producing oxygen-conducting tissues from above-ground plant parts to the roots. An initial greenhouse study done by the soil management specialist of the CATIE/IFAD project confirmed the adaptation of soybeans to flooded soils.

To further investigate soybean varietal response to flooded conditions, a trial of 14 tropically-adapted varieties was established in floodprone field in Turrialba. The experiment was planted in June, to coincide with a very rainy period. Some plots of the experiment were flooded throughout most of the growth cycle, yet the plants produced grain. Despite the highly humid conditions, very little disease attack was observed; the major field problem was insect control.

Data from this trial are currently being analyzed. From field observations, several varieties appear very promising. The prototype team in San Carlos will establish an on-farm trial with the best varieties from this evaluation in December of 1983.

- Screening of Common Bean Varieties for adaptation to the Humid Tropics

Little information exists in the performance of beans in humid tropical environmental as these are generally deemed inappropriate for bean cultivation. However, many farmers in San Carlos and in other similar areas continue to cultivate beans, primarily for home or local consumption. In order to gain insight into the improvement possible through varietal selection, a wide range of bean varieties are currently being planted in San Carlos, in collaboration with the prototype team there. Their adaptation to the environmental conditions, diseases, and insects present in the area will be observed.

Semi-arid Tropics

The major crops grown in this ecological zone are maize, photoperiod-sensitive and insensitive sorghum, and common beans. Genotype evaluation work has concentrated on these crops and on cowpeas, as a promising alternative to beans. Some attention has also been given to millet and pigeon peas, two crops which are known for their high levels of drought tolerance. Estelí, Nicaragua is being used as a research site. A discussion of the studies carried out follows.

- Evaluation of Yield and Stability of 15 Maize Varieties in 8 Sites with varying Severity of Drought Stress

One of the most limiting factors to crop productivity in the semi-arid areas of Central America is erratic rainfall distribution. Under such unreliable conditions, stability of production is of paramount importance to farmers. With the goal of identifying varieties of maize with stable yields superior to those of farmers' varieties, given the erratic rainfall conditions in the Estelí area, 15 varieties were planted at 8 different sites expected to show varying intensities of drought stress during the second planting season of 1982. The varieties included materials from CIMMYT, the Honduran maize breeding program (selected for drought tolerance), and locally used varieties.

Drought stress was so severe in two sites that the trial was lost. Yield data from the other six sites are presented in Table 22, with the varieties in order from highest to lowest mean yield and the sites in order, according to the mean yield for the trial at each site, which presumably gives a rough indication of the severity of drought stress at each site. The yield of the local check variety remained quite stable but low, even at the most favorable sites. Several varieties, notably two selections from Antigua x Rep. Dom., 'Jutiapa 7930' and 'Pool 16', maintained yields above the trial mean at all sites. Although these materials showed a marked response to better conditions (less drought stress), their yields were relatively good even under the worst conditions, and thus they should be of benefit to farmers in the area. 'Tuxpeño Planta Baja C-15' and 'Honduras A-502' appeared quite stable but of lower yield potential; these materials would be of use to a breeding program in the region.

This work is being followed up by trials in both the first and second planting seasons this year, to confirm the results presented above.

Table 22. Yields (Mg ha^{-1}) of 15 maize varieties in 6 sites with varying degrees of drought stress

Maize Variety	Site						Variety mean Mg ha^{-1}
	Santa Adelaida	La Grecia	Mateare	La Caña	San José	El Naranjo	
Antigua x Rep. Dom. Sel. Red. Hoja C-6	0.7	1.2	1.4	1.4	2.4	3.1	1.7
Jutiapa 7930	0.5	1.2	1.2	2.3	2.6	2.1	1.7
Antigua x Rep. Dom. Sel. Red. Espiga C-6	0.9	0.7	1.3	1.2	2.8	3.0	1.7
Pool 16	0.6	1.0	1.3	1.7	2.6	2.1	1.6
Blanco Cristalino - 2	0.4	0.9	1.4	1.4	2.6	2.1	1.5
Pirsabak (1) 7930	0.3	1.0	-*	-	2.5	2.0	1.5
Pool 15	0.3	0.8	1.1	1.2	2.8	2.3	1.4
Tuxpeño Planta Baja C-15	0.6	0.9	0.8	1.1	2.3	2.7	1.4
Honduras B-103	0.1	1.1	-	-	2.0	2.4	1.4
Tocumen 7931	0.2	1.1	1.3	1.4	2.0	2.1	1.4
Ant. x Rep. Dom. Sel. Red. Hoja y Espiga C-6	0.4	1.1	1.0	1.0	2.0	2.3	1.3
Honduras A-502	0.5	1.0	1.2	1.6	1.9	-	1.2
Honduras B-104	0.5	0.8	-	-	1.3	2.3	1.2
Tuxpeño Sel. Resist. a Sequía C-3	0.4	0.8	0.7	1.0	2.0	2.0	1.2
Testigo (Olotillo ó X-107-A)	0.2	0.9	1.1	1.2	1.4	1.0	1.0
Site mean, Mg ha^{-1}**	0.4	1.0	1.2	1.4	2.2	2.3	

* Indicates that not enough seed was available to include the variety at this site.

** Mg = Megagram = 10^3 kg (SI unit)

- Evaluation and selection of 52 photoperiod-insensitive sorghum lines.

Photoperiod-insensitive sorghum is cultivated during the second planting season in Estelí, in a range of different systems (maize-sorghum, maize-sorghum+beans, and sorghum monoculture are the commonest). Given its generally high level of drought tolerance, sorghum provides stability to production systems in the area. In many cases, when supplies of maize are not adequate, it is used on making "tortillas". However, sorghums being released from most varietal improvement programs have red grain which is unsuitable for human consumption.

In order to identify stable productivity sorghums with white grain color and good grain quality, 52 experimental sorghum lines were introduced from the ICRISAT Latin American Regional Program, and planted over 2 sites in the second planting season of 1982. These lines had been developed with the quality needed for making "tortillas" in mind, Although most rainfall received by the crop at San Juan de Limay (one of the sites in Estelí) came during the first 15 days after planting and the last rain fell at 34 days after planting, yields of up to 2.1 Mg ha^{-1}* were obtained. At Pueblo Nuevo, where water deficit was less severe, some lines yielded up to 4.4 Mg ha^{-1}. Yields and other characteristics for the best varieties from each site and the local varieties are given in Table 23.

Selections were made among and within lines, for adaptation, yield, grain color and grain size. These are currently being evaluated again in Estelí, both in the first and second planting season, and also in Honduras through the CATIE/IDRC project for technology development in semi-arid

* Mg = Megagram = 10^3 kg (SI unit)

Table 23. Agronomic characters of superior sorghum lines and local checks from an evaluation of 52 sorghum lines.

Site	Variety	Days to flower	Plant height, cm	Panicle length, cm	Yield Mg ha^{-1}*
San Juan de Limay	W823A (local check)	40	116	16	2.1
	D71444	46	105	12	1.8
	(IS12611 x SC108-3)-7-2-1	46	67	13	1.7
	E35 - 1	42	89	9	1.7
	Guatecau (local check)	39	78	11	1.1
Pueblo Nuevo	(Tx954063 x CS3541)-29	59	92	19	4.4
	(Tx954063 x CS3541)-3	60	99	13	4.3
	M63594(SC108 x CS3541)-10	60	113	17	4.1
	W823A (local check)	53	72	20	3.5
	Intasor (local check)	65	50	16	2.9

* Mg = Megagram = 10^3 kg (SI unit)

areas. They appear quite promising, and it is anticipated that a few of the best varieties will be more extensively evaluated on farms by the prototype teams or other such teams in 1984.

- Screening of 21 Bush Bean Varieties

The maize-bush bean relay system is common in Estelí as in much of the SAT. Local varieties are extremely early maturing, enabling them to escape the risks of erratic rainfall distribution, but are also of very low yield potential. Twenty-one varieties, including collections from other parts of Central America maintained by CATIE's Genetic Resources Unit, local varieties from the Estelí area, and several improved varieties from CIAT, were planted in the second season of 1982, to look for stable but higher yield potential materials with the grain color and quality demanded in the region.

Most varieties were quite early, and yields ranged from 1050 to 1790 kg/ha (Table 24). The three CIAT varieties, 'BAT 41' (which has been released in Nicaragua as 'Revolución 79'), 'BAT 179' and 'BAT 202' were not among the highest yielders. A number of Central American varieties did better, and would be promising candidates both for use in the Estelí area and for incorporation into a breeding program for the region.

- Evaluation of 10 Climbing Bean Varieties in Relay with Maize

Climbing beans are considered to have better yield potential than bush beans when planted in relay with maize, as they can take advantage of more space and light by climbing up the maize stalks. Farmers in the

Table 24. Characteristics of twenty-one bush bean varieties evaluated in Pueblo Nuevo, Nicaragua.

Variety	Source*	Yield Mg ha^{-1}**	Days to flower	Plant height cm
7441	CATIE	1788 a+	33 ab	68 bc
7539	CATIE	1721 a	33 ab	67 bc
Orgulloso	Estelí	1612 ab	32 b	66 c
7007	CATIE	1580 ab	34 a	90 a
6017	CATIE	1556 ab	30 b	42 d
7558	CATIE	1503 ab	33 ab	54 c
7559	CATIE	1500 ab	33 ab	66 c
6458	CATIE	1474 ab	33 ab	83 ab
7549	CATIE	1445 ab	33 ab	53 cd
Rama	Estelí	1439 ab	32 b	60 c
7006	CATIE	1434 ab	32 b	63 c
BAT 41	CIAT	1431 ab	33 ab	71 b
9106	CATIE	1376 ab	33 ab	58 c
Chile Rojo	Estelí	1367 ab	30 b	82 ab
BAT 179	CIAT	1308 b	33 ab	37 d
Vaina Blanca	Estelí	1296 b	36 a	84 a
Waspán	Estelí	1251 b	30 b	70 bc
BAT 202	CIAT	1199 b	32 b	55 c
Goaliceño	Estelí	1180 b	33 ab	54 c
Wiwileño	Estelí	1100 b	30 b	71 b
Honduras-46	Estelí	1050 b	33 ab	40 d

* CATIE = collections maintained by CATIE's Genetic Resources Unit

Estelí = local varieties from Estelí area

\+ Within a column, means followed by the same letter do not differ significantly according to Duncan's Multiple Range Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

Estelí area apparently used to grow them, but no longer do because (according to them) the variety they have used "degenerated". Then climbing bean cultivars from CIAT were introduced and planted in relay with farmer's maize in the second season of 1982.

Density of the beans was extremely low (about 56,000 plants ha^{-1} because of the spacing the farmer had used for the maize. This probably accounts, in some part, for the low yields observed (940 to 1170 kg ha^{-1}) (Table 25). Also bean plant development was not a vigorous as it might have been. Significant differences in yield were not observed, and few materials did any better than the farmer's semi-determinate variety ('Rama').

For 1983, more vigorous climbing beans have been introduced, and farmers using a different spatial arrangement of maize (which would allow higher bean density) were located.

