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CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSENANZA
Departamento de Producción Vegetal
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PREFACE

This report summarizes the progress made by the Plant Production Department of CATIE under the TA Grant 38-C CATIE from IFAD. During the period covered by the Grant, research was carried out on the major cropping systems responsible for the production of annual crops in three ecological zones of Central America and Panama. Research activities were carried out by the support research team and national prototype teams in cooperation with local farmers and research and extension institutions. Other activities financed by the Grant included training at different levels for nationals of the countries in the CATIE mandate area, outreach coordination of research activities in the area of cropping systems, technical assistance to national programs, and production of documents related to the research and training activities.

This document was written by personnel of the IFAD Support Team, who were responsible for the activities described. The editorial committee consisted of Dr. Donald Kass and Dr. Alberto Beale, of the support research teams and Ms. Susan Shannon, who edited previous IFAD reports. They are also responsible for the English translation. Typing and layout were done by Maricela Chaves and Amyel Locatelli, and graphics by Hector Chavarria and Andres Nuñez, personnel of the IFAD project.

We would like to thank the many national colleagues and farmers who participated in various activities financed by the grant and contributed to the progress made during the year.

A special recognition is extended 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

AID	Agency for International Development
ANACAFE	National Coffee Planting Association (Guatemala)
ANAI	New Alchemist Association (Costa Rica)
BANADESA	National Development Bank (Guatemala)
BCR	Bank of Costa Rica
BNCR	National Bank of Costa Rica
CATIE	Tropical Agricultural Research and Training Center
CENTA	Center for Agricultural Technology (El Salvador)
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CLAIS	Latin American Commission for Sorghum Researchers
CNP	National Production Council (Costa Rica)
DGA	General Directorate of Agriculture (Nicaragua)
DGEIA	General Directorate of Agricultural Research (Nicaragua)
DGTA	General Directorate for Agricultural Technology (Nicaragua)
DIGESA	General Directorate for Agricultural Services (Guatemala)
EAP	Panamerican Agronomy School (Zamorano, Honduras)
GEPLACEA	Group of Latin American and Caribbean Sugar Exporting Countries
IBSNAT	International Benchmark Soils Network for Agricultural Transference
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDA	Institute of Agricultural Development, Costa Rica

IDIAP	Agricultural Research Institute of Panama
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INTSORMIL	International Sorghum and Millet Program
IPPC	International Plant Protection Center
ITCR	Technological Institute of Costa Rica
LHT	Lowland Humid Tropics
MAG	Ministry of Agriculture and Livestock
MIDINRA	Ministry of Integrated Development and Agrarian Reform
OSPA	Sectional Agricultural Planning Office (Costa Rica)
PCCMCA	Central American Cooperative Program for the Improvement of Food Crops
PPD	Plant Production Department (CATIE)
PROMECAFE	Program for Coffee Improvement
SAT	Semi-Arid Tropics
SBN	National Banking System (Costa Rica)
SRN	Secretary of Natural Resources (Honduras)
UCR	University of Costa Rica

INTRODUCTION

The IFAD TA 38 Grant to CATIE finances and supports 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 implemented by the Plant Production Department (PPD) of CATIE in the six countries of the Central American Isthmus but some of the training activities involve other countries of the American tropics.

The project has five basic components: 1) three prototype teams, consisting of three B.S. level national agronomists who do research and technology development in specific areas in representative ecological zones of the Central American Isthmus; 2) a support team, consisting of Ph.D. and M.S. level specialists in the areas of soil management, genotype improvement, weed management, cropping systems, agricultural economics, and plant physiology, who provide support to the prototype team, do research in their specialities related to each of the ecological zones, and strengthen the PPD's capabilities in their area of specialization; 3) training, which coordinates training activities in the department including participation in the graduate program of CATIE, a three-month course in farming systems research methodology, offered principally to B.S. level professionals in the CATIE mandate area, as well as to selected professionals from outside this region; and various short courses required by national programs of the member countries; 4) outreach, which coordinates farming systems activities in the CATIE mandate area and provides linkages between national programs and the various components of the IFAD supported activities; 5) operational support, which reinforces administrative and logistical capabilities 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, TA-38B during 1983, and TA-38C during 1984. In November 1984, Dr. A. Kesseba and

Dr. Ivan Buddenhagen of the University of California, visited CATIE and reviewed project activities in Costa Rica. A report on this mission was submitted to IFAD by Dr. Buddenhagen in June, 1985.

All of the personnel who resigned from the project in 1983 were replaced in 1984. These included the Training Officer who was replaced by the Plant Physiologist and the Cropping Systems specialist who was replaced in June, 1984. The Genotype specialist resigned in May, 1984 but was replaced by July, 1984. All vacancies in the prototype teams were also filled in 1984. Thus there were no major personnel gaps in the project at least in the second semester of 1984 except for the Plant Physiologist, who continued research and support activities in this area while filling the post of Training Officer.

Despite some budgetary limitation, progress was made in all components of the project during 1984. The prototype team in the humid tropics completed its first year of experimentation with cropping systems involving cassava and completed economic characterizations of systems involving cassava and pineapple. The prototype team for the wet dry tropics (Panama) was able to formulate recommendations for the vegetable components of the cropping systems that predominate in the area.

After relocating the area of study to an area more representative of the semiarid tropical zone and less subject to counterrevolutionaty activity, the team in Nicaragua was able to formulate recommendations for the bean-bean and maize-sorghum production systems. Support research for the lowland humid tropics indicated that nitrogen-fixing trees could be used to maintain yields of maize over three years, that living mulches could be used to control weeds in different cropping systems, and that associating maize with plantains would reduce initial cost of establishment of plantains considerably. A wide range of herbicides were screened for use in several non-traditional crops as well as the most critical period for weed control was determined. For the semiarid tropics, several experiments demonstrated how interactions with climate and soil conditions explained the greater yield stability of photoperiod sensitive sorghums and the inadvisability of replacing these with photoperiod insensitive sorghum. More stable varieties of maize, bean and sorghum were identified for these areas and turned over to the national program for multiplication.

Training was given to 213 professionals and non-professionals in short courses, four graduate level courses were offered by project personnel, and 6 graduate and 26 undergraduate theses were completed with project support. Outreach activities included a second meeting of the cropping systems working group, held in September 1984 in Guatemala, and the indexing and computarization of the contexts of the over 2000 papers presented in the Cooperative Central American Project for Food Crop Improvement (PCCMCA) in its annual meetings from 1954 to 1983, making this information readily available to researchers both inside and outside of Central America.

IFAD/CATIE GRANT BACKGROUND

The IFAD TA 38-C 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 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 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 being 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 is 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 1984 is presented in the following sections of this report.

PROTOTYPE TEAMS

The Prototype Teams installed in Estelí, Nicaragua, and San Carlos, Costa Rica in January 1982 are completing their third 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 second year of field research on the principal crop production systems based on maize, rice, tomatoes and other vegetable crops.

The operation of 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. An economist was hired in Nicaragua in March 1984 to complete the three person prototype team. The cropping systems specialist stationed in Nicaragua, began work in his speciality and as a direct supervisor of the prototype in May 1984.

In Panama, the crop production member of the team resigned during the first third of the year, but was substituted by May 1984. The crop protection specialist ceased work with the prototype at the end of the year. The national institution IDIAP does not plan to replace this person.

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 1984 and their main results can be grouped as follows:

LOWLAND HUMID TROPICS PROTOTYPE

During 1984 research was continued on the cassava-bean, cassava-maize and white cocoyam systems of production. New research trials were begun on ginger, pineapple and yam. With respect to agricultural economics, studies have been conducted on cassava-bean and pineapple. The grower costs of production of each of the systems studied at San Carlos were determined. Market studies for cassava and for white cocoyam were initiated.

Growers have shown greater interest and more acceptance for factors such as the use of preemergence herbicides in each of the systems under study. Planting distances and fertilization have also been factors of interest for the grower.

In order to disseminate the research highlights of the project, the prototype has been actively taking part in meetings of the Agricultural Sector of the North Huetar Region. In addition, together with students from the Agroecosystems II course, a series of talks were given in which the researcher methodology followed and the results obtained up to the moment were presented.

The national institution with which the prototype has had the closest working cooperation has been the Technological Institute of Costa Rica. The prototype supervised the research problem for graduation of 20 students.

RESEARCH

Characterization of Cassava-Bean System of Pital and La Fortuna, San Carlos

Results indicate that at the beginning of the dry period (December-January) growers plant cassava. Beans are planted in association either simultaneously or 12 to 15 days after the cassava.

The farm area planted in this system represents 22% of the total. The average size per plot is 1.7 ± 1.4 ha and the production of beans is 375 kg ha^{-1}. The average total cost of managing the systems until the bean harvest ranges from $180 to $300 ha^{-1}. Costs vary between the two sites due mostly to the cost of land preparation.

Tables 1 and 2 show the production practices conducted and their costs. Figure 1 presents the total distribution of hand labor, inputs and land preparation. Table 3 illustrates the activities and costs of the bean monoculture system.

TABLE 1. Summary of production costs per hectare of cassava bean system practiced by farmers in Pital, San Carlos, Costa Rica, 1984.

PRACTICE	PERCENTAGE 1/	HOURS/HA	LABOR COST 2/	INPUTS	INPUT COSTS	TOTAL COST (¢)
Land preparation	100	5,0				3,304
Preparation of cassava seed	100	13,8	345			345
Cassava sowing	100	52,0	1,300			1,300
Bean sowing	100	38,0	950	Seed 20,4kg	673	1,623
Fertilization 3/	66,7			12-24-12	912	912
Weed control	50,0	51,6	1,290			1,290
Spraying	40,0	4,2	105	Foliar fert.	131,5	236,5
Harvest	100	44,9	1,122,5			1,122,5
Threshing	100	24,0 5/	600			600
TOTAL		228,5	5,712,5		1,716,5	10,733,3
AVERAGE TOTAL COST 4/						9,870,0

1/ Percentage of farmers using practice

2/ At 25 colones/hour (1$ = ¢48)

3/ Fertilizer applied at sowing

4/ Average costs for all farmers

5/ Based on average production of 8 qq/ha and 3 hours per qq threshing (1 qq = 46 kg)

NOTE: For further information see document 'Caracterización ambiental y de los principales sistemas de cultivo en fincas pequeñas. San Carlos, Costa Rica (1983)'.

TABLE 2. Production costs per hectare of cassava-bean system practiced by farmers in La Fortuna, San Carlos, Costa Rica, 1984

PRACTICE	PERCENTAGE 1/	HOURS/HA	LABOR COSTS 2/	INPUTS	INPUT COSTS	TOTAL COST(¢)
Land preparation	100					4,697,0
Preparation of cassava seed	100	17,1	427,5			427,5
Cassava sowing	100	72,4	1,810,0			1,810,0
Bean sowing	100	51,2	1,280,0	18kg seed	594	1,874,0
Fertilization 3/	22			12-24-12	712	712,0
Weed control	67	137,5	3,437,5			3,437,5
Spraying	67	5,5	137,5		63	200,5
Harvest	100	49,6	1,240,0			1,240,0
Threshing	100	24,6 5/	615,0			615,0
TOTAL		357,5	8,947,5		1,369	15,013,5
AVERAGE TOTAL COST 4/						12,503,0

1/ Percentage of farmers using practice

2/ At 25 colones/hour

3/ Fertilizer applied at sowing

4/ Average costs for all farmers

5/ Based at 3 hrs/qq of beans and average production of 8,2 qq/ha.

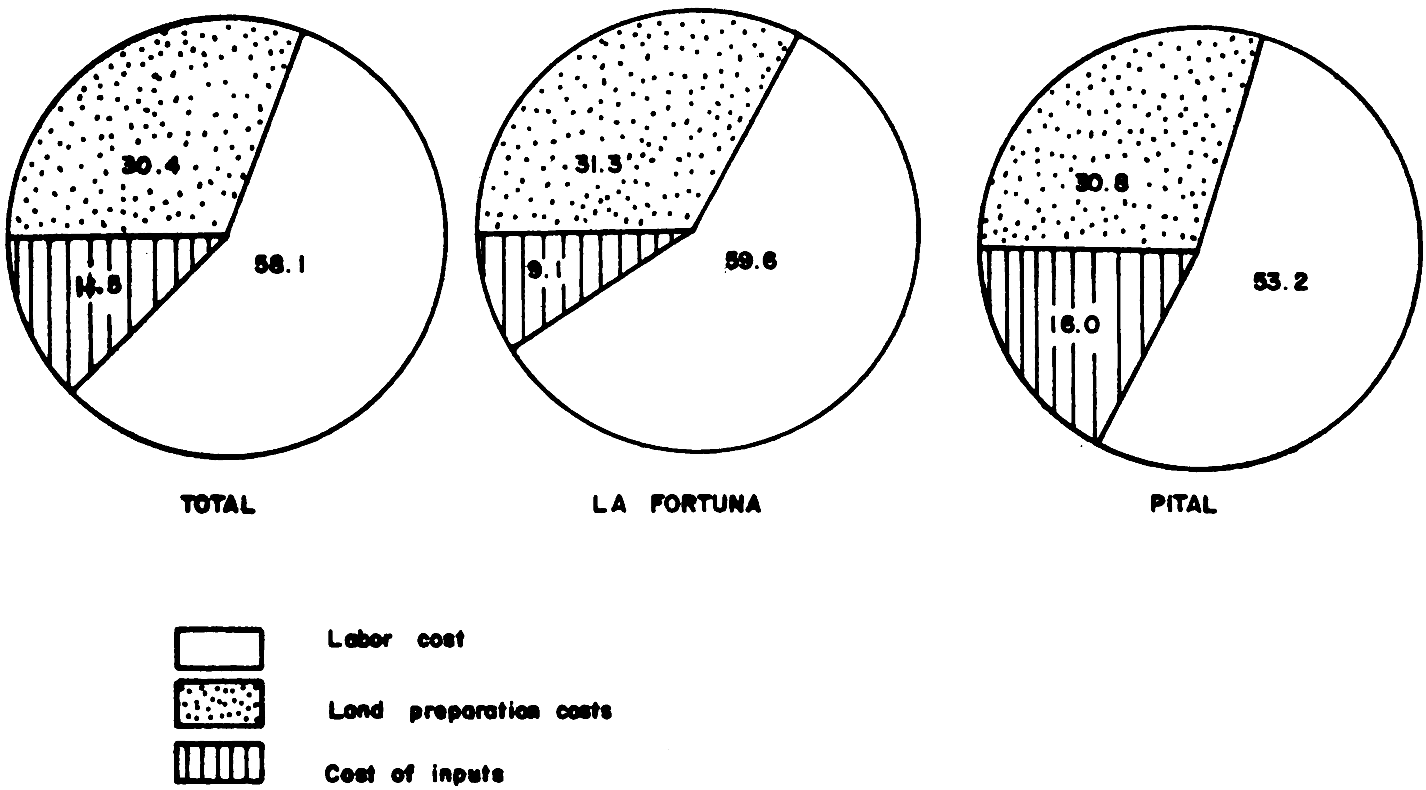

Figure 1. Distribution of total cost per hectare for cassava-bean system practiced by farmers in Pital and La Fortuna, San Carlos, Costa Rica, 1983-1984.

TABLE 3. Summary of production costs per hectare for bean monoculture system practiced by farmers in Pital and La Fortuna, San Carlos, Costa Rica, 1984.