- Evaluation and Selection of 25 Cowpea Lines

In some parts of the Estelí region, farmers are forced to buy beans for home consumption because the rainfall distribution is too erratic to make bean cultivation feasible. As a subsistence crop in these areas and, if markets can be identified, as an income earning crop which is more reliable than beans in marginal areas, cowpeas appear to be a promising alternative. Twenty-five cowpea varieties were introduced from IITA and planted in the second season of 1982, to evaluate their adaptation, response to drought stress, yield and grain quality. These were planted over two different sites, with one reference variety ('VITA-4') common to both sites.

Table 25. Yield, yield components and days to flowering for nine climbing bean varieties and a local check.

Variety	Yield kg ha^{-1}	No. of pods per plant	No. of seeds per pod	Days to flowering
V79116	1171	10 bc*	5.7 d	35 b
G2371	1168	15 a	5.0 e	36 b
G2333	1148	13 ab	7.3 a	35 b
G3912	1077	12 bc	6.9 ab	39 a
V79117	1038	13 ab	6.5 bc	35 b
Rama (local check)	1012	12 bc	6.3 bcd	34 b
V7916	995	13 abc	5.9 cd	35 b
G7128	994	11 bc	6.7 ab	36 b
G3910	994	12 bc	6.8 ab	39 a
V79119	938	11 bc	5.0 e	35 b

* Within a column, means followed by the same letter do not differ significantly according to Duncan's Multiple Range Test at the 0.05 probability level.

At the drier site, where common beans produced nothing due to drought, cowpeas yielded from 850 to 1350 kg ha^{-1} (Table 26). Farmers were very enthusiastic about them, and in an informal evaluation found several of the varieties quite acceptable in terms of cooking and eating quality. At the site with less severe drought stress, yields ranged up to almost 2000 kg ha^{-1}

Selection were made among these material and the best of them planted in several locations in Estelí, and also (by the CATIE/IDRC Project) in southern Honduras in both seasons of 1983. So far this year, virus diseases have increased dramatically in the first planting season in Nicaragua, causing severe yield reductions. In the second season the disease intensity dropped off considerably. The incidence has been much lower in Honduras. Nonetheless, it appears that disease resistant germplasm will have to be introduced and mechanisms for maintaining virus-free seed for planting investigated.

- Introduction and Selection of Millet and Pigeon Pea Germplasm.

In 1982, segregating composites of both millet and pigeon peas were introduced and planted. Both crops have good potential for forage production as well as for grain production in semi-arid areas. Initital selections were made for plants with adaptation to the area, as this was obviously a major limitation in both cases. These selections were planted in 1983 and are currently undergoing another cycle of selection for adaptation. The pigeon peas have improved markedly and various requests have been received from national programs and other CATIE projects for germplasm.

Table 26. Some characteristics of Cowpea varieties evaluated in Nicaragua

26a. Ten varieties evaluated in San Juan de Limay

Variety	Yield kg ha^{-1}	Days to Flower	Grain Color
TV x 1948-01F	1350 a[+]	41 bc	cream
TV x 4272-05D	1277 ab	40 cd	cream
Perico (local check)	1253 ab	40 cd	cream
VITA-7	1227 abc	40 cd	cream
TV x 2724-01F	1211 abc	41 b	brown
VITA-4*	1148 abcd	43 a	white
TV x 3408-02J	1030 abcd	41 b	cream
TV x 3629	987 bcd	39 d	cream
TV x 3871-02F	893 cd	39 d	brown
TV x 4262-014D	847 d	40 cd	white

26b. Fifteen varieties evaluated in Pueblo Nuevo

Variety	Yield kg ha^{-1}	Days to Flower	Grain Color
TV x 2938-02G	1980 a	48 ab	red
TV x 4272-013D	1559 b	48 a	brown
VITA-1	1492 b	44 ef	red
VITA-3	1475 b	49 a	red
TV x 4262-01E	1468 b	44 ef	black
TV x 1836-013J	1385 bc	46 cd	red
TV x 3368-03K	1358 bc	47 bcd	black
TV x 4571-07D	1331 bc	43 g	brown
VITA-4*	1322 bc	47 bc	white
VITA-6	1182 cd	48 ab	brown
TV x 2394-02F	1165 cd	48 a	red
TV x 1576-01E	1151 cd	43 g	red
N-105 (check)	1070 d	45 de	black
TV x 2912-011D	1036 d	44 ef	brown
TV x 4577-02D	1026 d	44 fg	brown

* Reference variety common to both planting sites

\+ Within a column, means followed by the same letter do not differ significantly according to Duncan's Multiple Range Test at the 0.05 probability level.

Millet will require continued selection; the Nicaraguan national program has taken some lines to evaluate them for rapid forage production in dry areas of the Pacific coastal plain.

- Collection and Evaluation of Photoperiod-sensitive Sorghum

In early 1983 a collection of local photoperiod-sensitive sorghum varieties was made in Estelí and the surrounding area. These materials were planted in association with maize, to evaluate their potential and to get an idea of the range of variability available in this crop. Unfortunately the trial was lost. New varieties are currently being introduced from other countries of Central America and from breeding programs in Honduras (INTSORMIL) and El Salvador, in order to re-initiate this work.

Through collaboration with CLAIS, five photoperiod-sensitive sorghum varieties are being evaluated in four countries of Central America and in Haiti, in the maize+sorghum system. This work is being coordinated by an agronomist from ICRISAT's Latin American Regional Program and the genotype specialist.

WEED MANAGEMENT

The IFAD weed management specialist began work in the PPD Department. His first month of work was devoted to reading IFAD project documents, and reports and publications made by former weed managements specialists (Myron Shenk, Eduardo Locatelli).

Communications were established with weed control researchers working at the University of Costa Rica and at the Fabio Baudrit Experiment Station

(Alajuela). A joint field trip was made to observe weed control experiments on a maize and bean intercropping system, and on rice. Visits were made to Quepos and Parrita to observe predominant weeds, and herbicide research on rice and oil palm, and the use of legumes (Pueraria sp.) as ground cover for oil palm fields.

Various trips were made to the research farm at CATIE to become familiar with the experiments being conducted by CATIE/IFAD support scientists, as well as by other PPD scientists. Initial observations were made on typical herbicide usage at the research farm. More detailed notes will be taken on the herbicides and rates used on specific crops and crop combinations. Trips were made to farm supply enterprises in Turrialba, Cartago and San Carlos to become acquainted with the principal herbicides in use and their costs.

- Lowland Humid Tropics

Meetings were carried out with the three members of the San Carlos prototype team. A trip to San Carlos was coordinated with IFAD's crop physiologist, during which observations were made on some of the problem weeds in the region; on the failure on the part of some growers to use any mechanical, chemical or integrated weed control systems; and on the misuse of herbicides by a few growers. Observations were also made on the effectiveness of integrating weed management practices with the use of high yielding, high quality varieties under conditions of proper fertilization and at improved plant population densities in intercropping systems.
Some of the experiments being conducted by the prototype team and by the

support research group were observed. Another trip to San Carlos was made in mid December in order to observe the remainder of the experiments, to meet with professionals from ITCR and from MAG, and to plan the first support experiments on weed control for the region. Because of the severity of the weed problem under the high rainfall conditions at San Carlos, initial weed management research will be directed towards the region.

- Semiarid Tropics

Plans have been made to meet with the prototype team from Nicaragua on their next visit to Turrialba. A trip to Nicaragua is planned for January 1984. During this trip, observations will be made on the major cropping systems in the SAT, on the research being conducted by the prototype team, and on the need for support research requested by the group.

- Wet-dry Tropics

A five day visit to the Los Santos prototype team in Panama was made in the latter part of November 1983. The trip's purpose was to acquaint the weed management specialist with the research being conducted by the prototype team and to discuss their views on the support research needed.

- Work Plan

Field research in weed management is still in the planning stage. The research will be aimed in part at the cropping systems being emphasized by the various prototype teams. An integration of variety, proper fertilization, disease and insect control, cropping patterns and costs will be included as part of the weed management experiments in order to minimize herbicide usage. However, some experiments will be conducted at the prototype teams research sites and at Turrialba in order to determine the behavior of herbicides at various rates on specific crops or combinations of crops. Herbicide experiments will include analysis of costs of the product vs. costs of mechanical or hand labor, as well as returns per unit of land and time, and will be coordinated with the IFAD crop physiologist's work on gramalote and living mulches.

SOCIOECONOMIC STUDIES

Socioeconomic research aims to resolve technical problems of on-farm research, cetected by the prototype teams or other similar teams, in order to allow more efficient design and testing of technical alternatives by these teams. During 1983 research efforts have been concentrated in two ecological zones, the LHT and the wet-dry tropics. Studies carried out are discussed below.

Lowland Humid Tropics

- Real cost of agricultural credit for Small-scale Farmers in San Carlos

In the prototype team's characterization of San Carlos, little information was found concerning agricultural credit services, either at the regional or the farm level. Most technological alternatives proposed to farmers involve increased inputs, and thus increased costs to the farmer. The availability of credit and its real cost are, therefore, of importance in determining whether technological alternatives will be adoped. Thus a study of the real cost of credit of small-scale farmers was done, as a direct support to the prototype team. Results should provide them with more appropriate parameters of economic analysis of their experiments.

The study was carried out in Pital and Fortuna, two districts of San Carlos. Samples of 60 farmers from Pital and 56 from Fortuna, all with landholdings of less than 35 ha, were interviewed. Analysis of the data emphasized breakdown of the total or real cost of credit into its components: (1) nominal cost (what the lender charges), and (2) extra costs (those incurred by the farmer in obtaining, utilizing and repaying the loan). Three levels of analysis were used. The most general related the cost of credit to its use by farmers, based on a simple demand model. The second level related resource availability on farms to the demand for credit. The third level involved a more detailed description of the relation between use of credit and various characteristics of the farm, the farmer, and his or her family.

The large difference between mean farmer age (41 years) and mean years of experience in agricultural activities (14 years) indicated that farmers do not have a strongly established farming background influencing their use in technology. This is primarily due to the relatively recent settlement of the area. Data on landholdings show that about 70% of the farmers own 10 ha or less, primarily used for annual crops or livestock.

Almost all farmers used credit, though the sources were more diverse and the total amount greater in Pital than in Fortuna. Of the credit used for crops, the majority was for cassava, confirming its importance in both districts (Table 27).

The most important sources of credit for both Pital and Fortuna were the banks (Table 28), which also provided the longer term loans. Other lending agencies provided up to 3-year loans, whereas some bank loans were for 6-year periods. Banks offered the lowest nominal interest rates, but required more extra costs than other lenders. Nevertheless, due to the lower interest rates, the real cost of credit from any of the banks was considerably lower than that from other sources. In general, bank credit is more expensive in Pital than in Fortuna, which may partly account for the presence of other diverse credit sources in Pital.

A breakdown of the cost of credit according to the amount borrowed is shown in Table 29. Apparently the amount borrowed is not related to the nominal cost of credit, but is related to the real cost. The relationship can be defined by the following equations, where Y = amount borrowed and X = real cost:

$$\text{Pital: } Y = 8930 + (10.1078 \times 10^{11})e^{-0.997X} \quad (r^2 = .84,\ P \leq .05)$$

$$\text{Fortuna: } Y = 2414 + (0.1221 \times 10^{9})e^{-0.704X} \quad (r^2 = .96,\ P \leq .05)$$

The above relationship, which define demand curves, were influenced primarily by the relation between the amount borrowed (Y) and the extra

Table 27. Uses of credit by small farmers in the Districts of Pital and Fortuna, San Carlos, Costa Rica.

Use	PITAL		FORTUNA	
	Number of loans	Percent of total	Number of loans	Percent of total
Cassava	34	42.0	16	26.2
Animal Production	25	30.9	25	41.0
Pineapple	8	9.9	--	--
Cacao	1	1.2	7	11.5
Construction	1	1.2	6	9.8
Papaya planting	4	4.9	2	3.3
Coconut planting	--	--	1	1.6
Land purchase	3	3.7	1	1.6
Transport (truck)	2	2.5	--	--
Maize	--	--	1	1.6
Home improvements	--	--	1	1.6
Electrification	1	1.2	--	--
Lumbering	1	1.2	--	--
Inputs	1	1.2	--	--
Travel	--	--	1	1.6
TOTAL	81	100.0	61	100.0

Table 28. Components of the real cost of credit for small farmers in the Districts of Pital and Fortuna, San Carlos, Costa Rica according to source of credit.

Source	No. of loans	Nominal annual rate, %	Cost of travel % annually	Labor opportunity cost % annually	Commission or gift % annually	Real annual rate %
PITAL						
National Bank of Costa Rica	46	10.95	2.29	0.74	0.02	14.00
Agricultural Credit Bank	21	9.50	0.92	0.13	--	10.55
Bank of Costa Rica	8	11.00	1.93	0.35	--	13.28
Private lenders	3	29.00	0.17	0.01	--	29.18
Friends and relatives	1	24.00	0.25	0.63	--	24.88
Cooperative "Coocique"	2	16.50	2.09	0.17	--	18.76
FORTUNA						
National Bank of Costa Rica	54	11.13	0.60	0.27	--	12.00
Agricultural Credit Bank	1	12.00	0.90	0.21	--	13.11
Bank of Costa Rica	3	8.67	0.74	0.13	--	9.54
Cooperative "Coope-Naranjo"	2	25.00	1.13	0.25	--	26.38

Table 29. Nominal, extra and real costs of credit according to the amount of credit obtained by small farmers in Pital and Fortuna, San Carlos, Costa Rica

Amount of credit colones*	No. of loans	Mean amount of credit colones	Nominal annual rate, %	Cost % annually	Real annual rate %
		P I T A L			
Less than 10,000	12	5854	12.00	4.67	16.66
10,000 - 19,999	25	14694	11.07	3.81	14.88
20,000 - 39,999	18	26504	11.72	1.47	13.19
40,000 - 99,999	8	59480	13.54	0.86	14.40
100,000 or more	8	128606	11.50	0.04	11.54
		F O R T U N A			
Less than 10,000	10	8843	10.70	2.24	12.94
10,000 - 19,999	12	14358	12.17	1.14	13.31
20,000 - 39,999	19	28783	12.32	0.91	13.23
40,000 - 99,999	6	59583	11.50	0.16	11.60
100,000 or more	3	180133	9.33	0.06	9.39

* $1.00 US = 44.10 Colones

cost (Z) incurred by the farmer. The following equations define this relationship:

Pital: $Y = 8258 + 126600e^{-1.147Z}$ ($r^2 = .99$, $P \leq .05$)

Fortuna: $Y = 17330 + 1231000e^{-33.72Z}$ ($r^2 = .99$, $P \leq .05$)

Analysis at more detailed level is still in progress.

- Study of the Grain Storage Situation in San Carlos, Costa Rica

The aim of this study is to identify the principal crops which are stored by small-scale farmers, the types of storage used, the post-harvest lossed suffered, and their causes. The results should complement work done by the prototype team in San Carlos, and should serve as support for research by national programs concerned with grain storage.

The information will be gathered by means of a questionnaire which, together with the required coding manual, has already been elaborated. Farmers interviewed will be a sample of those who cultivate primarily annual crops, have landholdings of 35 ha or less, and store at least one product on their farms.

- Marketing Study for Cassava Varieties

Cassava is one of the principal crops in San Carlos. A trial of 38 cassava varieties was established there in 1982 by the genotype specialist. Collaboration in this study involved an evaluation of marketing quality both for local consumption and for export.

The methodology used is represented in Figure 11. As mentioned briefly in the Genotype Evaluation section of this report, a selection index was generated based on published information and on farmer's opinions concerning the relative importance of different agronomic characters of the cassava. The variables used in this index, the coding of their values, and the weights assigned to each one are presented in Table 30, along with variable means for the two best varieties and the best local variety ('Mangī'). Fifteen varieties were preselected for quality evaluation, using both the selection index and farmers' opinions. Differences between these two criteria were minimal.

Data from quality evaluation are currently being analyzed. Farmer response in San Carlos was quite enthusiastic, and all those who participated in the evaluation requested planting stakes of one or more of the varieties. Response from the exporters was also positive, and it appears that most of the varieties evaluated have acceptable market quality.

- Characterization of Cassava Cultivation Systems in Fortuna, San Carlos, Costa Rica

As support to the San Carlos prototype team and as source of information to complement their characterization of the area, a study characterizing cassava cultivation systems in Fortuna is being done. The objectives of this work are to describe (agronomically and economically) the cassava cultivation systems in the area, to determine their importance relative to the whole farm, and to identify crop rotations which include cassava.

Table 30. Variables and weights used in the selection index for Cassava and means for the two best varieties.

Variable	Weight (%)	Varietal Means	
		CM 323-375	P 77-14
Fresh weight of commercial Roots/Plot (kg)	40	38.05	36.30
Ratio: weight of commercial Roots/Total Root Weight	10	.82	.85
Plant height at harvest 3: from 2.1 to 2.5 m 2: less than 2m or from 2.6 to 3m 1: more than 3 m	4	3	2
Height to the first ramification 3: more than 1.6 m 2: from 0.8 to 1.5 m 1: less than 0.8 m	8	1	1
Days to the first ramification 3: late 2: intermediate 1: early	8	2.5	1.5
Branch angle 3: less than 45° 2: from 45° to 60° 1: more than 60°	10	3	2.5
Root shape 3: cylindrical 2: intermediate 1: conical	10	3	3
Disease intensity 3: diseases absent 2: intermediate 1: high intensity	10	2.75	2.25

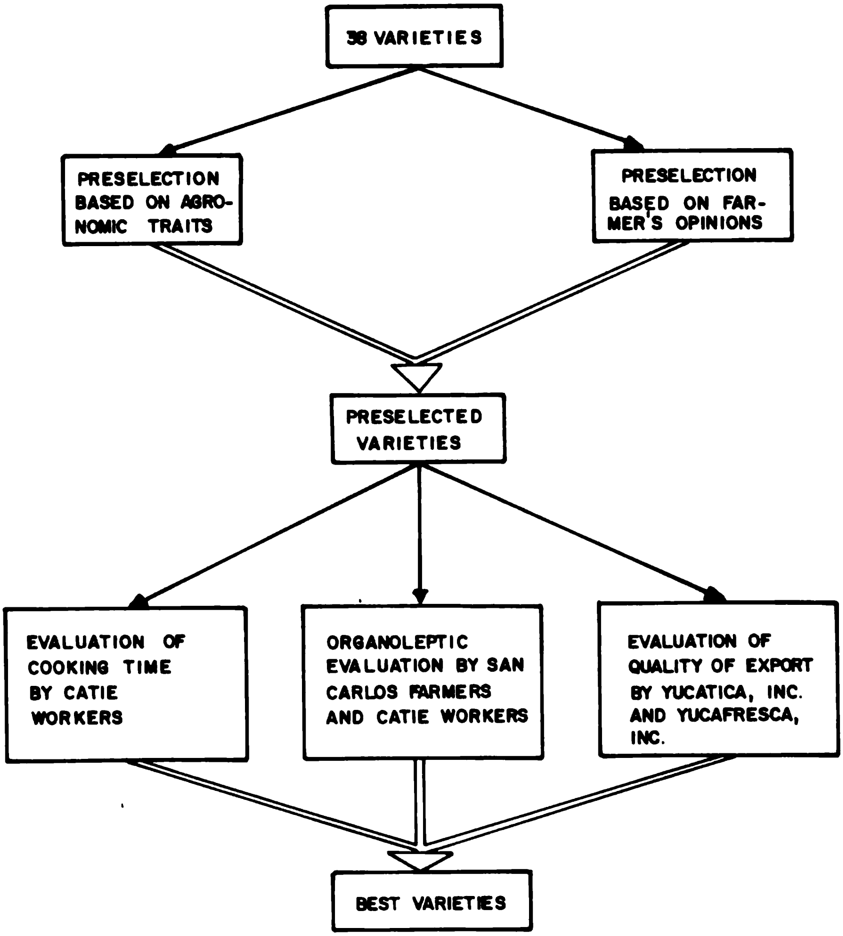

Figure 11. Methodology used for evaluation of cassava varieties for agronomic and marketing quality.

A survey was carried out to collect detailed information on landholdings, soil characteristics, the farmer and his or her family, land tenure, labor demand, field operations, use of credit, investments, farm outputs, limiting factors, advantages of cassava cultivation, and farmer attitude. Data are currently being analyzed.

Wet-dry Tropics

Study of the Grain Storage Situation in Los Santos, Panama

The prototype team's characterization of Los Santos indicated that grain storage drying and storage is a problem in the area, primarily for maize. A study similar to that described for San Carlos will be done, using the same questionnaire.

OTHER SUPPORT RESEARCH STUDIES

In addition to work done by the various specialists in the project, IFAD financing also covers support research done by other project personnel (such as the training officer and outreach coordinator) in their respective disciplines. As general support to the PPD, IFAD also finances certain short-term studies if importance to the overall research program of the PPD. These various studies are presented below.

- Effect of a Maize+Cassava Association on Insect Populations

The reduction of insect problems in polyculture cropping systems is an argument often used to explain the prevalence of such systems in the tropics. The tendency of increases stability with increased diversity, observed in natural systems, could cause such a reduction. The difference between monoculture and polyculture in factors controlling colonization and establishment of pest species could also be a factor. Little is known about the entomology of the maize+cassava system, a common association in the LHT.

Agronomic and entomological data (damage counts, soil samples, water traps, and pitfall traps) were collected from plots of monoculture maize, monoculture cassava, and associated maize+cassava, both with and without chemical insect control.

Maize data showed that only the percentage of rotten ears varied significantly. It was higher in the association, probably due in part to higher relative humidity in this system. Maize yields were not affected by association or by insecticide treatments. In cassava, both plant height and total yield were affected by association with maize (Table 31) the former increasing and the latter decreasing when maize was associated with cassava. Both phenomena are logical results of competition with the maize. Insecticide treatments had no significant effects.

Damage counts on maize showed reduced attack by chrysomelids, *Diatraea* sp. and *Spodoptera frugiperda* and increased attack by aphids when insecticides were used. The latter is a common occurrence due to mortality of the aphids' natural enemies. Associating maize with cassava resulted in increased *Diatraea* sp. damage and reduced *S. frugiperda* damage. The former is probably related to higher relative humidity in the association, as the

Table 31. Chacteristic of Cassava grown without insecticide, with insecticide and associated with maize.