PRACTICE	HOURS/HA	LABOR COSTS	INPUTS	INPUT COSTS	TOTAL COST ¢
Land preparation	5,5	5,5			4,700[1/]
Sowing and fertilization	120,0	3,000	Seed	600	3,600
			12-24-12	1,375	1,375
Harvest	100,0	2,500			2,500
Threshing, winnowing and drying	63,0	1,575			1,575
Sale			Transport	320	320
TOTAL		7,075		2,295	14,070[1/]
					12,770[2/]
FARMERS TOTAL[3/]		7,170		2,900	14,770[1/]

1/ La Fortuna

2/ Pital

3/ Average of total costs obtained per farmer

Characterization of Pineapple Systems of Pital, San Carlos

In August 1984 a follow up study of the pineapple in monoculture system was begun at Pital. The data obtained has been partially analized. Table 4 shows the costs of production until December 1984 of one grower.

Environmental characterization of the principal cropping systems of small farms, San Carlos

The final characterization document was published during the year.

Cassava + Maize System

Maize variety trials in monoculture or associated with cassava during 1983 and 1984 showed that with the Diamantes 8043 variety the growers yield (380 kg ha^{-1}) may be increased 3 to 5 times without affecting cassava yields.

A population of 20.000 plants/ha of maize associated with 10.000 plants/ha of cassava was found to be the optimum arrangement and showed greater acceptance by growers.

Response to fertilization varied with locations. Low rates were found as optimum in La Fortuna, while higher rates are recommended for Pital. Only the maize should be fertilized, since no response to fertilizer has been found in cassava. The most economic fertilizer levels were 90-180 kg ha^{-1} of 12-24-12 fertilizer at planting and 45 to 90 kg ha^{-1} of urea a month after planting.

High levels of aluminium saturation at certain sites in Pital make this recommendation uneconomic without the use of high levels of agricultural limestone (see Soil Management section under Support Research).

TABLE 4. Production costs of pineapple system, Pital, San Carlos, Costa Rica, 1984.

Farmer: Bienvenido Mondragón G, El Encanto

Starting date: August 1984

Area of pineapple plot: 8300m^2

DATE	WORK DONE	TOTAL HOURS	LABOR COSTS[1/]	PRODUCTS OR INPUTS	QUANTITY APPLIED	INPUT COSTS	TOTAL COSTS
June	Land preparation	23,8					₡ 13,090
July	Sowing	255,0	₡6375	Pineapple shoots	27 000	₡40,500	46,875
August	Fertilization	3,0	750	20-20-0 Foliar fertilizer	1 quintal	780	
August	Weeding	36	900				900
September	Hilling up	44	1100				1,100
October	Weeding	38	950				950
October	Disinfectant applic.	10	250	Carbolina	1 liter	110	360
October	Herbicide application	28	575	Radex	2.5 1	493	1,068
October	Hilling up ahd suckering	26	650				650
November	Lodging	41	1025				1,025
November	Herbicide appliction	12	300	Radex	1.0 1	197	497
TOTAL COSTS TO DEC. 1984		515	₡12875			₡42,565	₡ 68,530

[1/] 1 hour = ₡25,00

The use of preemergence herbicides, a new innovation for growers of the area, has had a very favorable acceptance. Results show that a mixture of alachlor at 1.44 kg ha^{-1} plus linuron at 0.75 kg ha^{-1} is the best alternative for chemical weed control.

Cassava + Bean System

Increasing bean population in this system up to 152,000 plants ha^{-1} increased bean yields significantly and did not affect cassava yields. Weed control was better with the higher bean population.

A spatial arrangement of cassava at a 1 x 1 m spacing was found to produce the highest yield.

Additional research on fertilization requirements of beans should be conducted, since due to environmental conditions and to fertilizer placement, many bean plots were lost. Fertilizer requirements for beans are greater at Pital than at La Fortuna.

The use of preemergence herbicides is a practice that should be adopted since it reduces the costs of production at the same time as facilitating the management of the system. Alachlor at 1.44 kg ha^{-1} of commercial product was the best alternative evaluated.

Table 5 shows the 15 bean varieties producing the highest yield of the 32 varieties studied. They are planted in monoculture.

TABLE 5. Yields of 15 bean varieties in monoculture.
Santa Clara, Florencia de San Carlos. 1984.

VARIETY	YIELD kg ha^{-1}
ICA PIJAO	2108,7
R-675	2065,3
COMPUESTO 1	1904,7
ICTA 81-66	1896,3
NEGRO HUASTECO 81	1861,7
ICTA QUETZAL	1835,3
ICTA 81-26	1816,0
SYNTHETIC PORRILLO*	1799,7
BRUNCA*	1770,0
BAT-1554	1767,7
A-227	1764,7
BAC-87	1689,3
ICTA TAMAZULAPA	1689,0
BAC-109	1621,0
BAT-1432	1614,7

*Synthetic Porrillo, Brunca and Talamanca studied in association with cassava. Selection made on the basis of yields obtained in variety trials, availability of seed, and recommendations made by CNP and MA.

White Cocoyam Monoculture System

No response was found to fertilization or to population density in the two experiments harvested. When the lower part of the main corm, or the secondary corm (cormel) was used for planting, increased yields of higher quality cocoyams and a higher total yield were obtained than when other parts of the plants were used for propagation. Lowest yields were obtained where the upper part of the main corm was used for planting.

The variety used during the 1983-84 season did not yield cormels of the quality required for export. Only 10% of the cormels produced were of grade A (export quality). The crop, because of the quality standards, was not profitable. For 1984-1985 period, a new white cocoyam variety is being used.

List of field experiments conducted during the year

Table 6 presents the types of field experiments, the objectives, their location and the principal results and conclusions obtained. Also included are trials begun in 1983 but concluded during 1984 and marketing studies made during 1984. Table 7 presents an inventory of outreach activities developed during 1984.

SEMI-ARID TROPIC PROTOTYPE

RESEARCH

Maize - Photoperiod Sensitive Sorghum System

The association of maize variety M3B with sorghum variety Sapo yielded 7% more than the association with "Criollo" sorghum. The M3B maize yielded 46% more than the "Criollo". The Criollo and Sapo

Table 6. Inventory of field trials carried out by the Prototype Team in San Carlos, Costa Rica, 1984.

Cropping systems, components and date of planting	Location	Results or Progress
HARVESTED TRIALS		
1. Cassava + maize		
1.1 "Central" trial (May 1983)	3 farms in La Fortuna, 1 in Pital	Maize yields were increased and cassava yields unchanged when maize population was increased to 20.000 plants/ha^{-1}.Under this system, maize yields averaged 1500 kg ha^{-1} and cassava yields 11.000 kg ha^{-1}
1.2 Complementary trials (May 1983)		
a. Plant density	3 farms in La Fortuna, 1 in Pital	ALthough maize yields were increased by increasing densities to 30.000 plants ha cassava yields were reduced by 20 to 30 per cent. The highest net return was obtained with 20.000 maize plants and 10.000 cassava plants ha^{-1}
b. Fertility	2 farms in La Fortuna, 1 in Pital	Highest yields were obtained with application of 75-80-75 kg/ha N-P_2O_5-K_2O in Pital and 37-40-37 kg ha ha^{-1} N-P_2O_5-K_2O in Fortuna in maize, but cassava did not respond to fertilizer. Economic analysis indicated low or no fertilization for maize and cassava
c. Weed control	1 farm in La Fortuna, 1 in Pital	Good control of grass weeds were obtained with linuron + alachlor kg ai/ha^{-1}. Yields in the linuron or alachlor by themselves or in combination were higher than in the hand weeded treatment with respect to maize. No differences in yields were found in cassava.

Table 6 (continued)

Cropping systems, components and date of planting	Location	Results or Progress
2. Cassava + beans		
2.1 "Central" trial (January 1984-January 1985)	2 farms in La Fortuna, 2 in Pital	Highest bean yields were obtained with 114,000 plants ha^{-1} with a 22-44-22 kg ha^{-1} application of $N-P_2O_5-K_2O$ and alachlor at 3 l ha^{-1}. The cassava was not affected by treatment
2.2 Complementary trials		
a. Plant density	2 farms in La Fortuna, 2 in Pital	The highest profit/ha was obtained with 114.000 plants of bean/ha and 10.000 plants of cassava at 1 x 1 m spacing. Populations of 152.000 plants of bean/ha had fewer weeds, but were not economical
b. Fertility	2 farms in La Fortuna, 2 in Pital	No response to fertilization was found in La Fortuna, response to 22-44-22 kg ha^{-1} of $N-P_2O_5-K_2O$ was found in beans at Pital
c. Weed control	2 farms in la Fortuna	The economic analysis indicated that the best treatment was the application oif alachlor at 2 to 4 l ha^{-1}
3. New cocoyam (*Xanthosoma* sp.) as a monoculture		
3.1 "Seed piece" type and fertilization (May 1983)	1 farm in La Fortuna	No response was found to fertilization. Higher yields were obtained when the lower part of the main corm or the lateral corms were used
3.2 Plant density and means of propagation (May 1983)	1 farm in La Fortuna	No differences were found due to densities of plants

Table 6 (continued)

Cropping systems, components and date of planting	Location	Results or Progress
TRIALS UNDER WAY		
4. Cassava + Maize		
4.1 "Central" trial (May 1984)	3 farms in La Fortuna, 4 in Pital	The maize was lost due to poor seed germination
4.2 Fertilization x varieties (May 1984)	2 farms in La Fortuna, 2 in Pital	The maize was lost due to poor seed germination
5. New Cocoyam (*Xanthosoma* sp.)		
5.1 Density x fertilization (July 1984)	1 farm in La Fortuna	The trial will be harvested in July 1985
6. Pineapple		
6.1 Fertilization x density	1 farm in Pital	Trial is in progress
6.2 Weed control	1 farm in Pital	Trial is in progress
7. Ginger + cassava		
7.1 Hilling up x shade	1 farm in La Fortuna	Trial is in progress
8. Ginger in monoculture		
8.1 Fertilization x density	1 farm in La Fortuna	Trial is in progress

Table 6 (continued)

Cropping systems, components and date of planting	Location	Results or Progress
9. Yam (*Dioscorea alata*)		
9.1 Varieties	1 farm in Pital	Trial is in progress
10. Market studies		
10.1 Cassava	San Carlos	Production varies from 11 to 15 t ha^{-1} and costs from 17 to 20.000 colones ha^{-1} Costs differed between La Fortuna and Pital. Commercialization has a 90% margin
10.2 New cocoyam (*Xanthosoma* sp.)		95% of production is bought for export. Mean profit is 17.000 colones ha^{-1}. Margin for commercialization is 60 to 70 per cent. Export market has higher prices in January and February.

TABLE 7. Inventory of the outreach activities[1/] developed by the Prototype Team in San Carlos, Costa Rica, during 1984

Type of activities and main purposes	Number of Events	Number of Total participants	Type of participants and institution represented	Location in Costa Rica and date
Direction of special research problems for graduation	19	19	Undergraduate students ITCR	San Carlos, 1983-84
Direction of Licenciatura thesis	1	1	Professional students, UCR	San Carlos, 1983-84
Meeting with the Prototype from Río Frío	1	4	Agronomists, UCR-IDRC	San Carlos, 3/29/84
Conference	1	30	Graduate Students, Research and extension institutions and universities of Central America and the Caribbean	Turrialba, 8/30/84
Meetings with the agricultural sector	20	Various	Ingeniero agrónomo and M.S. ITCR, MAG, CNP, IDA, Cooperatives SBN	San Carlos, every two weeks
Cycle of conferences on research and technology development in production systems		25	Ingeniero agrónomo and M.S. ITCR, MAG, IDA, CAFESA, CNP, BCR, BNCR, Cooperatives, MIDEPLAN	San Carlos, 11/19-23/84
Distribution of the environmental characterization and of the bibliography of San Carlos			MAG, IDA, CNP, ITCR, SBN, educational institutions	San Carlos, various dates

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

Inventory of the outreach activities[1/] developed by the Prototype Team in Estelí, Nicaragua, during 1984.

Type of activities and main purposes	Number of Events	Number of Total participants	Type of participants and institution represented	Location in Nicaragua and date
Technical meetings to:				
a) Presentation of work plans	1	22	Research, production and technical cooperation personnel from MIDINRA	Estelí, 3/2/84
b) Research strategies for the region	1	10	Director of CATIE, MIDINRA and researchers	Estelí, 6/2/84
c) Presentation and discussion of work plans	1	16	Research, production and techni-cooperation personnel from MIDINRA and CATIE	Estelí, 12/12/84
Field days to show promising results form trials	2	31	Same	Estelí, 8/7/84 and 11/29/84
Soil conservation seminar and systems of production focus	2	26	Agronomists from MIDINRA and CATIE	Estelí, 3/19/84 and 4/9/84

varieties of sorghum did not show a response in yield to fertilization.

The association of sorghum cv. sapo with maize cv. M3B yielded 14% more than when "criollo" sorghum was planted. Although no significant differences in yield were found between fertilizer treatments under both maize varieties studied, they yielded 15% more than with traditional fertilization.

Plant height was the only character in which Criollo maize was significantly greater than the M3B variety.

Fertilization with 51-58-4 kg ha^{-1} of N-P_2O_5-K_2O yielded a net gain of C$4.905 cordobas. For each cordoba invested, a gain of 2.07 was obtained. This represents 26% more than in traditional system.

Based on the results of the research, it is recommended that:

- Seed increases be made on commercial areas for maize variety M3B and sorghum variety Criollo Sapo

- Use of 51-58-4 kg ha^{-1} of N - P_2O_5 - K_2O for the maize sorghum system

- Promote a change of varieties by the growers, incorporating the fertilizer recommendation, and testing it on the improved technological alternative

- Disseminate the agronomic advantages of the proposed alternative

- At the same time that the validation is being conducted, experiments should be repeated to refine the proposed alternative

<u>Maize - Photoperiod Insensitive Sorghum</u>

Maize in relay with photoperiod insensitive sorghum yielded 28% more than with photoperiod sensitive sorghum (millon) ($P \leq 0.05$). In this system, the maize yielded higher because there was no competition for nutrients between the crops in contrast to the maize-millon system where competition takes place. The size and number of cobs was greater in the maize-sorghum than in the maize-millon system. However, millon associated with maize yielded 35% more than the sorghum in relay with maize.

Maize and sorghum associated or in relay with improved M3B maize yielded 95% more than with maize variety NB-100. The improved M3B maize in relay with sorghum produced the highest returns and the greatest benefit, 2.07 for each cordoba invested. In general, treatments including improved M3B maize showed the greatest economic returns. The lowest returns were obtained with criollo maize and millon varieties, C$2850, in contrast with the improved varieties, where returns of 9337 cordobas per hectare were obtained.

Based on the results, the following recommendations are suggested:

- Promote an understanding of and adoption of the maize-sorghum in relay system among the growers in the area. Farmers should understand that this system can produce higher maize yields but lower sorghum grain straw yields than the traditional system. Further discussion of the tradeoffs involved in changing from one system to another can be found under cropping systems in the Support Research section

- Introduce improved M3B maize variety and improved white or cream fleshed sorghum of tortilla grade quality

- Promote the establishment of this type of trial in other environments within the region

Maize - Potato in Succession

Maize produced a yield of 2512 kg ha^{-1} which is considered a good yield. The highest potato production was obtained using the fungicide Dithane M-45 at two week intervals in rotation with Benomyl.

No response was found to fertilization. The highest level of N-P_2O_5-K_2O used, is 50% less than that used by the potato growers of the region. Economically, the highest benefit was obtained with the application of Dithane M-45 every fourteen days. The benefit obtained per dollar invested was 6.61. The lowest benefit, a return of 3.34 cordobas per dollar invested, corresponded to the treatment with 200-245-17 kg/ha N-P_2O_5-K_2O and the application of Benomyl every seven days.