	Cassava without insecticide	Cassava with insecticide	Cassava associated with maize
Cassava plant height, cm	157	142	178*
Cassava plant population at 4 months, plants/ha	10,000	10,000	9,750
Total cassava root yield, Mg ha^{-1}**	21.1	18.6	15.1*
Percent commercial roots	61.3	53.6	66.7

* Significantly different at the 0.05 probability level from the cassava without insecticide.

** Mg = Megagram = 10^3 kg (SI unit)

egg stage of some Diatraea species is quite susceptible to dessication. No significant insect damage was observed on cassava.

Soil samples showed significantly fewer insects in monoculture cassava than in the association, with the exception of Phyllophaga sp. at one month after planting. The maize in monoculture did not differ from the association, except that there were more Cyrtomenus bergi in the monoculture at three months after planting.

Total number of insects present fluctuated with time, but generally there were fewer with insecticide treatments and in monoculture cassava plots. Species richness also fluctuated (350 different species were observed) but no patterns were evident in the fluctuations.

With only one year of data and generally low levels of pests, it is not appropriate to draw firm conclusions regarding insect pest dynamics in the maize+cassava association. From these limited data, the effect of association on insects appears neutral, increasing the populations of some species and decreasing those of others. Agronomically, associating the maize with cassava did not affect maize yields.

- Spatial Arrangements of Plantains (Musa sp.) Associated with White Tanier

Plantain has been a traditional crop in San Carlos which, due to its relatively long growth cycle, could not be considered in the prototype team's research. National organizations, such as MAG, ITCR and IDA have expressed interest in plantain, since plantains currently appear to be growing in importance after suffering a decline with the introduction of black sigatoka disease (Mycosphaerella fijiensis var. difformis) into the area. White tanier (Xanthosoma sagittifolium) has a reasonable export market and local consumption in San Carlos is increasing. As a support to the PPD and to the national organizations mentioned above, an experiment was designed to evaluate both monocultures and association of plantain and white tanier in three spatial arrangements: traditional (square), hexagonal and paired rows.

Results available to date include plant height and chemical analysis of leaves of the plantains (Table 32). At La Perla, plant height did not differ significantly among treatments, possible due to an early infection of black sigatoka. At Sona Fluca, however, black sigatoka was not a problem and significant differences in plantain growth were observed. The traditional arrangement associated with white tanier had the tallest plantains, followed by the hexagonal arrangement in monoculture. The hexagonal and paired row arrangements in association had the shortest plants. These results can be explained by plantain density (1100 plants ha^{-1} in the traditional arrangement compared with 1700 in others) and competition from the tanier.

Foliar analysis showed differences only in nitrogen content, which was highest in the hexagonal monoculture arrangement. This is probably attributable to the lack of competition for fertilizer from tanier.

Table 32. Effect of spatial arrangements on plant height and chemical composition of leaves of plantains associated with White Tanier and in monoculture.

Planting Systems	PLANT HEIGHT, cm						Site: Sona Fluca
	SITE: LA PERLA			SITE: SONA FLUCA			Foliar
	3 mo.	4 mo.	5 mo.	3 mo.	4 mo.	5 mo.	N, %*
Traditional (square) arrangement	60.6	108.2	174.5	104.0 a+	155.0 a	225.1 a	3.79 b
Hexagonal arrangement	60.9	108.7	173.6	93.4 bc	140.6 b	204.0 c	3.87 b
Paired rows	59.6	108.9	178.7	91.4 c	140.7 b	205.7 c	3.83 b
Plantain monoculture hexagonal arrangement	63.8	114.4	179.2	98.21ab	146.7 b	216.8 b	4.11 a
Mean	61.2 c	110.1 b	176.6 a	96.7 c	145.8 b	212.9 a	

* Analyses of foliar P, K, Ca, Mg, Zn, Mn, Fe, and Cu were also done but no significant variation was observed for the different planting arrangements

\+ Within a column, means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 0.05 probability level.

- Spatial arrangements of Plantains associated with Maize

Traditionally, the Talamanca area of Costa Rica has produced cacao; however, its cultivation has dropped off drastically since the introduction of "monilia pod rot" into the area. As an alternative, plantain cultivation has increased. Maize has been a traditional crop in the area and some farmers associate it with plantains. A trial was designed, similar to the one discussed above, to evaluate spatial arrangements of plantains associated with maize. This work should serve as support to the PPD's program in the LHT, and also to the small farmer's cooperative in the area (Coope-Talamanca), which requested help and is providing land and facilities for the trial.

Data available at the moment includes only maize yields (Table 33). The monoculture yielded best, indicating that in association plantains competed with the maize. Of the associated systems, maize yielded best in the traditional arrangement (which had the lowest density of plantains), followed by paired rows and the hexagonal arrangement, probably reflecting the degree of competition experienced in each system.

Maize appears to be a promising crop to associate with plantains, providing a relatively rapid source of income to farmers. Various members of the cooperative have expressed their interest in this work.

- Plant Protection Studies

Of the edible plants typical of the LHT, the aroids (Xanthosoma spp. and Colocasia spp.), yams (Dioscorea spp.), sweet potatoes (Ipomoea batatas)

Table 33. Maize yields for monoculture and three spatial arrangements in association with plantains.

Planting systems	Yield at 12% grain moisture $Mg\ ha^{-1}$**
Traditional (square) arrangement	2.2 b*
Hexagonal arrangement	1.9 c
Paired rows	2.1 cd
Maize monoculture	2.5 a

*Values followed by the same letter do not differ significantly according to Tukey's Test at the 0.05 probability level.

** Mg = Megagram = 10^3 kg (SI unit)

and cassava are quite important in the diet in many parts of the world. Many environmental factors limit the expression of the high energy producing capacity of these crops. Diseases are among the primary limiting factors, for two basic reasons: 1) the continuous proliferation of pathogens, insect vectors and alternate hosts; and 2) the vegetative reproduction of the host species, which allow pathogens to survive in host tissues for many generations.

For these reasons, part of the IFAD resources assigned to CATIE have been used to study the major diseases of these crops in the LHT, with the aim of generating information useable in designing disease control strategies which will allow improved harvests. Studies carried out to date are discussed below.

. Fungal and Bacterial Diseases of Aroids in Costa Rica

Three areas of Costa Rica were studied: the Atlantic coastal zone, San Carlos, and Turrialba. For each crop studied, the diseases were described in the field and samples were collected for pathogen identification. Pathogens were isolated in the laboratory, and their morphological and pathogenic characteristics studied in the laboratory and in the greenhouse.

A list of the diseases identified in white tanier (*Xanthosoma sagittifolium*), purple tanier (*X. violaceum*) and taro (*Colocasia esculenta* var. *esculenta*) follows, and distribution maps of the principal pathogens are presented in Figures 12 through 14.

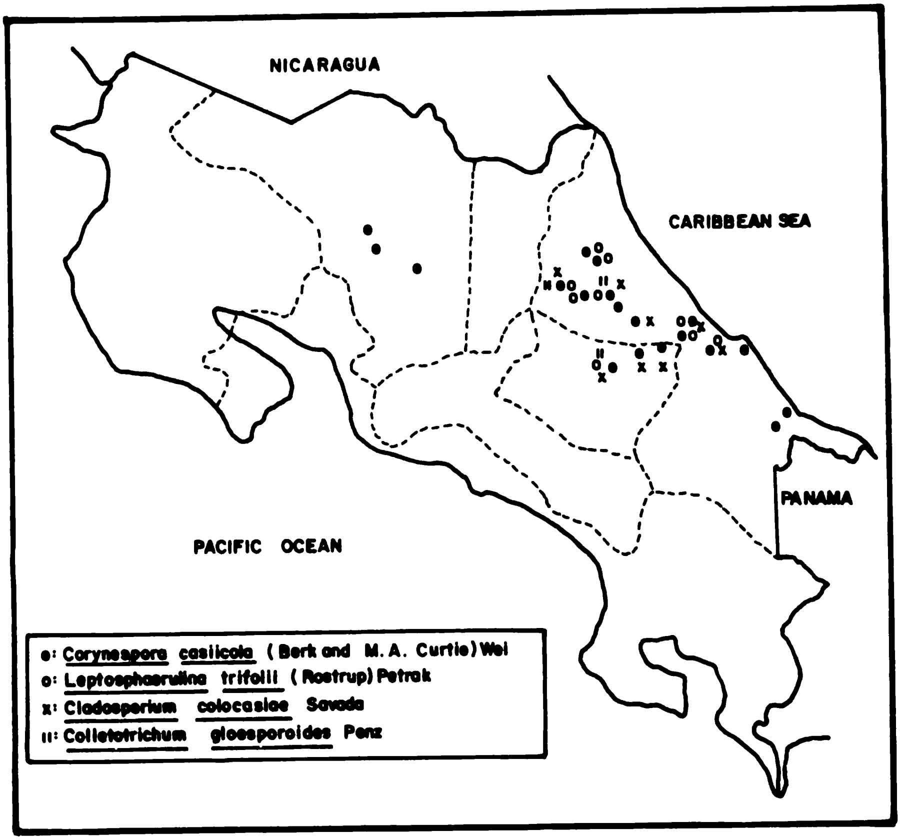

Figure 12. Distribution of fungal leaf diseases of the aroids in Costa Rica.

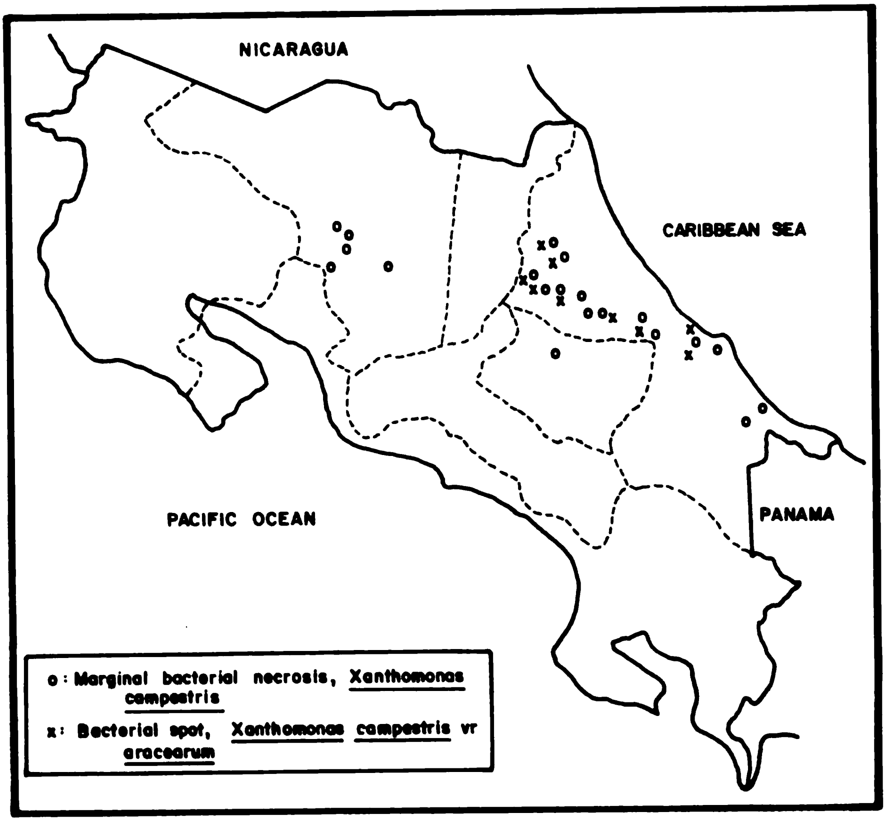

Figure 13. Distribution of bacterial diseases of the aroids in Costa Rica.