Based on the conclusions of the research, it is recommended that:

- Potato growers and cooperatives should be informed that reduction in the fertilizer rate to 50% of what is commercially used, results in good potato yield

- Preventive Dithane M-45 application should be made

- The maize-potato in succession system should be promoted, in which by planting the maize first, the presence of fungal pathogens in the soil is notably reduced

- The field trials should be repeated at other sites within the region

Bean-Bean Succession System

Red bean variety Revolucion 79 has a higher potential for adapting itself in the region, since it yielded 32% higher than variety criollo Chile Rojo. Both varieties responded to the application of fungicide ($P \leq 0.05$). Yields were increased by 31% with the application of fungicides. No response was found from a change in the fertilization rate used by growers.

In postrera, in spite of extremely dry weather for the season, variety Revolucion 79 was the highest yielder, producing 805 kg ha^{-1} which surpassed the criollo bean variety by 59% ($P \leq 0.05$). No response in yield was found from fungicide application to both sites.

Conclusions based on economic studies for the first and second cycle planting:

- The highest benefit/cost relation was obtained using variety Revolucion 79 without fungicides

- The use of fungicides increased the costs of production by C$675, resulting in a decrease in net return. The benefit/cost ratio was 3,78 which is less than the 0.50 ratio obtained when agrochemicals are not used

- Variety Chile Rojo requires fungicide application since it is more susceptible to diseases. When fungicides were not used, the lowest returns were obtained, and the benefit/cost ratio was 2.11

- When fungicides were applied to the Chile Rojo variety, costs of production were increased by C$675, but the benefit/cost ratio was increased to 3.70

Based on these conclusions, recommendations are:

- Substitute the criollo variety of bean for the improved variety Revolucion 79

- Suggest as an alternative proposal the cultivation of Revolucion 79 variety

- Evaluate variety Revolucion 79 during the next cropping cycles in commercial plots, or as a method of validation

- Propose the propagation of the variety in the region

Conclusions on the fertilization:

FIRST CYCLE

- Revolucion 79 variety yielded 42% more than the criollo bean
- Neither of the bean varieties used responded to fertilization
- Los Camaros, yields (1729 kg ha^{-1}). were higher that at the other sites
- At El Despoblado, yields were the lowest of all sites (966 kg/ha)

SECOND CYCLE

- Yields were extremely poor so the effects of the residual fertility could not be determined

- No yield differences were found between varieties

- No yield differences were found where fertilizer was applied in the first or in the second cycle

Conclusions of the economic study of the first and second cropping cycle:

- Substituting the traditional fertilization of 22-58-4 for 30-30-0 kg ha^{-1} of $N-P_2O_5-K_2O$, reduced the costs of production by C$87 cordobas, and produced the greatest benefit/cost ratio, 1.25

- The optimum level of fertilization was 32-48-3 kg ha^{-1} of $N-P_2O_5-K_2O$. Costs were not increased by its use in comparison to the traditional system, but the benefits were increased

- The fertilization rate of 22-58-4 kg ha^{-1} used by the grower produced the smallest benefit, 1.21

Based on these conclusions, the recommendations are:

- Repeat the same experiments during two additional cycles
- Use variety Revolucion 79 with 32-48-3 kg ha^{-1} of $N-P_2O_5-K_2O$ in commercial plantings

Table 8 presents the types of field experiments, the objectives, their location and the principal results and conclusions obtained.

WET-DRY TROPICS PROTOTYPE

The Panama, the Prototype Team began its second year of activities during 1984. Their efforts were concentrated in research

Table 8. Inventory of field trials carried out by the Prototype Team of Estelí, Nicaragua, 1984.

Cropping systems, components and date of planting	Location	Results or Progress
HARVESTED TRIALS		
1. Maize + Photoperiod Sensitive Sorghum		
1.1 "Central" trial (June 1984)	4 farms in Trinidad and San Nicolas	Highest yields obtained with maize variety M3B and photoperiod sensitive sorghum variety Sapo with 58-51-4 kg ha^{-1} $N-P_2O_5-K_2O$
2. Sorghum varieties in association and in relay with maize (June 1984)	3 farms in La Trinidad	Highest yields obtained under maize variety M3B, fertilization of 45-39-13 kg ha^{-1} $N-P_2O_5-K_2O$ and improved non photoperiod sensitive sorghum
3. Successive bean monoculture (June 1984)		
3.1 "Central" trial	3 farms in La Trinidad, 1 in San Nicolas	Highest yields were obtained with variety Revolucion 79 under a 33-48-3 kg ha^{-1} $N-P_2O_5K_2O$ fertilization rate, with no fungicide
3.2 Residual effect of fertilization	3 farms in La Trinidad	Highest yields obtained using the 33-48-3 fertilizer formula
4. Maize + potatoes		
4.1 Fertilization	1 farm in Naranjo	Highest maize yields were obtained with 45-39-13 kg ha^{-1} $N-P_2O_5-K_2O$. Highest potato yields obtained with 200-243-17 kg ha^{-1} P_2O_5- K_2O in three applications

Table 8 (continued)

Cropping systems, components and date of planting	Location	Results or Progress
TRIALS UNDER WAY		
5. Sisal		
5.1 Time of cutting	1 farm in La Trinidad	Trial is under way

on technology development to improve the main cropping systems of the region. The research included the design phase, field trials, analysis of the results obtained, and the preparation of manuscripts.

The teaching and technical cooperation activities have included technical meetings with IDIAP personnel, field days, and supervision of undergraduate thesis of two students from the University of Panama.

The activities of 1984 included field trials which will strengthen the results obtained during the first year of work. Some experiments were conducted for the first time during 1984. Results, therefore, were not reliable enough to allow the Prototype to begin a validation phase. However, after completing the analysis of the 1984 field trials, including those for the dry season 1984-85, a few technical recommendations will be developed for growers and for technicians in the area.

Table 9 presents the types of field experiments, their objectives and location. Table 10 presents an inventory of outreach activities.

RESEARCH

The basic information in the characterization of the area has been strengthened. However, a final review of the preliminary characterization document elaborated during 1983 is still pending.

As far as field research is concerned, work was continued in the same area selected during the characterization phase, and with the same systems of production. It included work on the following systems:

Fresh or Dry Maize - Pasture and/or Fallow - Industrial Tomato

The components studied in maize were cultivar and fertilization, with the aim of obtaining economically sound technical

TABLE 9. Inventory of field trials carried out by the Prototype Team of Los Santos, Panama, 1984

Cropping system, components and date of planting	Location	Results or Progress
Harvested Trials		
1. Fresh corn-pasture-industrial tomato		
1.1 Industrial tomato		
1.1.1 Fertilization		
a) Rates (November - December, 1983)	1 farm in Sabanagrande, 1 farm in La Espigadilla	
(November - December, 1984)	4 farms in Espigadilla Llano Abajo, Sabanagrade & Guerae, 1 at the experimental Station in Los Santos.	
b) Split applications (November - December, 1983)	3 farms in Sabanagrande	
1.2 Fresh Corn		
a) Residual fertilizer from split application trial on industrial tomato (May, 1984)	3 farms in Las Zatras	
b) Residual fertilizer from rate of application trial on industrial tomato (May, 1984)	1 farm in Sabanagrande, 1 in La Espigadilla	
c) -Fertilization x Variety (May, 1984)	1 farm in Llano Abajo	
-Fertilization x Variety (May, 1984)	1 farm in Llano Abajo, 1 in Tres Quebradas, 1 in La Espigadilla, 1 in El Espinol, 1 in La Jagua (Sabanagrande).	

TABLE 9. (Continued)

Cropping system, components and dates of planting	Location	Results or Progress
d) Tillage x Variety x Fertilization (May, 1984)	1 farm in Guarare Arriba 1 in Tres Quebradas, 1 in Sabanagrande.	
2. Rice - Onion		
2.1 Onion		
2.1.1 Fertilization		
a) Rates (January, 1984)	1 farm in Tres Quebradas	
(January, 1985)	1 farm in Tres Quebradas	
2.1.2 Weed Control (January, 1984)	1 farm in Guarare	
(January, 1985)	1 farm in Sabanagrande	
3. Field Corn - Pasture		
3.1 Field Corn		
3.1.1 Variety x Fertilization (September, 1984)	1 farm in Llano Abajo, 1 in Sabanagrande, 1 in Guarare Arriba 1 in Tres Quebradas	
3.1.2 Tillage (September, 1984)	3 farms in Sabanagrande	
4. Industrial Tomato		
Pasture - Rice		
4.1 Rice		
4.1.1 Fertilizer timing (July, 1984)	1 farm in Guarare Arriba, 1 in La Espigadilla and 1 in Llano abajo.	

TABLE 9. (Continued)

Cropping system, components and dates of planting	Location	Results or Progress
5. Rice - Pasture		
Rice		
5.1 Rice		
5.1.1 Variety (July, 1984)	1 farm in Las Cruces	
6. Cucumber - Rice		
6.1 Rice		
6.1.1 Irrigation (July, 1984)	2 farms in Sabanagrande	
7. Industrial Tomato - Onions		
7.1 Onion		
7.1.1 Residual fertility (March, 1985)	2 farms in Tres Quebradas	
8. Pasture - Onions		
8.1 Onions		
8.1.1 Weed Control (January, 1985)	1 farm in Sabanagrande	

TABLE 10. Inventory of outreach activities[1/] developed by the Prototype Team in Los Santos, Panama, during 1984

Type of activities and main purposes	Number of		Type of participants and institution represented	Location in Panama and date
	Event	Total participants		
Meeting with growers who colaborate with the project.	3	13	Growers, researchers and extensionists, IDIAP, MIDA	Sabanagrande, 2/2/84
Fieldtrip to work area with the Ambassador from Germany	1	5	Ambassador from Germany, researchers from IDIAP	Los Santos, 1/19/84
Technical meeting with research coordinator at national and regional level	1	13	Researchers from IDIAP	Los Santos, 3/28/84
Technical meeting with research coordinator and support group to discuss a new prototype team	2	13	Researchers from IDIAP and support group from CATIE	Santiago de Veraguas 4/6/84 and 5/28-31/84
Visit of the European Economic Community and IDIAP coordinator	1	15	Professionals from EEC, researchers from IDIAP and CATIE	Los Santos, 6/26-27/84
Onion and maize field day	1	15	Researchers and extensionists from CATIE, MIDA	Los Santos, 7/19/84
Technical meeting to discuss research on maize	1	9	Researchers from IDIAP	Los Santos, 7/25/84
Technical meeting to coordinate support from CATIE'/s resident in Panama	1	3	Researchers from CATIE	Los Santos, 9/25/84

TABLE 10. (Continued)

Type of activities and main purposes	Number of Event	Number of Total participants	Type of participants and institution represented	Location in Panama and date
Participation in an IDIAP field day on maize	1	15	Researchers from IDIAP, growers	Las Tablas, 9/26/84
Technical meeting with CATIE's resident in Panama to discuss research results in industrial tomato	1	3	Researchers from CATIE and IDIAP	David, Panama 10/16/85
Field trip to maize, sorghum and onion experiments with IDIAP personnel	1	8	Researchers from IDIAP	Los Santos and Las Tablas, 11/7-8/84
field trip with GTZ personnel	1	11	Researchers from GTZ, IDIAP MIDA and CATIE	Los Santos, 12/7/84
Field trip with members of the seed board to visit onion experiments planted during the winter	1	5	Researchers from IDIAP, CATIE, National Seed Board	Los Santos, 12/11/84
Technical meeting and field trip to weed management experiments.	1	5	Researchers from IDIAP-CATIE	Los Santos 12/11-12/84

recommendations. Other studies in maize included land preparation methods.

Other studies in this system included the residual effect of fertilizer applied to tomato or maize.

In the same system of production, or in the monoculture of processing tomato, studies were made on rates of fertilization.

Onion - Industrial Tomato

Fertilization of processing tomato is being controlled during the dry season of 1984-85 at three sites in order to study its residual effects on onions planted during the rainy season.

Trials were conducted to study the potential of onion cultivars during the rainy season of 1984. The best variety for the trial (Granex 429) will be used in those conducted during 1985 to study the technical and economical profitability of onion vs. fresh maize, followed in both cases by industrial tomato. The government is promoting the planting of onions during the rainy season. Onion production in this season, when the soils and environmental conditions allow it, may be an excellent alternative for growers who follow tomato with fresh corn, for which there is an uncertain market.

Rice - Onion

Onions have been studied during the dry season, which is the principal growing season for the crop in this area.

Herbicide and fertilizer trials have been carried out in fields which are later planted with rice, maize, or left fallow.

Trials were conducted to study the suplementary irrigation, nitrogen fertilization and evaluation of native cultivars of rice.

Dry Maize - Pasture and/or Fallow

Field trials were conducted to evaluate cultivars and fertilization. A grower's demonstration trial on tillage systems for dry maize was conducted during the second growth cycle.

TRAINING AND SUPPORT RECEIVED BY PROTOTYPE TEAMS

One member of the Panama and one of the Costa Rica Prototype Team attended a seminar on the use of computers for statistical analysis (SAS Program) held at Turrialba during January 26-29. A second member of the Panama Prototype participated in the Systems of Crop Production course offered at CATIE from August 6 through October 26, 1984. The third member of the Panama Prototype attented the annual meeting of the American Phytopathological Society -Caribbean Division- at San Jose from October 21 to 26, 1985.

The members of the Nicaragua Prototype Team attended the Seminar on Cropping Systems held at Esteli, Nicaragua in April, 1984.

S U P P O R T   R E S E A R C H

Support research was carried out in six areas in 1984: Soil Management, Crop Physiology, Genotype Evaluation, Weed Management, Cropping Systems, and Socioeconomic Research.

SOIL MANAGEMENT

The soil management component offers support in the areas of nutrient cycling, (in the humid tropical zone), adaptation to flooded soils in the humid tropical zone, liming and fertility problems in both the humid tropical zone and semiarid tropical zone, and soil and water conservation in the semiarid zone. These areas were identified in the original project proposal and activity has been maintained in each of them continuously since 1982.

Nutrient cycling

Since its inception, support in nutrient cycling has been concerned with the use of woody leguminous species to provide nitrogen and prevent declines of yield over time in annual food crops of the tropical zone. A long term experiment set up in 1982 with maize, beans and cassava was described in the 1983 report. The 5th, 6th and 7th harvest of this experiment were completed in 1984. Crop yields for the first seven harvests are presented in Table 11.

It can be seen that in the third maize harvest, decreases in maize yield observed in the control plots did not occur when a mulch of *Erythrina poeppigiana* was applied or where the maize was associated with the trees in alley farming systems. Not only were yields maintained at their original levels in these treatments, but there was also no response to fertilization with mineral N. With beans, significantly higher yields than those obtained in the control plots were obtained with the two Erythrina treatments as well as in the alley farming system with *Gliricidia sepium*. Unlike maize, however, beans continued to respond to mineral nitrogen fertilization even when fertilized with leguminous tree prunings. Cassava yields for the second year declined in all treatments as compared to the first year. Only treatments where large amounts of low nitrogen containing residues were applied (dairy manure or a mulch of *Gmelina arborea*) did cassava yields increase over the control. Cassava would appear to adapt itself poorly to the alley farming system.

At the same time as the maize was harvested for dry matter determination, associated cassava plants were also harvested for dry matter determination. Nitrogen content of this harvest, the nitrogen

Table 11. Crop yields in alley cropping experiments.