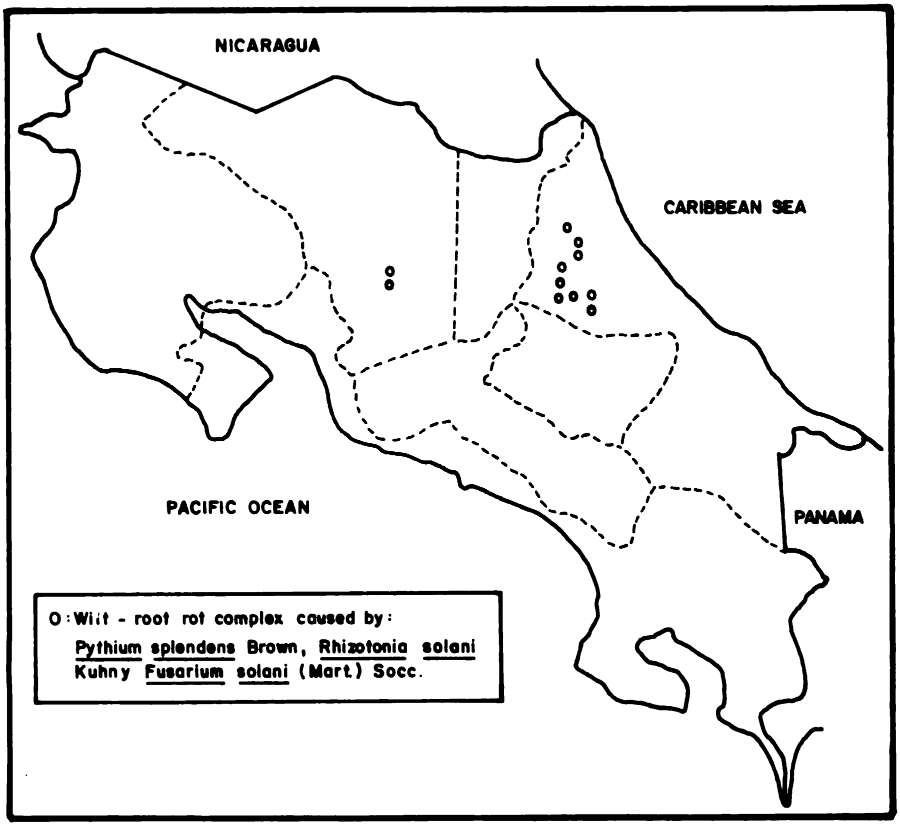

Figure 14. Distribution of the wilt-root rot complex affecting aroids in Costa Rica.

(1) Fungal leaf diseases:

- *Leptosphaerulina trifolli* (Rostrup) Petrak
- *Collectotrichum gloeosporiodes* Penz
- *Corynespora cassiicola* (Berk and M.A. Curtis) Wee
- *Cladosporium colocasiae*

(2) Bacterial diseases:

- Marginal bacterial necrosis: *Xanthomonas campestris* (Pammel) Dowson. (This is the first record of this disease in aroid-producing countries.)
- Bacterial spot. *Xanthomonas campestris* (Berniac) Dye

(3) Wilts:

- Wilt - root rot complex caused by various fungi: *Phythium splendens*, *Rhizoctonia solani* and *Fusarium* spp.
- Rot caused by *Corticium rolfsii* (Sacc) Curzi

(4) Post-harvest corm rots:

- *Corticium rolfsii* (Sacc) Curzi
- *Erwinia chrysanthemi* Burkholder, MacFadden and Dimock
- *Ceratocystis fimbriata* Ell and Halst
- *Fusarium oxysporum* Schlecht

. Viral Diseases of Aroids in Costa Rica

There are no reports in the literature of viral diseases of aroids in Central America. However, comparing symptoms observed in this region with references from other aroid-producing regions of the world has suggested the presence of viruses. In the Atlantic zone of Costa Rica, both tanier and taro cultivars show symptoms typical of dasheen mosaic virus (DMV). In tanier only, symptoms typical of taro large bacilliform virus (TLBV) and taro small bacilliform virus (TSBV) have been observed. Due to its world wide importance and the high levels of damage it causes, primary attention has been given to identification, isolation, and preparation of antiserum for DMV.

Virus particles identical to those causing DMV were observed on leaf tissue under an electron microscope at the University of Costa Rica. The presence of the virus was also confirmed with serological techniques, using antisera prepared in Florida, USA. The virus has been purified, but the purification obtained is insufficient for antiserum preparation. Even double centrifugation has left a level of impurities which impedes adequate purification. Because of this, final ultraviolet absorption spectrum trials of purified preparations indicate the presence of only viral proteins.

Contacts in several countries have been made to obtain other virus hosts, such as _Tetragonia expansa_, which would allow high virus concentra tion in the absence of the latex and mucilage commonly found in aroids. Currently, stocks of _Philodendron selloum_ (another acceptable virus host) are being increased for the same purpose. Once sufficient material of acceptable host plants is obtained, the antisera necessary to confirm with certainty the distribution of the virus in Central America will be prepared.

Specific antisera will also allow measurement of the extent of infection of individual plants, which can then be correlated with their yields. Virus-free plants (obtained through meristem culture) are currently available, and will be used in confirming the presence of DMV.

- Data Bank for Information from the PCCMCA

The PCCMCA is an organization of national program scientists dedicated to the improvement of food crops in Central America. Its mannual meeting represents the main opportunity for presentation of research results from Central America. As the meetings are held in a different country each year, the organization and thoroughness of their documentation varies considerably from year to year. Furthermore, there is no convenient indexing system available for the proceedings of these meetings.

Meetings of the PCCMCA have been held annually since 1954, and they have generated approximately 2800 articles, which constitute a substantial part of the literature on basic food products in Central America. Between 1978 and 1980 an effort was made to collect and process the information in these articles, with the aim of establishing a Documentation Center for the PCCMCA. Due to changes in computer hardware at CATIE, this work became partially obsolete.

After the 1983 PCCMCA meeting, it was decided to update and continue this work with financing from IFAD. The aims are to collect and organize the existing technical information about corn, sorghum, rice common beans, vegetables, crop and animal production systems, and some aspects of seed production and human nutrition, and to make it easily and opportunely available to researchers. This should benefit IFAD-supported researchers not only by making relevant literature readily available, but also by providing an effective mechanism for publication and diffusion of their research results.

To date, most of the documents produced by the PCCMCA have been collected, bound and numbered for simple, rapid access. All the documents have been entered into the computer, both in a file of bibliographic references and in a normal and inverted file of key words or descriptors. Software has been prepared to allow various types of listings or searches in these files. Informal leaders of the PCCMCA in each member country have been advised of the objectives and progress of this work, and have expressed their interest and support for the work.

Future efforts will concentrate on bringing computer files up to date with recent PCCMCA documents and on publication of a bibliography. Mechanisms will be established for promotion of the documentation services offered; for searches, loans, and scales of the documents on file; and for future updating of the data base.

TRAINING UNIT

The training unit of the PPD is under the leadership of the "Training Officer" and a professional assistant, both financed by the Project.

The unit has the following functions:

a) To maintain up to date information of national teams' training needs and priorities which will enhance their capabilities in research and technology development

b) Within the framework of the cropping systems research and technology development methodology, to orient the PPD's training plans and activities according to the national teams' priorities. Also to encourage the teams to take advantage of the training opportunities available

c) To program and coordinate all training activities within the PPD, including those of the UCR/CATIE M.Sc. Postgraduate Program

d) To coordinate the training activities of the PPD with those of CATIE in general and help to obtain the necessary resources to implement them

The major disruption of the work of this unit during 1983, was the resignation on June 30, of the training officer, who accepted a position in the United States. The first attempt to recruit a replacement in September was aborted due to health problems of the selected candidate. A second candidate has been selected and the position offered him beginning in January 1984. However, most activities planned for the Unit have been supported by the whole PPD team, particularly the Crop Physiologist of the Project who was assigned temporarily to lead the Unit.

According to the work objectives of the unit, several activities and results can be reported.

UPDATING ON TRAINING NEEDS AND PRIORITIES AT COUNTRY LEVEL

The main activity here was a mail survey of 115 participants from 12 countries who had attended seminars or workshops in cropping systems research held by CATIE in previous years. The rate of response was 27%.

From those who responded, 94% considered the training provided had been helpful for orienting their research work and 97% were working in cropping system; research. Ninety six percent were interested in participating in other training activities of a similar kind. The specific recommendations for future training events included: longer events, more exchange of experiences with participants in contemporary projects, more detailed discussion of the implications of the approach for technology transfer, more discussion on the proper use of statistics as part of the method.

Ninety four percent of the respondents were interested in participating in a different but related type of training event. Their suggestions include: plant protection in cropping systems, integrated development projects, data processing, genetics and genetic resources, socioeconomics, extrapolation, irrigation, educational methodology and experimental design.

COORDINATION OF TRAINING ACTIVITIES IN THE PPD

These activities included short courses, seminars and workshops, in-service training, technical meetings, supervision and guidance of students and their thesis work. They involved the participation of all professional personnel in the PPD and financing from different projects and institutions.

The most important training event was an intensive 3-month course in Cropping Systems Research and Technology Development. It was held in Turrialba for professionals from different institutions of the region. Those attending included 14 researchers and extensionists from the Central American Isthmus, 2 from South America and 1 from the Caribbean region. The course was implemented with contributions from different projects financed by the Kellogg Foundation, IFAD, ROCAP and the EEC. It was structured so as to present, as the central theme the principles and procedures of the different phases which constitute the methodology used by CATIE for cropping systems research and technology development. They are: area selection; area, farmer and cropping systems characterization for identification of research and technology development priorities; design of improved and appropriate technologies according to these priorities and the research for testing and evaluating them at farm level; validation of the most promising technologies and assessment of their adoption and transference potential with the direct participation of farmers; diffusion of technology to target farmers through appropriate institutions. To reinforce the training of the different phases in the methodology, the course included: a) disciplinary sections in economics, systems theory, statistics, soils, plant protection, anthropology; b) case studies presentations and discussions; c) visits to sites in which the methodology is being used and field practice for the students. The course was well evaluated by the students and several of their suggestions will be incorporated for improvement next year.

The present demand for this type of training in the area, is greater than that which the PPD is capable of providing. An additional effort is being made in agreement with national institutions in Honduras, Guatemala and El Salvador, through what is being called "Training by Phases of the Methodology". This consists of a series of separate events, each of which is centered around one of the phases taken in sequence from the methodology. A student should attend all of the events in the sequence. Each event is composed of a) review of the theme and the assignment from the previous meetings; b) presentation and discussion of the theme for the present methodological phase; c) assignments for the group of students in relation to the present topic, to be reviewed during the next event.

An inventory of these courses and other non-degree training activities developed by the PPD under the coordination of the unit, are provided in Tables 34, 35 and 36. These training activities do not include those developed by the Prototype Team which have already been presented.

GRADUATE TRAINING

The participation of the Training Officer and other Project personnel in the Graduate Program of UCR/CATIE is important. They function as students' advisor during their studies and thesis work development and also participated in the selection and admission of students to the program besides teaching particular courses. During the year 1983, the PPD Graduate Program comprised a total of 34 students; 7 of them from the 1981-1983 entry; 11 from the 1982-1984 and 16 new students of the 1983-1985 entry. Professionals from the

Table 34. Short courses provided by the PPD during 1983.

Title or content of the course and main purposes	Participants: Number	Participants: Type and institutions represented	Place, date of initiation and duration	Financing
Intensive course in cropping systems research and technology development	17	Researchers and extensionists from National Institutions including universities of Central America South America and Caribbean	Turrialba, August 22, 1983 3 months	Kellog Foundation, IFAD
Cacao Production	21	Research, extension, teaching and credit staff from institutions of the region	Turrialba, 4 - 9 of July, 1983	Kellog Foundation
Cacao processing at farm level	30	Staff from national institutions and producers	Nicaragua, 5 - 10 of September 1983	Simon Bolivar Fund, IICA
Sixth International Forum on Soil Taxonomy	18	Soil researchers and professors from the area	Turrialba October 24 - November 4, 1983	ROCAP, Kellog Foundation, SMSS
Validation/Transfer of technology and methods of extension (3 one week short courses)	108	Researchers and extensionists from Honduras, Costa Rica, El Salvador and Guatemala	Comayagua in Honduras, Turrialba in Costa Rica, San Salvador, El Salvador, Jutiapa in Guatemala; first semester of 1983	Kellog Foundation, ROCAP with support from IFAD
Analysis and evaluation of production systems for research (2 one week short courses)	25	Researchers from IDIAP in Panama and MIDINRA/DGTA	Panama city, Panama in February and Matagalpa, Nicaragua in May	Kellog Foundation, ROCAP, support from IFAD

Table 35. Seminars and Workshops provided by the PPD during 1983

Title or content of the event and main purposes	Participants		Place, date of initiation and duration	Financing
	Number	Type and institutions represented		
Applied Statistics	17	Researchers from SRN of Honduras	Comayagua, Honduras; 14-16 March 1983	IFAD, ROCAP
Economic analysis in cropping systems research	13	Researchers and extensionists from SRN in Honduras	Comayagua, Honduras; 21-23 March 1983	IFAD, EEC
Methodology for research and technology development in cropping systems (by phases)				
Phase 1; area selection and characterization				
a) In Honduras	38	Researchers and extensionists from SRN in Honduras	Comayagua, Honduras; 17-20 January 1983	IFAD
b) In Guatemala	30	Researchers and extensionists from ICTA, DIGESA, DIGESEPE	Quezaltenango, Guatemala; 3-7 October 1983	IFAD
c) In El Salvador		Researchers, extensionists and other staff from CENTA and other institutions	San Salvador, El Salvador; 26-27 October 1983	IFAD
Experimental design and analysis	10	Students and teachers from the ITCR in San Carlos	San Carlos, Costa Rica 20-23 July 1983	IFAD

Table 36. In-service training provided by the PPD during 1983.

Title or content of the event and main purposes	Participants		Place, date of initiation and duration	Financing
	Number	Type and institutions represented		
Cacao production	3	Students from the Turrialba Agricultural High School	Turrialba, May 30 - August 16, 1983	Kellog Foundation
Cacao breeding	1	Graduate student, UCR/CATIE	Turrialba, May 12 - June 8	ACRI
Field data gathering tools and procedures	8	Researchers from CENTA in El Salvador and SRN in Honduras	San Salvador, El Salvador, Comayagua, Honduras - May 1983	EEC
Production system analysis and evaluation	1	Professor from Universidad de Huamanga Ayacucho, Perú	Turrialba, September 1983	IDRC, IFAD
Guidance and supervision of thesis or special research for undergraduate students*	15	Students from the University of Costa Rica	Turrialba, during the year	IFAD, ROCAP, ACRI, GTZ

* Most of these research work is being developed under the supervision of professionals in the Project.

Project participated as members of 15 of the graduate students advisory committees and as principal advisors in 8 of them. IFAD funds financed 8 of the 14 degree theses under development during the year.

The interest of the Project in the Graduate Program is consistent with its objectives. CATIE alumni often assume positions of importance in their countries' agricultural institutions. Thus they would be able to project the cropping systems research and technology development at country level in a very efficient manner. Toward this end, efforts have continued to establish a core series of courses in relation to the methodology within the PPD M.Sc. Program. This was partly interrupted during 1983 by the resignation of the Training Officer. However, one course in "Introduction to the Study of Agricultural Systems" and another one in "Agroecosystems", with emphasis in research and technology development, were taught. The latter included field trips to the IFAD Prototype Team sites.

The Crop Physiologist is the professor for the second course and other IFAD personnel are involved in both courses. Other graduate courses given by IFAD personnel this year were: "Soil Management and Physics"; Graduate Seminars in: "Varieties as a component of Cropping Systems" and "Thesis Projects"; tutorial course in "Qualitative Genetics".

OUTREACH COORDINATION

The Outreach Coordinator for the PPD and his professional assistant are also financed as part of the IFAD TA 38 Grant to CATIE. His principal function is to facilitate the PPD's communication and linkage with the national counterpart institutions in its outreach work throughout the mandate region. This is required for a proper and timely adjustment of the support that the Department can provide in areas of research, training and technical cooperation related to crop production according to the needs and priorities at country level.

The Outreach Coordinator also helps to improve communication and the ties between: a) multidisciplinary teams working on cropping systems research and technology development and their respective national institutions; b) those teams within each country and in other countries. This is needed to motivate and maintain the interest of the teams and channel support for their work in technology development, particularly when they use the on-farm and with-farmers approach promoted by the PPD.

The work of the Outreach Coordinator is of great importance since most of the PPD activities are developed at country level, in conjunction with national institutions and in support of teams engaged in research for technology development.

The Outreach Coordinator began his activities in September 1982. They include constant travelling to the different countries and meeting with authorities from the national counterpart institutions as well as with members of the various research and technology development teams in those countries. Other consultation meetings have been held at CATIE with professionals and authorities of the different departments. Based on these meetings and other source of information, a mechanism for outreach coordination was devised which was considered appropriate for the PPD.

The outreach coordination mechanism is based on: a) the joint effort of the Outreach Coordinator and, where there is one, the PPD resident technician in each country, to link the department with the national counterpart institutions and teams working at area level in cropping systems research and technology development; b) a "Working Group", formed by professionals in different fields to evaluate the methodology, its application and results, or proposed modifications. These people have a recognized interest and experience in the type of work and methodology promoted, and act as consultants or advisors when required; c) a network of researchers and extensionists working or interested in cropping systems research and technology development across the region, particularly using the on-farm and with-farmers approach promoted by the PPD.

Several activities of the Outreach Coordinator during 1983 have been related to the development and installation of the mechanism described.

INVENTORY OF THE PPD OUTREACH COORDINATION ACTIVITIES

The Outreach Coordinator activities for the PPD during 1983 include: 1) contacts and consultations with technical personnel and authorities of the different counterpart national institutions in the mandate countries; 2) representation of the PPD in technical and coordination meetings, seminars and field days at country level; 3) interviews with the professional personnel of the PPD assigned in every country, particularly the Prototype Teams, in order to communicate instructions and coordinate activities; 4) project evaluation by national institutions or by CATIE; 5) participation in Departmental training activities, including planning and coordination; 6) organization of a first meeting, held in Turrialba, of the Working Group as stated above and 7) motivation support and participation in meetings of professionals in El Salvador and Guatemala as an initial step for the formation of the "Central American Network in Cropping Systems Research and Technology Development".

An inventory of these activites is summarized in Table 37. They include the participation of the Outreach Coordinator and also other professionals in the Project. The Outreach activities developed by the Prototype Teams have already been presented in appropriate section. In addition to the activities reported in Table 37, members of the Project have received visitors interested in different aspects of the Project and the general work of CATIE.

FIRST MEETING OF THE CROPPING SYSTEMS RESEARCH AND TECHNOLOGY DEVELOPMENT WORKING GROUP FOR THE PPD

The organization and coordination of the first meeting of the Cropping Systems Research and Technology Development Working Group, formed to assist the PPD, was among the most important activities in outreach coordination. The meeting was held in Turrialba during September 1983.

Participants in this meeting included directors, subdirectors and coordinators of agricultural research and extension from the six countries in the Central American Isthmus. The distribution by country was: Guatemala 2; El

Table 37. Outreach coordination and other outreach activities, other than research and training, developed by the PPD of CATIE under the IFAD Grant, 1983.

Activity and main purpose, by country	N of events and representative for PPD		Type of personnel contacted and number[2/]			Institutions contacted
	N	Representative[1/]	Dir/Adm	Staff/Farm	Grand Total	
1. Meeting for coordination of activities with Prototype Teams						
a) Costa Rica	5	OC, I		3	3	MAG, ITCR, CATIE, FIDA
b) Nicaragua	4	OC, I		3	3	MIDINRA/DGTA, CATIE
c) Panama	5	OC, I		3	3	IDIAP, MIDA, CATIE
2. Meeting with personnel from different institutions at country level and CATIE outreach staff						
a) To explain the purpose of the outreach coordination and discuss particular joint actions						
a.1 Guatemala	1	OC	4	2	6	ICTA, CATIE
a.2 El Salvador	1	OC	4		4	CENTA, CATIE
a.3 Honduras	3	OC	17		17	SRN, FAO, AID, CATIE
a.4 Nicaragua	2	OC	6	7	13	MIDINRA, DGTA, CATIE
a.5 Costa Rica	2	OC	5	4	9	MAG, ITCR, CATIE
a.6 Panama	1	OC	3		3	IDIAP, CATIE
b) For revision/evaluation of specific projects						
b.1 Nicaragua	1	OC, I		3	3	DGTA, MIDINRA, CATIE
b.2 Costa Rica	2	OC, I		10	10	MAG, ITCR, CATIE
b.3 Panama	1	OC, I	6	5	11	IDIAP, MIDA, CATIE

Table 37 (cont./)

Activity and main purpose, by country	N of events and representative of PPD		Type of personnel contacted and number[2/]			Institutions contacted
	N	Representative[1/]	Dir/Adm	Staff/Farm	Grand Total	
c) To present the PPD in planning or evaluation meeting by national institutions						
c.1 Panama	1	OC	4	7	11	IDIAP, CATIE
d) To participate in planning and coordination meetings of the PPD and national institutions						
d.1 Guatemala	1	OC	1	5	6	ICTA
d.2 El Salvador	1	I	1	24	25	CENTA, MAG-El Salvador
d.3 Honduras	2	OC, I	2	24	26	SRN, UNM
d.4 Nicaragua	3	OC, I	2	42	44	MIDINRA, DGTA
d.5 Costa Rica	1	OC	2	3	5	ITCR
d.6 Panama	1	OC	5	9	14	IDIAP
3. Representation of the PPD in field days, seminars, and other meetings with professionals or farmers						
a) Honduras	3	OC, I	6	66	72	SRN, INAFOR
b) Panama	1	OC	1	25	26	IDIAP, PCCMCA

Table 37 (cont./)

Activity and main purpose, by country	N of events and representative for PPD		Type of personnel contacted and number 2/			Institutions contacted
	N	Representative 1/	Dir/Adm	Staff/Farm	Grand Total	
4. Meetings with groups of professionals in relation to the formation of a Working Group and a Central American Network in Cropping Systems Research and Technology Development						
a) Guatemala	1	OC	4	2	6	ICTA, CATIE
b) El Salvador	2	OC	5	12	17	CENTA, CATIE
c) Honduras	2	OC	12		12	SRN, FAO, AID
d) Nicaragua	2	OC	6	12	18	MIDINRA, DGTA
e) Costa Rica	1	OC	2		2	MAG
f) Panama	2	OC	8	17	25	IDIAP
5. Consultancy services or technical assistance based on specific demand by countries or international institutions						
a) El Salvador	1	I		5	5	CENTA
b) Honduras	1	I		14	14	SRN
c) Nicaragua	2	I		40	40	MIDINRA, FAO
d) Costa Rica	1	I		2	2	IICA
6. Meetings with special interest groups in research and technology development						
a) Mexico (sorghum and millet)	2	I		126	126	Latin American National Programs, INTSORMIL, ICRISAT, CIMMYT

Table 37 (cont/.)