	Mineral N	MAIZE 1ºyr	MAIZE 2ºyr	MAIZE 3ºyr	BEANS 1ºyr	BEANS 2ºyr	CASSAVA 1ºyr	CASSAVA 2ºyr
		kg ha^{-1}						
Control	0	2379	2268	1306	662	716	12912	7651
	+	2469	2915	1780	868	1155	14173	8838
Erythrina mulch	0	2613	3318	2782	1310	1295	13397	6734
	+	2855	2782	2608	1063	1553	15191	9496
Manure	0	2325	2504	2155	617	887	13346	11152
	+	2389	2824	2280	911	904	16818	10627
Gmelina mulch	0	193	2454	2147	1230	823	8789	10626
	+	268	2796	2207	1484	1094	7378	11528
Vigna	0	1651	2085	1259	530	686	14105	7786
	+	1871	2860	2164	680	972	15905	9049
Erythrina Alley Crop	0	1588	2088	2621	304	1330	12707	4778
	+	1483	2524	2502	549	1628	12502	6111
Gliricidia Alley Crop	0	1427	1681	1449	321	1095	14820	3261
	+	1745	1460	1385	429	1222	16548	3367
L.S.D. for comparison different subplots in different main plots $P \leq 0.05$		640	792	974	321	241	4776	3665

removed in the years previous crops, the nitrogen contained in the tree prunings 30 months after planting, together with total amounts of N applied are presented in Table 12.

Judging from the N content recovered in the crop in the control treatment, the soil supplied 225 kg/ha of nitrogen in the first 30 months of the experiment. In the alley cropping treatments, as much as 385 kg ha^{-1} of nitrogen was recovered, indicating fixation of 60 kg/ha/yr^{-1}. Recovery of applied nitrogen was low, being only 17% of the mineral N applied to the control treatment. Only 12% of the nitrogen applied to the crops as Erythrina prunings was recovered. It would seem that although the leguminous trees are able to supply enough nitrogen to maintain yields of the crops, much of the nitrogen produced in the system is not being utilized by the crops, but is being lost by leaching, volatilization, immobilization or other processes.

An extension of this work to the farm situation was begun in October 1984 in the San Carlos area, where the humid tropical zone prototype team operates. Two alley farming experiments were set up, using a maize-bean rotation and Gliricidia sepium as woody legume.

Flooded Soils

Some refinement of the work presented in the 1983 report was attempted in 1984. Reconstruction of the dikes and canals in the area used for experimental work was carried out to permit more control of flooding regimes in the field. The results of the 1984 field study are included in the Genotype section since eight different soybean varieties were tested with 4 different flooding regimes (see Table 21). While some varieties produced more than 50% of the yields obtained at field capacity when flooded continuously, yields of all but one variety (Baru) declined by more than 50% with alternate flooding. In any case, yields were lower than in 1983 in all treatments. Possibly, phosphorus should have been applied to the trial although soil test levels of this element were adequate. A

Table 12. N recovery in harvested portion of crops and trees, 0-30 months.

Treatment		kg ha^{-1} Total N applied 0-30 months	1st. year crop harvest	2nd. year crop harvest	3rd. year maize + cassava	Tree prunings at 30 months	Total N recovered
Control	0	0	90.9	70.0	64.2		225.1
	+	400	87.3	105.0	99.9		292.2
Erythrina	0	726	119.8	100.1	96.8		316.7
Mulch	+	1126	120.4	134.8	118.4		373.6
Dairy	0	278	87.6	88.1	84.4		260.1
Manure	+	678	107.3	107.4	118.1		332.8
Mucuna -	0	368	91.0	93.5	77.4		261.9
Gmelina Mulch	+	768	85.1	96.2	105.5		296.8
Vigna	0	0	84.8	69.2	68.6		222.6
Intercrop	+	400	90.1	103.8	89.0		282.9
Erythrina	0	0	78.9	83.4	71.7	102.3	336.3
Alley Crop	+	400	92.6	108.8	116.2	68.5	386.4
Gliricidia	0	0	90.7	83.3	65.0	145.9	384.9
Crop	+	400	98.1	105.5	81.4	228.5	513.5
L.S.D. for diff. subplots diff. main plots, $P \leq 0.05$				32.9	27.3		77.2

greenhouse study with the same soil showed even more negative effects of permanent or alternate flooding. Manganese levels in the leaves seemed to be more affected by the flooding regime in greenhouse than in field conditions. Efforts to locate farmers with a flooding problem to try out soybean as an alternative to wet season maize were not successful due to reduced funding and termination of other CATIE programs in these areas during 1984.

Liming and Fertility

Work in this area consisted of four separate activities in 1984: 1) determination of liming and phosphorus requirements of bean in acid soils of the San Carlos area of Costa Rica, 2) determination of phosphorus, magnesium, potassium and zinc requirements of maize at the La Montaña experiment station (Typic Humitropept), 3) determination of response to phosphorus, potassium, sulfur and zinc in the maize-photoperiod sensitive sorghum system in northeastern Nicaragua on a range of soil types, 4) determination of response of photoperiod insensitive sorghum to nitrogen and phosphorus fertilization following maize in northeastern Nicaragua.

1. Liming and phosphorus requirements of beans in acid soils of San Carlos

This work was begun in response to problems encountered by the prototype team in the San Carlos area. As pointed out in the 1983 report, the soils on which the prototype team was working were characterized by low levels of exchangeable aluminium, even though pH values were often below 5.0. However, in 1984, the prototype team encountered soils with higher levels of exchangeable aluminium where yields of crops such as maize, cassava and Phaseolus beans were extremely low. Two farms were found where levels of aluminium saturation varied from 15 to 80%. Results of these trials are presented in Table 13. There was response to liming with all soils

TABLE 13. Bean yields and net return from liming, phosphorus, potassium, and nitrogen applications, and inoculation with selected Rhizobium strains at 2 sites in Pital district, San Carlos canton, Costa Rica.

Bean Yields: kg ha^{-1}	SITES					
	La Trinchera		La Fama 1*		La Fama II*	
% Al Sat.	22.5		18.7		64.0	
Mn Olsen ppm	102		147		101	
% O.M.	3.73		3.97		4.27	
Treatment	Unlimed	Limed**	Unlimed	Limed**	Unlimed	Limed**
0	231	546	687	1192	84	280
P	297	608	860	777	403	323
PK	185	651	696	1209	124	341
PKI	226	504	716	1034	388	304
PKNI	386	729	1050	1039	323	437
Significant F effects p = 0.05	Effect of P and N significant		Effect of P significant		Effect of P and N significant	

Net returns: ₡1000/ha^{-1}	SITES					
	La Trinchera		La Fama I		La Fama II	
	Unlimed	Limed**	Unlimed	Limed **	Unlimed	Limed**
0	8.3	17.0	24.6	40.2	3.02	7.4
P	8.7	17.3	29.1	23.5	12.6	7.1
PK	3.4	17.6	21.8	37.6	1.2	6.4
PKI	4.8	12.2	22.4	31.3	10.6	5.0
PKNI	18.4	19.0	33.6	30.2	7.1	8.5

*Because of the difference in aluminum levels, the four replicates at this sites were split into 2 groups.
P = 50 kg ha^{-1} P_2O_5 as triple superphosphate
K = 60 kg ha^{-1} K_2as KCl
N = 30 kg ha^{-1} N as NH_4NO_3
I = Inoculated with selected Rhizobium strains.
** Locally available agricultural limestone applied at 2 t/ha

but bean yields responded more to liming in soils with less than 35% aluminium saturation. In soils with higher levels of aluminium saturation, yields remained low (below 500 kg ha^{-1}) even with the application of 4 t ha^{-1} of calcium carbonate. Although there was a response to phosphorus at both sites, economic analysis showed a much greater return from liming than from application of triple superphosphate. Despite inoculation with a selected rhizobium strain, a response to nitrogen fertilization was often significant, but the yield increase was not always sufficient to justify the practice economically. At one of the sites, incorporation of 1 t ha^{-1} of triple superphosphate was tried to saturate the soil P retention capacity and form insoluble aluminium phosphates. This treatment increased nodulation significantly but produced smaller yield increases than applying 2 t ha^{-1} of limestone, which is a much less costly practice. Soil manganese levels whether determined by the Olsen extraction, as water-soluble manganese, or as exchangeable manganese were high. Bean tissue levels were as high as 800 ppm manganese, and were not always reduced by liming but were significantly increased by phosphorus application. Bean yields were found to be more negatively correlated with soil levels of aluminium saturation than with levels of manganese, however.

In connection with this work, some farms in the area were sampled to determine the extent of the occurrence of high aluminium levels. Of the seven farms sampled, about 30% of the area had aluminium saturation levels of over 30%.

As a result of this work, the soil microbiologist of the University of Costa Rica, who had been hired as a consultant to the project, did greenhouse studies on the La Trinchera soil. He used 8 selected rhizobium strains at two lime levels, with and without additions of phosphorus and molybdenum. Nitrogen levels of the bean plants differed significantly with rhizobium strains. Highest nitrogen recovery was obtained with the highest lime level (10 t ha^{-1}) without additional phosphorus and molybdenum.

2. Phosphorus, Potassium, Magnesium and Zinc requirements of Maize in la Montaña

Despite many years of research at the Montaña experiments station, there were certain doubts about the optimal fertilizer levels. The soil is classified as a Typic Humitropept, fine, halloystic, isothermic, and is fairly representative of considerable areas in the Atlantic zone. The soils had 5.5% organic matter, 0.29% N, and 14.8 ug/ml of P by the Olsen extraction. Exchangeable cations were 0.17 cmol (p^+) L-1 K^+, 1.67 cmol (p^+) L-1 Ca^{+2} and 0.55 cmol (p^+) L-1 Mg^{+2}. Exchangeable acidity was 1.3 cmol (p^+) L-1 giving an aluminium saturation of approximately 35.2%, rather high for this soil. Copper, zinc, manganese and iron, determined by the Olsen extraction were 19.6, 4.7, 14.5 and 300 ppm, respectively. A split plot experiment was planted, using magnesium and zinc levels as main plots and phosphorus and potassium levels as subplots. Magnesium levels were 0 and 70 kg ha^{-1} of Mg; zinc levels were 0 and 10 kg ha^{-1} of Zn, P_2O_5 0, 125 and 150 kg ha^{-1}; K_2O levels were 0,75 and 150 kg ha^{-1}. Results are given in Table 14. There was a marked response to P_2O_5, highest yields being obtained with 250 kg ha^{-1} of P_2O_5 and 75 kg ha^{-1} of K_2O. There was a greater reponse to potassium when phosphorus was not applied. The response to such high levels of phosphorus is greater than expected and might even be economic despite high costs of phosphorus fertilization. The potassium response would be expected in a soil with the low levels of exchangeable potassium determined and especially with the unfavorable Mg^{++}/K^+ ratio. Response to magnesium was not significant and might be due to the sulfur contained in the fertilizer since neither the levels of Mg nor the Ca:Mg or K:Mg ratios would indicate the likelihood of a Mg response.

3. Response of Maize - Photoperiodic Sorghum System to Phosphorus, Sulfur and Zinc

Fertilizer response of the maize-photosensitive sorghum cropping system was studied in both 1983 and 1984. Every effort was

TABLE 14. Yield of maize in response to phosphorus, potassium, magnesium, and zinc on a Typic Humitropept, La Montaña Experiment Station, Turrialba, 1984.

Main Treatment Effects		Maize Yields
Magnesium	Zinc	
kg ha^{-1}		kg ha^{-1}
0	0	4120 ab
75	0	4857 a
75	10	4593 ab
0	10	3513 b

Subtreatment effects		Maize Yields
P_2O_5	K_2O	kg ha^{-1}
0	0	2765 e
0	75	3184 e
0	150	3500 de
125	0	4592 bc
125	75	4943 abc
125	150	4214 ce
250	0	4388 bcd
250	75	5642 a
250	150	5213 ab

Values followed by same letter do not differ significantly by Duncans Multiple Range Test to the level of P = 0.05.

made to locate experiments on the different soil types found in the area: Entisols in Pueblo Nuevo, Vertisols in Esteli, and Mollisols in La Trinidad. Response to phosphorus was observed in Pueblo Nuevo for both crops in both 1983 and 1984. Response to phosphorus was not observed in maize in Esteli in 1983 but was observed in 1984 when overall yields were lower. Response to both phosphorus and sulfur was observed in photoperiod sensitive sorghum in Esteli in both 1983 and 1984. In La Trinidad, maize responded only to phosphorus only in 1984 while the photosensitive sorghum responded only to phosphorus in 1983 and to both phosphorus and sulfur in 1984. One would conclude that the principal limiting factor in these soils is phosphorus despite the fact that levels of this element by the Olsen (bicarbonate) delimitations may be as high as 20 ppm. Response to sulfur does not appear to be limited to soils of volcanic origin (Entisols of Pueblo Nuevo) but has only been observed in photoperiod sensitive sorghum and never in maize.

4. Response of photoperiod insensitive sorghum to nitrogen and phosphorus following maize in Nicaragua

Work in this area was begun in 1982 with an experiment which showed a phosphorus response in photoperiod insensitive sorghum planted following maize in the Esteli area. Due to its higher grain production, it was thought that the responses to nitrogen would be greater in photoperiod sensitive than non-sensitive sorghum. Many of the soils in northeastern Nicaragua are low phosphorus fixing Mollisols, Vertisols, and Alfisols so it was thought that phosphorus applied to maize would be sufficient for a subsequent sorghum crop. In any case, two N x P factorial experiments were set up in 1983, one on a Vertic Haplustoll at the Esteli experiment station and the other on a Typic Haplustalf at an agricultural cooperative in Sabana Larga. Rainfall was quite low at the Esteli site with only 430 mm falling from June to December (the sorghum was planted in September) while 630 mm fell in the same period at Sabana Larga. Yields of sorghum averaged only 768 kg ha^{-1} at Esteli and there was no response to either phosphorus or nitrogen. In fact yields declined as fertilization increased, probably due to increased moisture stress. On the Hapludalf, there was a significant nitrogen response but only to 30 kg ha^{-1} of N. Yields of sorghum increased from 1700 to 2300 kg ha^{-1} with the application of 30 kg ha^{-1} of N but increasing the N to 90 kg ha^{-1} only increased yields of 2480 kg ha^{-1}. Response to phosphorus was insignificant and there was no N x P interaction.

In 1984, these experiments were modified to include locally available fertilizer materials. Again, there was no significant response to either N or P at the Esteli station although both rainfall and sorghum yields were higher in 1984 than in 1983. On the Haplustalf in Sabana Larga there were significant responses to both N and P. With the application of only 30 kg ha^{-1} of N (1 quintal of urea per manzana), sorghum yields increased from 632 to 1470 kg ha^{-1}. A further increase to 1982 kg ha^{-1} could be achieved with the application of 2 quintales of urea and 2 quintales of 10-30-10 per manzana but such a practice is probably not economically justified.

An economic analysis of the results at both sites showed the greatest marginal return with the application of only 30 kg ha^{-1} of urea.

Soil and Water Conservation

Work in this area began in 1982 with the establishment of two experiments in the Department of Esteli. In both experiments, eight different types of barriers were installed along the contours, spaced according to U.S. Soil Conservation Service Recommendations (see 1983 report). Crop yields in 1983 and 1984 for the different treatments are presented in Table 15. Although there were statistically significant differences among treatments only for a second bean planting in 1983, higher yields for first planting beans in 1983, maize in 1984, and photoperiod sensitive sorghum in 1984 were obtained with barriers than without.

Table 15. Production of different crops with eight different types of barriers, Sabana Larga, Nicaragua, 1983-1984.

Barrier	1983 Bean yields kg ha^{-1}		1984 Maize kg ha^{-1}	1984 Sorghum kg ha^{-1}
	1st planting	2nd planting		
Leucaena leucocephala	1265	984	1973	1391
Stone walls	1159	693	1884	1470
Pineapple (Ananas comosus)	1139	683	1782	1405
Gliricidia sepium	1166	582	1902	1267
Pennisetum spp.	1042	545	1846	1369
Cajanus cajan	1266	542	1755	1330
Henequen (Agave foureroides)	1373	534	2023	1286
No barrier	1373	434	1667	1050
L.S.D. (5%)	391	437	333	477
C.V.	27.6	39.9	10.3	20.3%

Barriers of Leucaena produced the highest yields in second planting bean in 1983; agave produced the highest yields of maize in 1984, while stone walls produced highest yields of sorghum in 1984. The latter treatment has the advantage of ease of maintenance and reduction of stoniness of the field since stones from the field are used to construct the walls. As the walls follow the contour of the slope, they are readily used by farmers who plant following the contour, increasing infiltration and reducing runoff.

CROP PHYSIOLOGY

Influence of light (PAR)* and root competition on crops associated with Maize

The effect of artificial shading, simulating shading by maize plants, was evaluated in relation to crops which may be associated with it. Various spatial and chronological arrangements were evaluated in relation to maize.

To isolate the effect of shading on maize, the effect of root competition between maize and the associated crop was evaluated.

The crops evaluated were rice, vigna, adzuki, sweet potato and soybean associated with maize var. Tuxpeño C-7 at 3 planting dates (at the same time, 90 and 110 days later).

The initial results for soybean (PK7394) show higher yields for the crop without shade (monoculture), in comparison to those with artificial shade or associated with maize (Figure 2). The differences have a similar tendency for the three dates of planting.

The yield differences of soybean under shading and under monoculture may be explained through the effect of shading, microenvironment and root competition. The differences in yield

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* PAR - Photosynthetically Active Radiation.

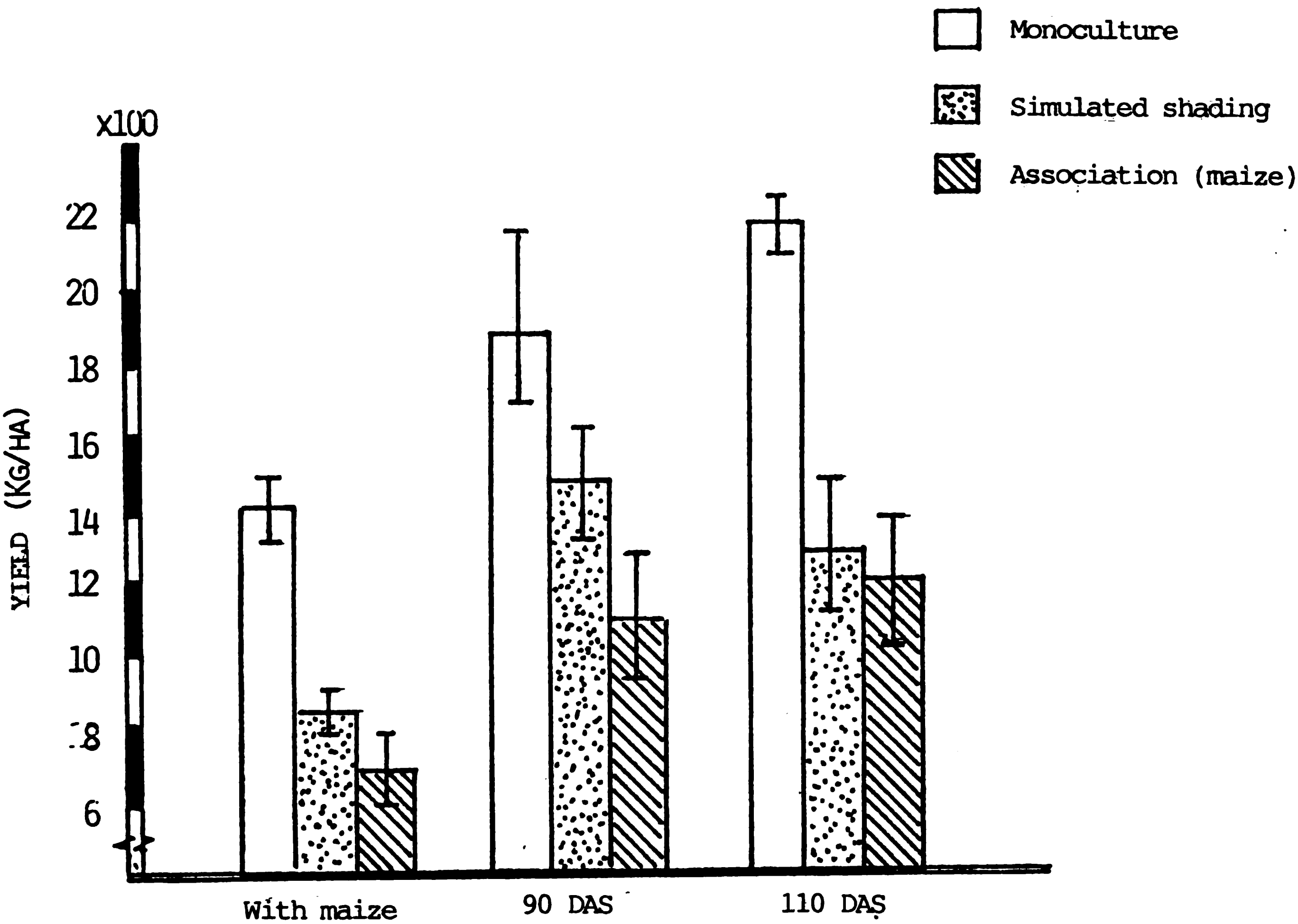

Figure 2. Yield of soybean (PK7394) for three sowing times, in monoculture, associated with maize and under artificial shade.

within the treatments with shading can be attributed to the effect of root competition and to the environment created by the association with maize.

Growth Analysis and Yield of Sweet Potato Clones

Thirty six of the 105 sweet potato clones from the Unit of Phytogenetic Resources of the PPD were evaluated. The selection of the 36 clones was made looking for the maximum variability in the collection. To this end, the following parameters were considered:

1. Outer color of the tuberous root
2. Inner color
3. Yield of foliage
4. Yield of tubers
5. Length of the vegetative cycle

Every 15 days samples were taken of the 36 clones. Harvest was done at 150 days after planting. The yield of tuberous roots shows great potential for the clones evaluated.

The clones 8523 and 8467 both of dark outer skin, showed highest total yields, 65.43 and 55.27 t ha^{-1}, respectively (Table 16). The highest values in the group of red outer color varied between 33.4 and 27.3 t ha^{-1} and in the group of highest skin color the highest yield was 28.9 t ha^{-1}. Yields of commercial tubers (Table 17) follow a similar tendency as that for total production. Clone 8523 was the highest yielder with 53.46 t of commercial tubers in relation to total production which was higher, on average in sweet potatoes with red outer color (94%), followed by dark outer color (69%) and light outer color sweet potatoes (57%).

Table 16. Total yields for sweet potato roots, by clone and outerskin color.

DARK		RED		LIGHT	
Clone No.	Yield (t ha^{-1})	Clone No.	Yield (t ha^{-1})	Clone No.	Yield (t ha^{-1})
8523	65.43a	7723	33.93b	8458	28.89bcd
8467	55.27a	8520	28.66bcd	8499	21.34cde
8464	30.50bc	8524	27.32bcd	C-15*	21.09bcdef
8511	29.49bcd	8517	18.50bcdefg	8516	18.81bcdefg
8505	24.94bcd	1753	18.45bcdefg	8485	15.52bcdefg
8486	17.70bcdefg	8473	13.83bcdefg	8462	14.98bcdefg
8461	17.06bcdefg	8476	13.73bcdefg	8445	12.09cdefg
8483	15.82bcdefg	8503	9.72efg	8474	11.84cdefg
8488	9.04efg		--	8449	11.47cdefg
8479	3.72efg		--	8448	1.34efg
8471	2.46efg		--	7127	0.61fg
8482	1.90efg			6079	0.51g
$\bar{X}$	22.6	$\bar{X}/8$	20.4	$\bar{X}$	13.21
		$\bar{X}/12$	13.63		

* Check

Table 17. Tuber yields for commercial sweet potatoes by clone and color.

DARK		RED		LIGHT	
Clone No.	Yield (t ha^{-1})	Clone No.	Yield (t ha^{-1})	Clone No.	Yield (t ha^{-1})
8523	53.46a	7723	28.16bc	8458	20.44cdefg
8467	34.41b	8520	26.98bc	8516	10.47efghi
8511	24.42cde	8524	26.35bcd	8449	8.67fghi
8564	18.32cdefgh	11753	21.23bcdef	8462	6.64ghi
8505	17.34cdefgh	8517	17.05cdefgh	8474	5.66hi
8461	12.40defghi	8473	12.65defghi	C-15*	4.95hi
8483	9.29fghi	8476	12.47defghi	8485	4.46hi
8486	8.93fghi	8503	8.66fghi	8499	4.23hi
8488	2.46i			8445	2.16i
8479	2.09i				
8482	0.98i				
8471	0.67i				
$\bar{X}$	15.50	$\bar{X}$	19.18	$\bar{X}$	7.52
		$\bar{X}/12$	12.78	$\bar{X}/12$	5.64

* Check

Clone 8523 had the highest yield of total and commercial tubers. The percentage of commercial tubers was 82% in comparison to the control variety (C-15) which reached 23%.

The yield of foliage at the time of harvest was 50 t ha^{-1} in clone 7127 (Table 18). The general mean varies between 25 and 33 t h^{-1} a for light and dark outer colored clones, respectively, while the control variety C-15 yielded 19 tons/ha.

Growth analyses were made for the 36 varieties studied. In 10 of them (3 from each group and the check) the nutrient content (N, P, K, Ca, Mg, S) was determined at each sampling date by plant parts (tuberous root, stems and leaves).

Some of the growth analysis responses for clone 8523 (highest yield) and for clone C-15 (check) are presented in Figures 3 and 4.

The N content showed a different distribution in both clones. The N content in the leaves was higher than in the stems in clone 8523, while the tendency for clone C-15 was the reverse. The accumulation of N in the tuberous roots begins at 75 days from planting. The accumulation is much greater in clone 8523 than in C-15 (Figures 3 and 4).

The P content in the stem of clones C-15 is higher than that in the leaves, while the difference is not as marked in clone 8523. The accumulation of P in tuberous roots is intensified at 75 days from planting in clone 8523 (Figures 5 and 6).

The variations in the K content of both clones follow similar tendencies in the stems and leaves. As with the other nutrients, in clone 8523 the accumulation of K in the roots is intensified at 75 days after planting (Figures 7 and 8).

Table 18. Sweet potato foliage yields by clone and color.

DARK		LIGHT	
Clone No.	Yield (t ha^{-1})	Clone No.	Yield (t ha^{-1})
8511	46.8ab	7127	49.8a
8471	42.1abcd	6079	44.8abc
8482	38.4abcde	8448	39.5abcd
8505	37.2abcde	8445	35.0bcde
8467	35.0bcde	8474	30.5def
8461	34.1bcde	8449	29.8defg
8523	31.8cde	8485	19.3fghi
8486	31.3cdef	C-15*	18.9fghi
8483	28.4defg	8499	13.1hi
8488	28.3defg	8462	10.6i
8464	24.9efgh	8516	7.3i
8479	16.6ghi	8458	6.5i
$\bar{X}$	32.9	$\bar{X}$	25.4

* Check

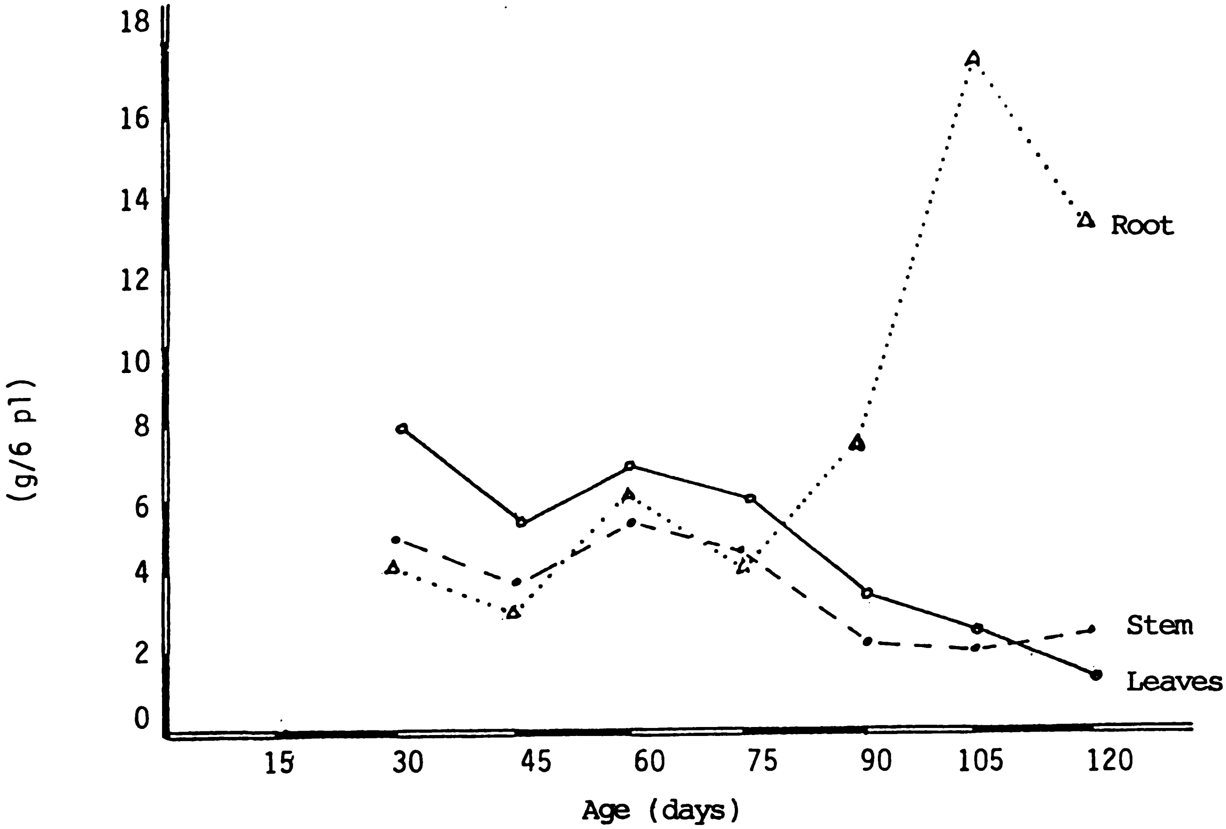

Figure 3. Variations in nitrogen content with age of crop for different parts of sweet potato clone 8523.