Activity and main purpose, by country	N of events and representative for PPD		Type of personnel contacted and number 2/			Institutions contacted
	N	Representative 1/	Dir/Adm	Staff/Farm	Grand Total	
b) Honduras (sorghum and millet)	1	I		2	2	INTSORMIL
c) Costa Rica (legume and cropping systems research working group)	2	I		35	35	UCR, CIAT, MAG, CNP, CATIE
7. Meeting of coordination of activities with other International Institutions						
a) Mexico	1	I		4	4	CIMMYT
b) Costa Rica	2	I		40	40	Central American National Programs, CIAT, FAO, IICA, MAG, CNP, UCR
8. Participation in International Professional Meetings in different disciplines (USA, Brazil)	3	I			Many	ASA, International Symposium on Nitrogen Fixing Trees for the Tropics)

1/ OC = Outreach Coordinator; I = Other researchers in the Project.

2/ Dir/Adm = Directors and/or Administrators in the institutions; Staff/Farm = Staff from the institutions and/or Farmers.

Salvador 2, Honduras 1, Nicaragua 2, Costa Rica 4, Panama 3. The central objectives of this first meeting were:

1. For a group of influential professionals in agricultural research and extension from the different countries to meet for consultation as a first step towards the formation of the Cropping Systems Research and Technology Development Working Group for the PPD at CATIE.

2. To submit for discussion and evaluation by the group, the methodology utilized and promoted by the PPD for cropping systems research and technology development.

3. To submit the outreach mechanism devised by the PPD for discussion and evaluation by the group.

4. To establish the basis for future activities of the Working Group.

The recommendations of the group were as follows:

A. The convenience and requirements for using the method proposed at national level

   1. The group accepted as convenient the use of the method at national level, provided it is flexible enough for adaptation to the national priorities and conditions in terms of personnel and other resource edowments. It was also thought that such flexibility exists.

2. The group identified several requirements for the use of the method at national level, which could imply changes to the present situation. They are:

   a. The planning of agricultural research and agricultural extension should be a joint effort of the responsible groups allowing for a clear identification of individual as well as joint responsibilities

   b. The design of joint technology development projects for specific geographic areas, alloting the human and material resources which allow the proper integration of effort and accomplishment of common objectives

   c. The promotion and facilitation of structural and methodological changes in the research and extension programs to accelerate and improve the process of technology development and transference to farmers

   d. The phase presented as Validation/Transfer in the method, should achieve greater integration of the researchers' and extensionists' efforts at farm level

   e. The careful training of personnel who will form the required multidisciplinary teams, particularly during the first stages of implementation

f. To consider the participation of other support institutions in the joint research-extension projects, such as agrarian reform, credit, marketing, etc.

g. The establishment of more and clearer mechanisms to allow and promote the maximum participation of farmers in the research-extension process

B. Objectives and/or limitations for the use of the approach at national level

The group also identified several objections and limitations for the establishment and use of the method at national level. They are:

a. The present organization of the research institutions which focus their activities by commodity and in isolation from the extension effort, clearly makes it difficult to form the multidisciplinary teams required to use the approach

b. Another difficulty stems from the lack of sufficient knowledge about the approach at directive and executive level of research and extension

c. Lack of information and human resources to obtain the detailed characterization and analysis of the situation considered basic for developing appropriate technology using the approach

d. Lack of basic information to identify analogous areas so as to extrapolate results obtained in specific areas. This would improve efficiency in the use of institutional resources

e. In its present state of development, the evaluation of the rate of adoption of technologies is still weak

C. Strategies proposed for establishing and operating the approach at national level

Based on the above, the group identified several strategic steps as necessary for the establishment and operation of the approach at national level.

a. The establishment of training programs to create the necessary capability at national level

b. The establishment of a permanent mechanism for the updating and evaluation of the methodology by personnel from the national institutions which would use it

c. The inclusion of courses in agricultural research, extension and production systems in course work at university level, relating this to the present work of public institutions

d. Institutional integration of the research and extension services. To promote and facilitate this, the following ideas were suggested:

- The formation of a regional network of researchers and extensionists engaged or interested in cropping systems research and technology development

- To promote and encourage the formation of one or more multidisciplinary teams in pilot areas to integrate research and extension work using the approach

- To promote the integration of these teams and their work into programs in universities and other institutions of the agricultural sector

e. To evaluate the methodology used as part of CATIE's work in each country and identify necesarry changes and adjustments to national programs. To pay particular attention to the Validation/Transfer phase considering the measurement of potential adoption of technology and the co-participation of researchers, extensionists and producers in the process

D. Recommendations to CATIE

The following recommendations to CATIE were approved by the group:

a. To continue the interactive work with national institutions in order to develop further, and adjust the method to national circumstances

b. To include in future meetings of the working group, the presentation by national institutions, of case studies in technology development with and without the participation of CATIE

c. To include courses in Agricultural Extension as part of the UCR/ CATIE postgraduate course work

d. To provide related short courses including Production Systems, Experimental techniques, Technology Transfer, Processing of Data obtained from diagnostic studies

Finally, the Working Group accepted as necessary the objectives and structure of the outreach mechanism designed for the PPD. They expect something similar to be developed for the whole of CATIE and that the national institutions will develop a counterpart mechanism to facilitate interaction and coordination with CATIE and other international institutions in support of national programs.

OPERATIONAL SUPPORT UNIT

The Operational Support Unit's main objective is to help the Head of the Department, the different project coordinators and other scientists in the PPD with the many administrative and logistical support activities under their responsibility. This support greatly increases the time availability for technical activities and their coordination. It also allows a closer monitoring of project expenditure in relation to the receipt of funds and the approved budget.

The Unit is under the control of an Administrative Assistant who is responsible to the Head of the Department. It includes the Executive

Secretary to the Department Head, other secretaries and typists as well as auxiliary administrative and office personnel.

The activities carried out by the Unit include the following:

1. Control of the level of execution of the different projects in the PPD and the flow of receipts and use of budgeted funds. This control is being centralized through use of the CATIE computer facilities

2. Aid to scientists of the PPD, especially those stationed at country level, in the preparation of financial reports, the maintenance of rotating funds, other accounting matters and office management

3. Administration of personnel, particularly sub-professional staff, including authorization for vacation, overtime and sick leave, and obtaining official permission for other requests, when these can be resolved without the intervention of the Head of Department

4. The preparation of purchase orders for the Department and speeding their processing through CATIE 's central administration

5. Supervision of the duplication and distribution of publications

6. Control of the issue of office and field supplies

7. Control of the used and maintenance of Department vehicles and equipment

8. Help with the initial steps necessary for recruiting new personnel, in coordination with CATIE's personnel office

The Unit performed these activities without major problems during 1983. The Administrative Assistant responsible for the Unit resigned his position in February 1983, but he was immediately replaced.

Personnel from the Unit visited all the countries in the Isthmus, as needed, to support and instruct assigned personnel in the routine administration. In Guatemala the personnel helped to form an administrative unit for all CATIE personnel assigned to the country. This unit is directly responsible to the Director of CATIE.

The distribution of expenditure by budget item over the 10 months from January through October 1983 is presented in Table 38. Profiles for total expenditures by month and by item are presented in Figures 15 and 16. Finally, Table 39 contains a summary inventory of equipment purchased during this period and Table 40 lists the personnel financed under the IFAD Grant to CATIE.

TABLE 38. Expenditure (US$) distribution by budget item and by month during the January-October period for the IFAD TA 38B CATIE Grant 1983.

ITEM	JAN-FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCTOBER	TOTAL
A	27,180.92	32,906.13	40,917.06	33,956.27	39,462.55	30,398.28	37,262.24	41,097.79	33,995.67	317,176.91
B	4,279.69	4,136.75	7,165.06	10,970.94	4,817.52	12,848.96	3,589.47	12,198.24	1,900.17	61,906.80
C		147.99	668.01	737.49	978.31	1,255.44	2,863.73	4,713.52	1,538.65	13,903.14
D	621.85	5,360.29	5,035.77	5,954.24	1,068.02	1,478.22	9,077.79	2,855.32	4,450.89	35,902.39
E	1,857.65	2,456.02	2,067.39	2,199.82	1,256.86	2,103.14	5,091.51	3,429.95	5,358.45	25,820.79
F	13,619.87	13,312.52	6,933.78	4,651.35	4,605.57	6,214.10	2,072.43	10,840.78	5,296.73	67,547.13
G	16,365.00	16,365.00	16,365.00	16,365.00	16,365.00	16,368.33	16,368.33	16,368.33	16,368.33	147,298.36
H	2,789.09	7,365.49	2,918.62	8,332.39	4,871.66	7,789.02	4,688.99	9,149.09	10,974.61	58,878.96
TOTALS	66,714.07	82,050.19	82,070.69	83,167.50	73,425.49	78,455.49	81,014.49	100,653.02	80,833.54	728,434.48

A - Salaries and benefits
B - Travel
C - Training
D - Equipment and vehicles
E - Communication and supplies
F - Operation and maintenance of equipment and vehicles
G - Administration and logistic support
H - Miscellaneous items

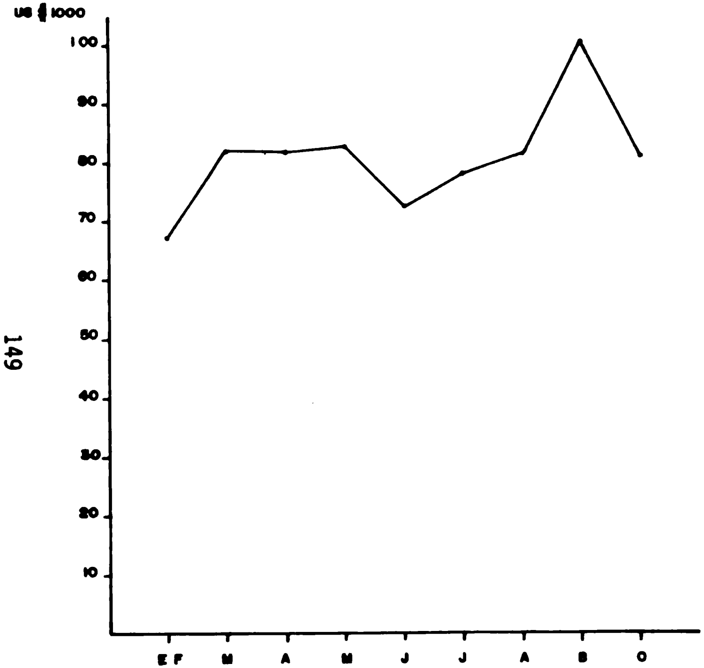

Fig. 15 Expenditure profile for the IFAD TA 38B CATIE grant during the January-October of 1983 period.