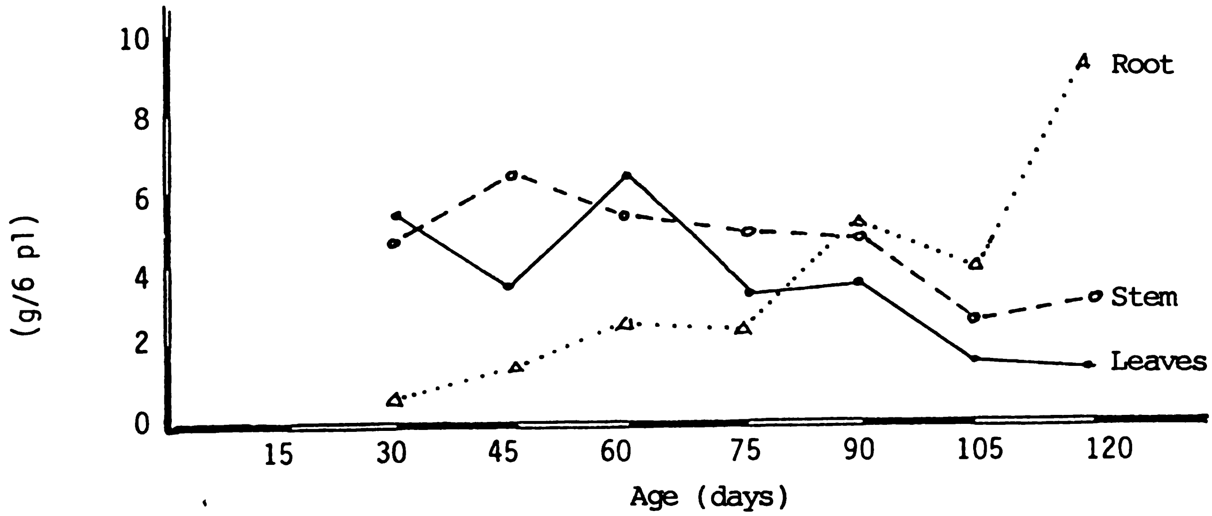

Figure 4. Variations in nitrogen content with age of crop for different parts of sweet potato clone C-15.

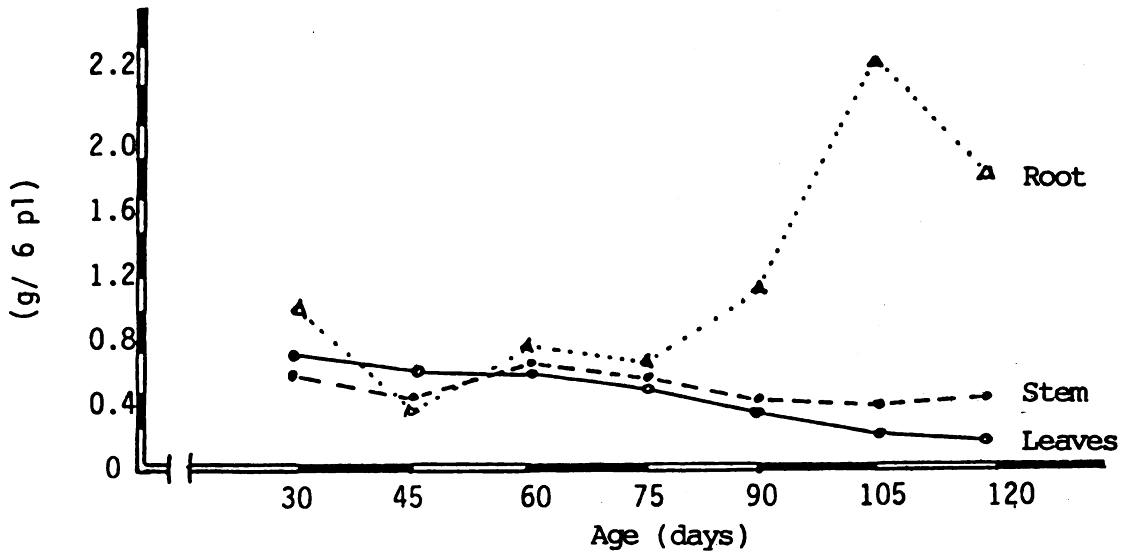

Figure 5. Variations in phosphorus content with age of crop for different parts of sweet potato clone 8523.

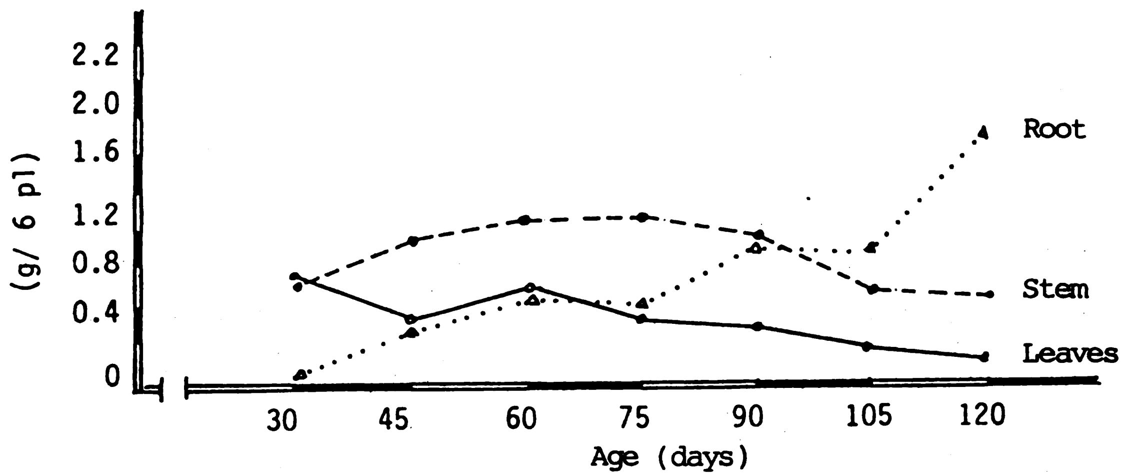

Figure 6. Variations in phosphorus content with age of crop for different parts of sweet potato clone C-15.

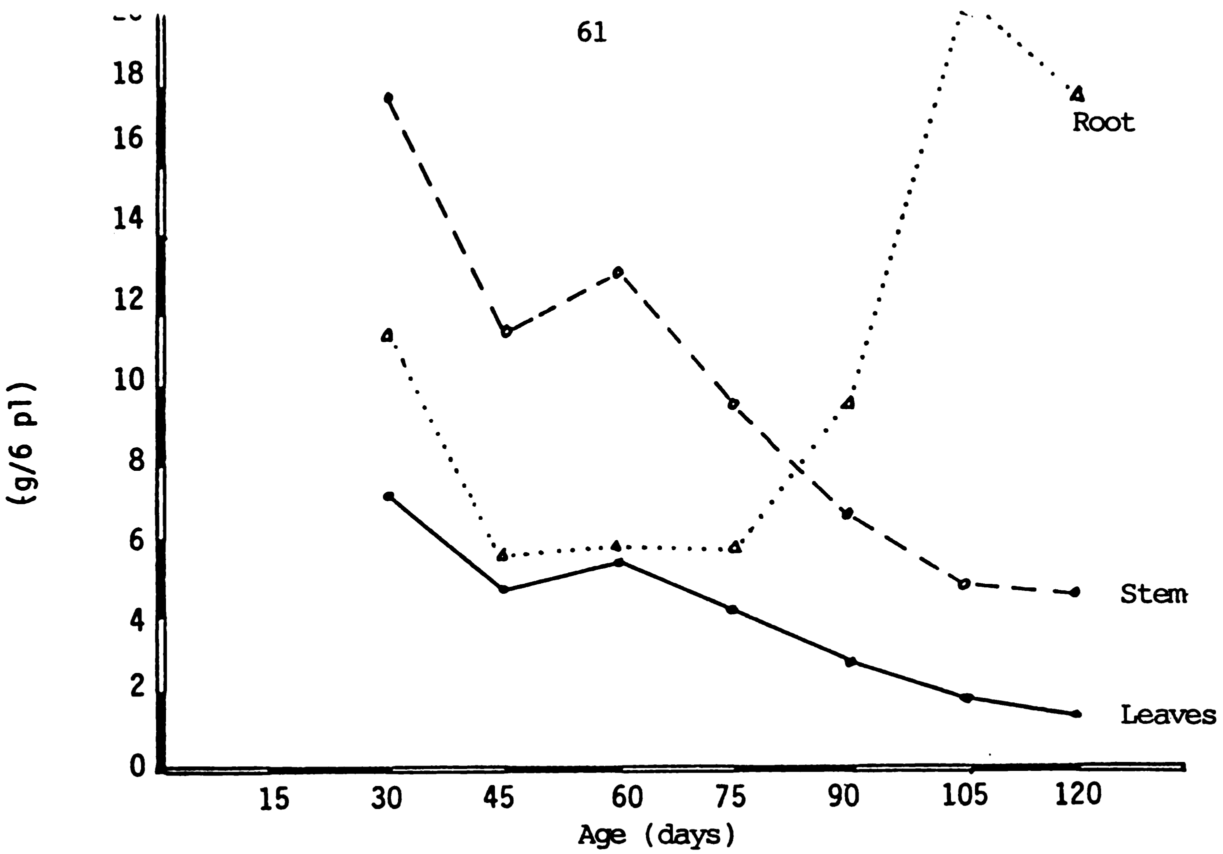

Figure 7. Variations in potassium content with age of crop for different parts of sweet potato clone 8523.

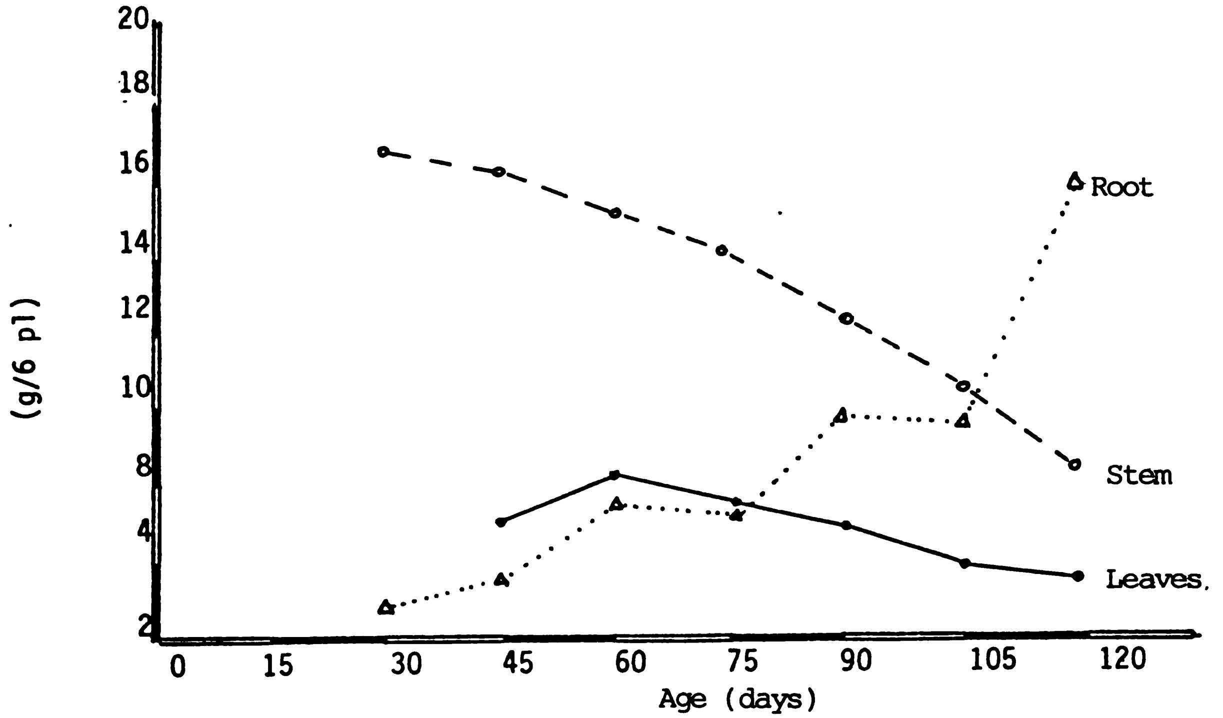

Figure 8. Variations in potassium content with age of crop for different parts of sweet potato clone C-15.

GENOTYPE EVALUATION

Genotype evaluation has been central to IFAD's support to CATIE for food crop production in the Central American Isthmus. Research in this area follows two principal lines: 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, specific environmental stresses, and polyculture cropping systems. The first activity is of an applied nature and results should be of immediate practical value both to teams working in technology development for small-scale farmers in Central America, and to national programs, 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 of it) for varieties tried specifically for certain environments, management levels or crop mixtures. In this area, the program interacts strongly with the other areas of support research of the IFAD project as well as with the international centers working with crops such as maize, sorghum, beans, and cassava which are the major food crops grown on Central American farms.

The program operates in two ecological zones of Central America and Panama, the lowland humid tropics and the semiarid tropics which together account for 62.7% of the arable land and where 50% of the total population is presently located. In addition, research was carried out at the Turrialba station on the maize-bean system, the principal food crop production system in mid-elevation areas of Central America.

LOWLAND HUMID TROPICS

Work in the lowland humid tropics has centered on cassava production systems, which include cassava monoculture, cassava-maize associations, and cassava-bean association. Although neither maize nor beans are normally considered well adapted to the lowland humid tropics, association with cassava can often make low yields of maize and beans due to unfavorable climate in the lowland humid tropics more economically viable. Favorable prices and a longer-than-usual dry season in certain years can make even low yielding monoculture beans an economically viable alternative in the San Carlos area where the prototype team operates. Interest in soybeans as an alternative for the lowland humid tropics, where it has shown itself more adapted to conditions of high humidity than common bean, especially on the part of Costa Rican students, IITA and INTSOY, stimulated trials with this species. Table 19 summarizes the experiments carried out by the Genotype Evaluation component in the Lowland Humid Tropics in Costa Rica.

Cassava Monoculture

In the 1983 report (TA 38-B), results of a trial of 38 varieties of cassava carried out at the La Esmeralda experimental farm of the University of Costa Rica in San Carlos were reported. This trial was repeated at the same site in 1984 using the 13 most promising varieties of the 1983 trial. In addition to the characteristics screened in the 1983 trial (yield, foliage density, root flavor and quality, resistence to scab (*Elisinoe brasiliensis*), Cercospora leaf spot, and thrips), the present trial will be harvested on three different dates to see the effect of harvest dates on root yield and quality, with a view to utilization in the production of starch and concentrates. It is hoped to select three varieties for use in both monoculture and associations in the San Carlos area in 1985. Material with similar agronomic characteristics was received from CIAT in 1984. It is presently being multiplied in the CATIE Tissue Culture Unit for use in 1986 trials, in both San Carlos and other humid tropical areas. A more rapid means of cassava multiplication using 1 - 3 nodes of 3 - 5 month old material, was studied in 1984 at CATIE, under the supervision of the Genotype Specialist, by an Austrian student of the

TABLE 19. List of Experiments carried out by the Genotype Evaluation Component in the Lowland Humid Tropics in Costa Rica in 1983 - 1984.

Cropping system, type of experiment and date of planting	No. of experiments	Localities	Present status and principal results
1. Cassava Monoculture	2		
a. Evaluation of 11 varieties pre-selected for yield and other desirable root characters. (June, 1984)		Sta. Clara, San Carlos, (collaboration with ITCR).	To be harvested in June, 1985. Plan to select 1 - 2 varieties for national programs.
b. Studies of rapid vegatative propagation of cassava (June, 1983)		La Montaña, Turrialba (Study of Austrain student).	Being analyzed
2. Maize-Cassava System	3		
a. Performance of 13 maize varieties in monoculture and associated with cassava. (June, 1983).		a) Cuestillas, San Carlos (cooperation with MAG).	Significant variety x system interaction, implying need to select within the system. Varieties with good potential for both association and monoculture are Guaymas (1) 8022; Across 7728; and La Maquina 8027.
b. Promising maizé varieties in association with cassava at 3 fertility levels (July, 1984).		Pital, San Carlos	No significant differences in fertilizer levels. Fertility x variety interaction also not significant. Best varieties were Guaymas (1) 8022; Ferke (1) 8129
c. Cassava phenotypes in association with maize (June, 1983).		La Montaña, Turrialba	The best cassava phenotype for association with maize should have the following agronomic characteristics: 1) Intermediate plant height; 2) intermediate foliage density; 3) about 1-3m height to branching.

TABLE 19. (Continued)

Cropping system, type of experiment and date of planting	No. of experiments	Localities	Present status and principal results
3. Maize Monoculture	4		
a. Evaluation of 16 experimental maize varieties (August, 1983)		La Montaña, Turrialba	A group of six varieties was identified with better potential for the area: Ferke (1) 8128; Ferke (1) 8129; Across 7728 RE, Poza Rica 8136; Poza Rica 8121 and Across 8043.
b. Evaluation of 11 elite maize varieties (ELVT-18A) (May, 1983)		La Montaña, Turrialba	
c. Evaluation of 15 elite varieties (ELVT-18A) (June, 1984).		La Montaña, Turrialba	
d. Evaluation of eight varieties preselected under farmer's management and according to recommendations of Costa Rican Ministry of Agriculture (December, 1984).		Pital, San Carlos	Presently in field
4. Bean-Cassava System	4		
a. Performance of 10 preselected bean varieties in association with cassava (Dec., 1984).		Zona Fluca, San Carlos (farmer's field)	Presently in field
b. Multiplication and evaluation of 15 promising bean varieties. (October, 1984).		La Montaña, Turrialba	Seed was obtained for trials to be carried out in San Carlos. Best material BAC 109.
c. Evaluation of 10 preselected bean varieties in 2 sites and in two planting systems. (December, 1984).		Pital and San Carlos (farmer's field)	Presently being analyzed.

TABLE 19. (Continued)

Cropping system, type of experiment and date of planting	No. of experiment	Localities	Present status and principal results
5. Soybean	6		
a. Exploratory study of performance of 14 soybean varieties in poorly drained soil (May, 1983).		La Laguna, Turrialba	Acceptable yield of soybean could be produced on poorly drained soils. The most promising varieties under these conditions were Jupiter and PK 7394.
b. Evaluation of advanced genotypes with good seed quality and intermediate or late maturity. (3 experiments, June, 1984).		La Montaña, Turrialba	The best lines did not differ statistically from the local variety SIATSA 194-A but some of the material which performed equally well was superior with regards to other characteristics. Yields and nodulation were comparable to sites in the Pacific zone of Costa Rica.
c. Performance of 25 genotypes in four methods of conserving seed (Sept., 1984).		La Montaña, Turrialba	The evaluation made in the fourth month detected differences among genotypes and method of storage. Storage in hermetically sealed glass bottles gave results comparable to storage in a controlled environment chamber (15°C and 60% relative humidity).
d. Evaluation of 8 soybean varieties with 4 levels of soil water. (July, 1984).		La Laguna, Turrialba	All varieties performed better with soil at field capacity or saturation than with continuous or intermittent flooding. The Bauru variety however, showed only a 30% yield reduction with continuous or intermittent flooding.

Universität für Bodenkultur in Vienna, who received a scholarship from that institution. The results are presently being analyzed.

Maize - Cassava System

Studies made in this area in 1984 consisted of three trials on the association, carried out in both San Carlos and Turrialba, and three screenings of maize varieties, for eventual inclusion in the system, carried out in Turrialba.

The maize-cassava trials were a study of 13 maize varieties in monoculture and associated with cassava, carried out in association with the Costa Rican Ministry of Agriculture at their station in Cuestillas, San Carlos, a study of 10 promising maize varieties grown in association with cassava at different fertility levels on a farmer's field in Pital, San Carlos, and a study of the effect of association with maize on five cassava phenotypes at the Turrialba Station.

In the Cuestilla study, there was a significant effect on varieties with respect to yield, plant height, grain per ear, and unfilled, poorly covered, germinated, and rotted ears. There was a variety x system interaction for yield, unfilled ears, and germinated ears. Twelve of the thirteen varieties yielded more in monoculture than in association with cassava, though the reduced plant population and later planting date used in the associated treatments may have exaggerated the effect of system. There was less variation of maize yield in the associated treatments and there was better covering of ears by the husks than in monoculture, perhaps due to smaller ears in the associated treatments. In general, there were fewer differences among varieties in association with cassava than in monoculture but the highest yielding materials in monoculture (Guaymas 8022, Across 7728 and La Maquina 8022) also were the highest yielding in association, raising the question of at what point in the selection process should material be screened for adaptation to the maize-cassava association. Results of this trial were reported at the 30th Annual Meeting of the PCCMCA, Managua, Nicaragua, 1984.

Despite the fact that soils in the area used for the fertility study are generally considered to respond to fertilization more than other soils in the San Carlos area, there was no response of maize to fertilizer (32-22-11, 59-33-16.5, and 84-44-22 kg ha^{-1} of $N_1P_2O_5$ and K_2O, respectively). However, maize yields in this trial were low (364 - 1414 kg ha^{-1}) and it is possible that most of the applied fertilzer was taken up by the cassava. There were significant differences* among varieties, however, with Guaymas 8022, which was also superior in the trial at Cuestillas, being statistically superior to all other varieties in the trial, with the exception of Ferke 8129. Some of the local varieties yielded quite poorly in this trial, less than 500 kg ha^{-1}, with poor grain filling in more than 50% of the ears.

The study with five cassava varieties grown in monoculture and associated with maize, at the station in Turrialba was a repetition of the trial at the same site reported in the 1983 report (TA 38-B - pp. 73-80). Despite similarities in site and management, yields of both maize and cassava were much higher in the 1984 study.

There was more evidence of differences in competitive effects due to cassava phenotypes, especially with regard to maize yields, than in the 1982 study. Tall leafy cassava types (CMC-84) reduced maize yields more than short non-leafy types M-Col-22. Intermediate types (Valencia, Criollo Zamorano, CM342-180) produced moderate reductions in maize yields. Yields and agronomic characteristics are summarized in Table 20. Maize yield would appear to be most related to leaf area and rotted ears, while not related to bird damage, which in the 1982 study caused considerable losses especially in monoculture. All cassava cultivars showed reduced yield due to association with maize. One cultivar (Criollo Zamorano) showed relatively small yield reductions due to associations. Yield was positively correlated with

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* Duncan's Multiple Range Test at 5% level.

Table 20. Variables of cassava varieties sown in monocrop and in association with maize. Turrialba, 1984.

Variety	Height*	Leaf Area	No. plants harvested	Harvest index	Edible roots/ha No.	Edible roots/ha Weight t	Inedible roots/ha No.	Inedible roots/ha Weight t	Weight $\bar{X}$/commercial root, g	Total root t
Valencia	H	L	36.0^{a}	0.55^{ab}	40.222^{ab}	16.86^{b}	39.111^{b}	5.58^{b}	419	22.44
CMC-84	H	H	35.7^{a}	0.51^{b}	44.528^{ab}	19.92^{ab}	68.417^{a}	8.89^{a}	447	28.91
Criollo del Zamorano	I	H	35.5^{a}	0.58^{ab}	46.528^{an}	23.61^{a}	58.611^{a}	9.42^{a}	507	33.03
CMC 342-180	I	L	35.7^{a}	0.66^{a}	50.417^{a}	21.36^{ab}	61.167^{a}	8.81^{a}	424	30.17
M Col-22	L	L	35.8^{a}	0.64^{a}	32.444^{b}	10.88^{c}	43.111^{b}	5.63^{b}	336	16.51
Systems										
Monocrop			35.7^{a}	0.65^{a}	52.083^{a}	22.44^{a}	61.917^{a}	8.61^{a}	431	31.05
Association with maize Tico V-1 Improved			35.7^{a}	0.52^{b}	33.583^{b}	14.58^{b}	46.250^{a}	6.75^{a}	436	21.33

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

Means within the same column with the same letter do not differ significantly at the 5% level by Duncan's Multiple Range Test.

number of commercial roots per hectare, and was less affected by association with maize than were plant height and harvest index. These were less correlated with yield of commercial roots. Thus, certain cassava phenotypes, such as Criollo Zamorano produced more than 80% of monoculture yields while effecting a less than 50% reduction in maize yields. This cultivar would seem most adequate for the maize-cassava association if it is acceptable in terms of quality and if cassava prices do not become much lower than maize prices.

In addition to the work on the cassava-maize association, some tropical maizes received from CIMMYT were evaluated at the Turrialba station previous to trials in a lower elevation site. In one of the trials, the same varieties used in the fertilization trial in association with cassava were tested at Turrialba in monoculture.

Some of the most promising materials to emerge from these studies were Ferke (1) 8128, Ferke (1) 8129, Across 7728 RE, Poza Rica 8136, Poza Rica 8121 and Across 8043.

Cassava - Bean Systems

While of lesser importance than the cassava-maize system, favorable prices and weather, and the possibility of offsetting a low bean yield by a good cassava yield makes this system of considerable importance in the San Carlos area. Material for study in the cassava-bean system was tested and multiplied in Turrialba in 1984 and three trials were planted in the San Carlos area in December, 1984. Results of these trials are presently being analyzed.

Soybean

Because of their greater tolerance to humid conditions and high temperatures than common beans, soybeans were considered a promising alternative for the flat Atlantic coastal plain of Central America where there are no obstacles to mechanization. As a protein and oil source, the crop could replace a considerable amount of material that is presently imported. There is considerable interest in the crop on the part of government agencies. Contact has been established with INTSOY and IITA who have supplied genetic material for testing.

A total of eight experiments with soybeans have been carried out under the TA 38-C Grant. These include two greenhouse studies on the effect of flooding, five studies on soil subject to varying degrees of flooding using IITA and INTSOY supplied material, and a study of seed storage methods carried out at the Turrialba station. There has been considerable cooperation in this work with the soil management specialist of the support team since soils subject to flooding were identified as a priority area in the TA 38 Grant.

Two greenhouse studies served as undergraduate theses for students at the Atlantic Center of the University of Costa Rica. The theses should be presented during 1985. While both theses showed a reduction in soybean yield due to flooding, especially intermittent flooding, some varieties showed considerable resistance to some of the negative effects (high levels of soluble manganese and negative redox potential), associated with these conditions. A study of adaptation to water-logging similar to that described in the 1983 report (p. 34-40) was carried out in 1984, using eight soybean clones. Special provisions were made to be able to control conditions to provide four different water regimes: field capacity, saturation, continuous inundation, and intermittent inundation. It can be seen (Table 21) that, with the exception of the Bauru cultivar, much less tolerance to flooding was observed in 1984 than in 1983 despite expected changes in soil Eh and pH. It would seem, however, that Mn toxicity was less of a factor in the present study than in previous years as levels of exchangeable, water-soluble, or readily reducible Mn were not significantly affected by the different flooding treatments and leaf Mn levels were neither very high nor highly correlated with yields ($r = -0.29$).

The second field study was carried out in the same soil in 1983 but without control of water. Results of this trial were presented

TABLE 21. Yields of 8 soybean cultivars under 4 flooding regimes on a Typic Tropaquept, Turrialba, 1984.

Variety	Water Regime			
	Field Capacity	Saturation	Continuous Inundation	Intermiediate Inundation
Jupiter	2529	2762	996	646
SIATSA 194-A	2635	2276	1730	595
UFU-1-BP_2	2382	2233	1364	555
M-79	2323	2218	866	599
Ecuador 1	2205	2738	1066	559
Bossier	2126	2330	739	359
Baru	1611	1796	1239	1143
F675122	2102	2351	594	285
Eh 2 months after planting	75.47	102.66	-12.19	20.09
pH - 2 months after planting	4.99	5.14	5.45	5.83
Mean Mn content of soybean leaves (ppm)	225	238	256	293

at the 30th Annual Meeting of the PCCMCA in Managua*. To overcome expected problems of manganese toxicity, two of the four replicates of the trial were limed with 4 T/ha of agricultural limestone. Few significant differences were observed among varieties although yields varied from 2571 to 4982 kg ha^{-1}. Variability was high due to variation in the severity of flooding within the experiment. It was therefore decided to control flooding by the use of dikes which were constructed for the 1984 experiment reported previously. The highest yields (4982 and 4549 kg ha^{-1}, respectively) were obtained with the Jupiter and PK 7394 cultivars. Like most of the cultivars in this study, yields were higher in the unlimed plots. The poorest yielding varieties (Purple Stem Star, ICA-125; B1667) were the only ones to show a response to liming.

The third and fourth field studies utilized material supplied by IITA. These materials have been selected for their ability to produce well in the lowland humid tropics using strains of Rhizobium already present in the soil. One trial included late maturing varieties and the other varieties of intermediate maturity. Both trials were carried out at the CATIE station in Turrialba. In both cases, the varieties Jupiter and SIATSA 194-A were included as checks. Although none of the material significantly outyielded SIATSA 194-A, yields of over 3 T ha^{-1} were obtained with several of the cultivars (Papillon, TGX 297-1926, and TGX 536-100C, all intermediate maturity) which also presented favorable agronomic characteristics such as resistance to lodging, uniform maturity, and low shattering, all of which would be of importance in mechanical harvesting. Although acceptable levels of nodulation were obtained, both with and without artificial inoculation, nodulation was not correlated with yield.

The fifth field study was planted in October 1984, in the Guapiles area of the Atlantic zone of Costa Rica where flooding is

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* Smith, M., Herrera, F., and Kass, D. Evaluación de 14 variedades de soya bajo condiciones de exceso de agua en el suelo. XXX Reunión Anual del Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios. Managua, Nicaragua, 1984.

often a problem. Sixteen varieties are being evaluated with a view to their use as protein supplement for source feeding.

One of the problems associated with soybean production in the humid tropics is the rapid loss of germination in storage, resulting in higher production costs as difficulty in storing seed often makes seed importation necessary. Addressing itself to this problem IITA has identified some soybean lines (TGX-307-0470, TGX 573-104C and TGX 342-356D) which do not lose viability as quickly under humid tropical conditions. In the present study, it was hoped to identify lines whose seed could be stored for the longest period as well as to evaluate this characteristic in the lines with the best agronomic performance.

Four treatments, three of which should be easily adoptable by farmers with limited resources in the humid tropics, were tried on 19 soybean lines. The treatments were: 1) bunches of twenty plants hung at a two meter height in a well-ventilated barn, 2) seed storage in cloth bags at ambient temperature, 3) seed stored in hermetically sealed glass jars also at ambient temperature and 4) seed stored in cloth bags in a controlled environment chamber at 15° C and 60% relative humidity. Relative humidity in Turrialba, where this study was carried out during 1984, averages 85% in dry months and 88% in wet months. Tests for germination, vigor and other characteristics were made every two months.

The preliminary results (after 2 and 4 months of storage) indicated that seed loses viability most rapidly when bunches of 20 plants are hung in a barn, with significant differences among genotypes. SIATSA 194-A was most negatively affected by this treatment retaining only 3% viability after four months. The non-tolerant control, Bossier, showed 13% viability after 4 months of this treatment while the TGX-647D line still maintained 93% viability. The other lines tested (both of intermediate and late maturity) showed variation in viability under this storage method but only six of the nineteen varieties tested showed over 60% viability after four months. Storage in sealed glass jars seemed as effective as the controlled environment chamber as viability for all varieties averaged 95% after four months of both treatments.

Material stored in cloth bags without temperature and humidity control averaged 86% viability. Final results will be analyzed in the 1985 report.