A= Salaries and benefits
B= Travel
C= Training
D= Equipment and vehicles
E= Communication and supplies
F= Operation and maintenance of equipment and vehicles
G= Administration and logistic support
H= Miscellaneous items

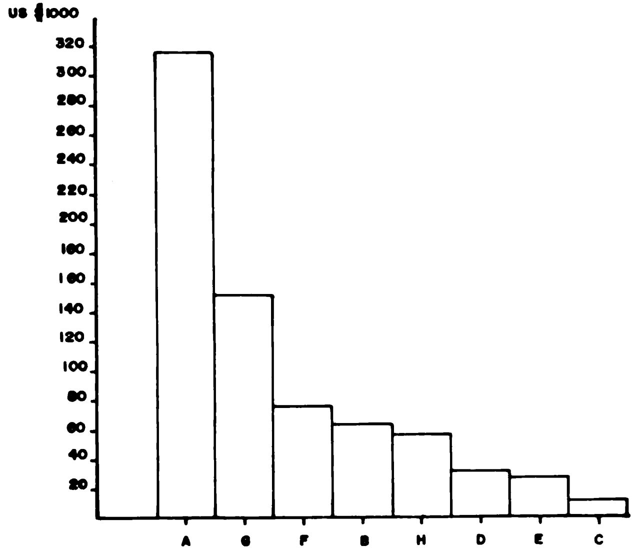

Fig. 16 Comparative level of expenditure for the different items of the IFAD TA 38B CATIE grant up to October 1983.

Table 39. Summary inventory of equipment purchased during period January-October 1983 under the IFAD 38-B CATIE Grant.

Type of equipment	Expenditure US$
Agricultural machinery 1/	16,977.0
Office equipment 2/	9,026.0
Audiovisual equipment	991.0
Field and other minor equipment	8,904.4

1/ Includes a small tractor and a harrow

2/ Includes the renewal of 5 typewriters

Table 40. Plant Production Department Personnel financed under IFAD Grant to CATIE

Component of the Grant and Name	Post	Nationality	Location	Dates of Assignment Initiation	Termination
PROTOTYPE TEAMS					
Rolando Araya (Ing.)	Crop Protection Specialist	Costa Rica	Costa Rica	01-04-82	
Byron Argüello (Ing.)	Crop Protection Specialist	Nicaragua	Nicaragua	01-25-82	
Luis Barrientos (Ec. Agr.)	Agricultural Economist	Costa Rica	Costa Rica	08-01-83	
Jorge Miranda (Bach. Agr.)	Agricultural Economist	Costa Rica	Costa Rica	12-01-81	04-01-83
Adys Pereira (MS)	Agricultural Economist	Panama	Panama	01-01-83	
Alexis Rivera (Ing. Agr.)	Crop Production Specialist	Panama	Panama	01-01-83	
Orlando Torrez (Ing. Agr.)	Crop Production Specialist	Nicaragua	Nicaragua	01-18-82	
Ulises Ureña (Ing. Agr.)	Crop Production Specialist	Costa Rica	Costa Rica	01-18-82	
SUPPORT TEAM					
Tannia Ammour (Dr.)	Consultant	France	Turrialba	02-07-83	04-07-83
Francisco R. Arias (MS)	Cropping Systems Specialist	El Salvador	Nicaragua	02-01-82	06-30-83
José A. Arze (MS)	Plant Physiologist	Peru	Turrialba	03-01-82	
Alberto J. Beale (Ph.D.)	Weed Control Manag. Specialist	U.S.A.	Turrialba	10-28-83	
Michael Bristow (Dr.)	Consultant	Canada	Turrialba	11-01-82	03-31-83
Franklin Herrera (Ing. Agr.)	Assistant Plant Breeder	Costa Rica	Turrialba	09-16-82	
Humberto Jiménez (MS)	Information Specialist	Colombia	Turrialba	08-01-83	
Donald L. Kass (Ph.D.)	Crop Production Specialist	U.S.A.	Turrialba	01-01-82	
Irma Laguna (Dr.)	Research Assistant	Argentina	Turrialba	10-10-82	11-18-83
Anabelly Rodríguez (Ing. Agr.)	Assistant Agronomist	Costa Rica	Turrialba	04-16-83	
Margarita Meseguer (MS)	Agricultural Economist	Costa Rica	Turrialba	10-15-81	
Margaret E. Smith (Ph.D.)	Plant Breeder	U.S.A.	Turrialba	05-01-83	
Reynaldo Treminio (MS)	Consultant	Nicaragua	Nicaragua	11-01-83	01-31-84
Walter Bermúdez	Lab. and Field Assistant	Costa Rica	Turrialba	10-01-80	
José Fuentes	Field Assistant	Costa Rica	Turrialba	09-07-82	03-03-83
Mario Jiménez	Lab. and Field Assistant	Costa Rica	Turrialba	04-12-83	

Table 40 (cont./)

Component of the Grant and Name	Post	Nationality	Location	Dates of Assignment	
				Initiation	Termination
Antonio Mora	Lab. and Field Assistant	Costa Rica	Turrialba	07-26-82	
Oscar Portuguez	Field Assistant	Costa Rica	Turrialba	08-08-82	
Albay Gerardo Quesada	Field Assistant	Costa Rica	Costa Rica	08-01-83	09-06-83
Sergio Quesada	Field Assistant	Costa Rica	Turrialba	08-01-83	
Jacob de Jesús Reyes	Research Assistant	Nicaragua/Estelí	Nicaragua	06-06-83	
Elí Rodríguez	Document/Data Proces. Assist.	Costa Rica	Turrialba	08-16-83	
Jesús Sánchez	Lab. and Field Assistant	Costa Rica	Turrialba	07-01-80	
Limberth Vega	Field Assistant	Costa Rica	Costa Rica	11-12-83	
Lloyd Winter	Lab. and Field Assistant	Costa Rica	Turrialba	07-01-83	
TRAINING UNIT					
Manuel Carballo (MS)	Assistant	Costa Rica	Turrialba	05-03-82	
Frank Peairs (Ph. D.)	Training Officer	U.S.A.	Turrialba	01-01-82	07-01-83
OUTREACH COORDINATION					
Juan Luis Morales (Ing. Agr.)	Assistant Agronomist	Costa Rica	Turrialba	01-20-83	
Marciano Rodríguez (Ph. D.)	Outreach Coordinator	Panama	Turrialba	09-01-82	
SUPPORT UNIT					
Guillermo Chaverri (Ec. Agr.)	Project Coordination Assist.	Costa Rica	Turrialba	11-09-81	02-16-83
Hernán R. Rodríguez (Ad. Emp.)	Project Coordination Assist.	Costa Rica	Turrialba	12-31-82	
Maricela Chaves F.	Bil. Executive Secretary	Costa Rica	Turrialba	06-07-82	
Milena Dennis S.	Secretary	Costa Rica	Turrialba	06-06-83	
Osckarina León	Secretary	Costa Rica	Turrialba	08-18-83	
Amyel Locatelli	Bilingual Secretary	Uruguay	Turrialba	11-01-81	

Table 40 (cont./)

Component of the Grant and Name	Post	Nationality	Location	Dates of Assignment	
				Initiation	Termination
Lisbeth Ramos N.	Secretary	Costa Rica	Turrialba	10-20-80	
Martha Rodríguez	Secretary	Nicaragua	Nicaragua	06-01-82	
José R. Alvarado	Documentation Assistant	Costa Rica	Turrialba	09-08-83	
Juan B. Hidalgo	Documentation Assistant	Costa Rica	Turrialba	08-01-83	
Jorge Madrigal	Documentation Assistant	Costa Rica	Turrialba	11-20-81	
Hannia Pereira	Office Keeper	Costa Rica	Turrialba	08-18-83	
Antonio Salas	Administrative Assistant	Costa Rica	Turrialba	03-16-83	

NOTE: In parenthesis: Ph. D. Doctor of Philosophy; MS Master of Science; Ing. Agr. Ingeniero Agrónomo; Agr. Agrónomo; Adm. Emp. Business Administrator; Ec. Agr. Agricultural Economist; Dr. Doctor

DOCUMENTS PREPARED

Several documents were prepared as part of the activities of the Project during 1983. Their purpose is to reinforce the outreach or constitute part of the training activities. They include the following:

WORKING DOCUMENTS AND REPORTS

1. Esquema de investigación en sistemas de cultivos con sorgo. Presented for discussion during a research programming meeting for maize and sorghum. Costa Rica, CATIE, 1983. 15 p. Responsible: J. Arze

2. Evaluación de fijación de fósforo en suelos de San Carlos, Costa Rica. Informe 1983. Responsible: Mazzarino de Schlichter, M.J.

3. Evaluación de Genotipos. Progress Report. October 1983. Responsible: M. Smith

4. Identificación de las principales malezas de San Carlos, Costa Rica. Informe 1983. 14 p. Responsible: M. Bristow

5. Información General sobre el Proyecto de Evaluación de Genotipos. February 1983. Responsible: M. Smith

6. Informe Anual 1982, Proyecto Piloto de Investigación para el Desarrollo de Tecnologías Agrícolas en Areas Geográficas Específicas. Turrialba, Costa Rica, CATIE, 1983. 77 p. (in press). Responsible: M. Meseguer and L. Navarro

7. Plan Operativo para Introducción y Evaluación de Variedades. Estelí, Nicaragua, 1983-1984. Responsible: M. Smith

8. Proyección Externa - Primera Reunión de Consulta. Turrialba, Costa Rica, CATIE, 1983. 6 p. Responsible: M. Rodríguez

9. Proyecto de Investigación y Transferencia de Tecnología para la Zona de Las Flores, Comayagua, Honduras. Turrialba, Costa Rica, CATIE, 1983. 10 p. Responsible: G. Escobar, J. Arze, M. Rodríguez and M. Meseguer

10. Red Centroamericana de Investigación en Sistemas de Producción; Propuesta. Turrialba, Costa Rica, CATIE, 1983. 10 p. Responsible: M. Rodríguez

11. Resumen de Investigación en Evaluación de Variedades. Estelí, Nicaragua, 1982-1983. Responsible: M. Smith

12. Revisión/Evaluación Interna de los Equipos Prototipo. Turrialba, Costa Rica, CATIE, 1983. 23 p. Responsible: J. Arze, G. Escobar, D. Kass, F. Peairs, M. Rodríguez, M. Smith and R. Arias

FORMAL DOCUMENTS

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