SEMI-ARID TROPICS

Although it might not fit all definitions of the term semi-arid tropics, the pacific slope of Costa Rica from southeastern Guatemala to northeastern Nicaragua is generally considered to represent this ecological zone. IFAD supported research for this zone is centered in Esteli, Nicaragua, one of the driest areas in Central America, with an average annual rainfall of less than 700 mm, which, as in most semi-arid areas, may vary by as much as 30% from year to year. Genotype research is carried out in the townships of Jalapa, San Juan de Limay, Pueblo Nuevo, Palacagüina and Esteli (in the latter there are three sites: El Naranjo, El Triunfo and the Esteli Experimental Station of the Nicaraguan Ministry of Rural Development and Land Reform). Genotype selection is carried out in maize, beans, and sorghum -the three crops which are combined in the cropping systems which predominate in the area: maize-beans-photosensitive sorghum, maize-beans, maize-photosensitive sorghum, beans-beans monoculture, and maize monoculture followed by photoperiod insensitive sorghum monoculture. Additionally, work has been carried out with three promising alternative crops for the area: pearl millet (*Pennisetum americanum* (L.) Leeke); pigeon pea (*Cajanus cajan* L.) and cowpea (*Vigna unguiculata* (L.) Walp.).

IFAD supported genotype evaluation in Nicaragua has been highly integrated with the activities of the national program, which operates in the area.

Selections of sorghum, maize and beans have already been made for testing on farmer's fields. In September, 1984, an agreement was reached under which ten sorghum varieties selected by the genotype evaluation program would be tested by agronomists of the Land Reform Agency (MIDINRA). It is hoped that similar agreements can be reached in 1985 for the testing of maize and bean varieties.

In Table 22, the experiments carried out in 1984 and their principal results are summarized.

Maize

In the semi-arid tropical zone, maize is an important component of the cropping systems practiced by farmers with limited resources such as maize-photosensitive sorghum; maize-photoinsensitive sorghum, and maize-bean. The low and erratic precipitation of this region requires that the maize have drought tolerance and preferably a short growth duration to escape droughts. Stable yields from year to year are perhaps more important than high yields.

In the semi-arid ecological zone, there are commonly two plantings: one with the first rains of May and June and another with the second rainfall maximum in September.

Work with maize began with the second planting of 1982 with a test of 15 drought tolerant varieties from CIMMYT and PNIA in Honduras. This study involved eight sites which were supposed to have different amounts and times of drought stress (see 1983 report). Research has continued to the present, identifying varieties with stable and acceptable yields for further testing in both maize monoculture and the maize-millon (photoperiod sensitive sorghum) system. As the millon is only harvested in January, work on this system in 1984 will be analyzed during 1985.

In 1984, nine types of maize trials were carried out, some of which were planted at more than one site for a total of 14 trials. These included a determination of yield and yield stability of 30 local varieties of intermediate or late maturity (2 sites), an

TABLE 22. List of experiments carried out by the Genotype Evaluation Component in the Semi-Arid Tropic Ecological Zone of Nicaragua in 1983-1984 (38 experiments).

Cropping systems, type of experiment and date of planting	No. of experiment	Localities	Present status and principal results
1. Maize monoculture	11	El Triunfo, Esteli	The material Jalapa #2, 8 and 9
a. Evaluation of 30 maize varieties of intermediate or late maturity (June, 1984)		El Guapinol, Esteli	Esteli #2 and Pueblo Nuevo #9 and 11 gave the best results, with yields similar to the NB type commercial varieties. 10 of the best lines were selected for evaluation by MIDINRA in 1985.
b. Agronomic evaluation of seven white maize varieties, tolerant to drought (June, 1984)		El Guapinol, Esteli	Tuxpeño drought selection C4 yielded best. More trials are necessary.
		El Triunfo, Esteli	No material was clearly superior to the local improved check NB-4, but there were many similar materials with good characteristics.
Early and Intermediate Maturity Maizes		La Grecia, Limay	
c. Evaluation of 14 experimental early white maize varieties (EVT 14-B).			The best varieties were Ikenne (1) 8149, Guadajaika (1) 8149 and Ferke (1) 8223 with high yields and good stability.
d. Evaluation of 14 white and yellow early and intermediate maizes (18-B).			Across 8035, Rattray Arnold (1) 8149 and Across 8149 had highest yields.
e. Evaluation of 15 varieties of early yellow maizes (EVT 14-A).		El Triunfo, Esteli	High yields; 14 materials yielded more than 5 ha^{-1} but NB-4 was best. The early check NB-100, was much surpassed by introduced material.

TABLE 22. (Continued)

Cropping systems, type of experiment and date of planting	No. of experiment	Localities	Present status and principal results
Evaluation of late maturity maizes			
f. Evaluation of 15 elite varieties of late maturity white and yellow maize (ELVT 18-A)		El Triunfo, Esteli	Ilonga 8043 and Across 8024 performed best, outyielding the NB-4 check. They are acceptable with respect to other characteristics.
g. Evaluation of 18 late yellow varieties (EVT-B)		El Triunfo, Esteli	The best varieties were Piorra 8224 and Guarere 8224 but they were not statistically superior to NB-4.
h. Evaluation of 18 late white varieties (EVT 12-D1)		El Triunfo, Esteli	The highest yields of 1984. No material was statistically superior to NB-4. The outyielding materials were: Sta. Rosa 8243; Ikenne (1) 8243; Across 7622 RE: Catacamas 8243; and El Plantel (1) 8129.
2. Bean Monoculture	12		
Bush Types			
a. Agronomic evaluation of 16 bean varieties (IBYAN 83B) (September, 1983).		El Rodeo, Esteli	The highest yielding variety, BAT 1493 outyielded by 93% the local variety, Revolution 81, which yielded least in the trial. Early materials yielded best as they were able to utilize best the little moisture available. BAT 1493 was least affected by rust (*Uromyces phaseoli*).

TABLE 22. (Continued)

Cropping systems, type of experiment and date of planting	No. of experiments	Localities	Present status and principal results
b. Agronomic evaluation of 31 local varieties of common bean (June, 1984).		El Guapinol, Esteli	The most productive materials (2 t ha^{-1}) were Baya, Barreño Estelí, Tico Rama, Estelí, Chile Rojo, Revolution 82, and Rosado. Earliness and other characteristics were evaluated.
c. Evaluation of 20 improved varieties of common beans. (June, 1984).		El Guapinol, Esteli	Improved material was of later maturity than the local varieties, but still produced well. Outstanding were BAC 90-1 and BAT 1514 with over 2 t ha^{-1} for outyielding the commercial variety Rojo Seda.
d. Introduction of 82 lines of red beans (June, 1984)		El Guapinol, Esteli	12 lines were selected. Some will be evaluated in second planting (September, 1984)
e. Evaluation of stability and yield of 16 local varieties of common bean. (September, 1984)		El Guapinol, El Rosario, La Lamilla, Centro Experimental, Estelí	Highest yields were obtained at the Centro Experimental and the lowest at La Lamilla. Outstanding were Rojo Pardo, Chile Ligero, Rojo Seda, Rojo Masuli and Mono Esteli with yields averaging more than 1 t ha^{-1}. Revolution 79 showed little yield stability.
f. Agronomic evaluation of 14 varieties and improved lines of bean (September, 1984).		El Guapinol, El Rosario, La Lamilla, Centro Experimental, Estelí	Varieties differed in their performance at different sites. The most stable and productive were H772202-72 CMCM and BAT 1514. Rojo Nacional and Revolución 79A performed well in some sites but showed poor yield stability.

TABLE 22. (Continued)

Cropping systems, type of experiment and date of planting	No. of experiments	Localities	Present status and principal results
3. Maize-Bean	2		
a. Agronomic evaluation of 9 varieties of climbing beans in association with bush beans in association with maize (September, 1983)		El Rodeo El Motolin	Six climbing varieties in the modified traditional system (inclusion of one row of climbing beans) produced higher yield than the traditional system and the alternative proposed by IDRC The best climbing variety was V916.
4. Sorghum Monoculture	13		
a. Agronomic evaluation of white sorghum varieties suitable for tortillas. (June (A) and Sept., (B), 1983)		Esteli (A) El Rodeo (A) Sta. Adelaida (A) Esteli (B)	The highest yields were obtained in Esteli. Various introduced lines and varieties outyielded the hybrid W-823-A and the check varieties, Guatecau and Intasor. A group of 35 varieties were selected for evaluation.
b. Agronomic evaluation of 35 grain sorghum varieties. (September, 1983).		La Grecia, Limay	Nine lines were outstanding with yields of over 4.5 t ha^{-1}. These were evaluated in various sites in September, 1984.
c. Evaluation of agronomic performance and yield stability of 10 grain sorghum varieties. (September, 1984).		Las Culebras, Somoto Uniles, Somoto El Guapinol, Esteli La Lamilla, Esteli Casa Blanca, Esteli Gualila, Limay La Grecia, Limay Mateare, Limay	Some varieties performed differently in different sites. The following varieties were recommended on the basis of their yield stability, short stature and high yields: ISIAP DORADO and (S 108-3 X E 35-1)-5-1S (S3541) deri-34. Sepon 77 and M5009 perfomed well but their taller stature may lead to lodging. Uniles was the best site.

TABLE 22. (Continued)

Cropping systems, type of experiment and date of planting	No. of experiments	Localities	Present status and principal results
4. Cowpea Monoculture	4		
a. Evaluation of 32 varieties of cowpea (<u>Vigna</u> <u>unguiculata</u> (Walp)).		Las Cañas, Esteli Los Carbonales	There was considerable site x variety interaction. In general, no material outyielded the local cultivar, Perico VITA 4 and 1T3E18 showed good potential, but this line of research was discontinued in 1984.
5. Maize-Photosensitive Sorghum System		Various	This work will be reported in the 1985 report since harvest was not completed until January, 1985.

agronomic evaluation of seven varieties of drought-tolerant white maizes, and seven of the ELVT and EVT trials of CIMMYT, through which a total of 37 early and intermediate-maturity and 67 late maturing varieties were evaluated (a total of 11 trials at 4 sites). Results of these trials are summarized in Table 22.

1a. Evaluation of local maize varieties of intermediate and late maturity

Two experiments of this type were run following a collection of local maize varieties from Region I of Nicaragua, one in Guapinol (32 varieties) and another in El Triunfo (30 varieties).

In El Guapinol, the best local material was Jalapa #2, #8 and #9 and Pueblo Nuevo #9 and #11. The commercial varieties NB-3, 4, 5 and 100 also performed well. The variety Esteli #2 had the second highest yield but being very tall could lodge severely. In El Triunfo, yields were good (mean 3579 kg ha^{-1}) but not as high as in El Guapinol (mean 5658 kg ha^{-1}). The only material to outyield the commercial varieties NB-3, NB-4 and NB-100 were Esteli #2 and Pueblo Nuevo #1. Its good performance in both sites would indicate good yield stability for Esteli #2.

The good yields obtained in the trials would seem to indicate that maize production in the region could be increased with further improvement of local varieties. Further progress could involve the use of improved material from other sources. Ten varieties with the best performance in the two trials will be tested in Region I by MIDINRA with CATIE's supervision.

1b. Agronomic evaluation of drought tolerant white maizes

The genotypes used in this study come from the CIMMYT maize program; some of them were specifically selected for drought conditions (Tuxpeño drought selections C-0, C-2, C-4 and C-6); the others are varieties which have already been released but have shown good performance at sites with moderate drought stress. A randomized complete block design with seven treatments and four repetitions was used. Yields were quite good (4687 to 6193 kg ha^{-1}) comparable to those obtained under more favorable conditions. The highest yield was obtained with Tuxpeño Drought Selection C-4.

CIMMYT Trials

1c. Evaluation of early and intermediate maturity maizes (ELVT 14-B)

This experiment was carried out in two sites, El Triunfo, Esteli and La Grecia, Limay, the latter site being at a lower elevation and having a higher evapotranspiration demand as well as less rainfall during the growing season. Neverthelss, average yields were higher in La Grecia but there were no significant differences in yield among varieties. In a combined analysis for the two sites, Ikenne (1) 8149 Gandajika (1) and Ferke (1) had the highest yields. These varieties can be considered to show good stability, and, in spite of a significant site x variety interaction, were among the top five varieties in both sites.

The variety Pirsaback (1) 7930 RE was the least stable, being one of the highest yielders in La Grecia, Limay and the lowest in El Triunfo, Esteli.

1d. Agronomic evaluation of 14 early and intermediate maturing varieties of yellow and white maize (ELVT 18-B)

This trial was also carried out in two sites: in Region I, El Triunfo and El Guapinol. Twelve of the fourteen varieties tested in each site were the same. The local checks in el Triunfo were NB-4 and NB-100 while in Guapinol, they were "Olotillo" and Jutiapa 7930. A randomized complete block design with four repetitions was used in each site. An analysis of variance was made for each site separately and in combination.

The combined analysis detected highly significant differences among maize varieties, between sites, and for the site x variety interaction for the following variables: days to flowering, plant height, and weight of grain per ear. There were significant differences in yield among varieties but the site x variety interaction was not significant for yield, indicating that the sites were rather similar. The highest yielding varieties were Across 8035, Rattray Arnold (1) 8149 and Across (1) 8149 but they were not significantly superior to the local checks. In general, plants were taller, flowered earlier, and had a higher weight per grain per ear at El Guapinol, but yielded similarly in both sites (mean yields were 5134 kg ha^{-1} for El Triunfo and 5177 kg ha^{-1} in El Guapinol).

1e. Agronomic evaluation of 15 varieties of yellow maizes of intermediate and early maturity (ELVT 14-A)

This experiment was planted at only one site, El Triunfo, using a randomized complete block design with four repetitions. There were significant differences among varieties with respect to days to flowering, ear height, and grain weight per ear, but not with respect to grain yields per hectare, which were very high in this trial. Fourteen of the fifteen varieties averaged over 5000 kg ha^{-1} while mean yield for the trial was 5493 kg ha^{-1}. The highest yield was obtained with the local variety NB-4 while NB-100 was fourteenth in terms of yield, confirming the poor yield stability that this variety has shown in other trials.

The results of these trials with maizes of intermediate and early maturity show that there are materials such as Across 8035, Across 8149, Rattray Arnold (1), Ferke (1) 8235 and Ferke 8235, which yield as well as NB-4 but which have superior agronomic characteristics such as earlier maturity, and reduced height, which might lead to better performance under stress conditions. The variety NB-100, however, would appear to have a site-specific rather than general adaptability for the region as a whole.

Agronomic evaluation of late maizes

With late-maturing maizes, a total of five trials were carried out, two with white maizes (EVT 12D), one with yellow maizes (EVT-13) and two with 15 elite varieties having both white and yellow grains (EVT 18A). One of each of these trials was conducted at El Triunfo, Esteli, and one of EVT 12D and EVT 18A at Jalapa, Nicaragua but only the results of the El Triunfo trials have been analyzed and will be reported here. The only local materials available for inclusion in these trials were the commercial varieties NB-4 and NB-100.

In all of these trials, a randomized complete block design with four repetitions was used at each site.

1f. Agronomic evaluation of 15 elite varieties of late-maturing white and yellow maizes

At the El Triunfo site, the statistical analysis showed highly significant ($P \leq 0.05$) differences among varieties with respect to yield, days to flowering, plant and ear height, and grain weight per ear. All of the materials in this trial outyielded the two check varieties NB-4 and NB-100, which yielded 4806 and 4193 kg ha^{-1}, respectively, while ten of the materials averaged more than 5497 kg ha^{-1}, the mean for all materials in the trial. The best of the elite material were Ilonga 8043, Across 8024, both of which significantly outyielded the checks at the $p \leq 0.05$ level by Duncan's multiple range test, Guarare 8128, Los Baños 8027 and Santa Rosa 8073. All of the forementioned materials were slightly taller than the higher yielding check, NB-4 but were superior in terms of ears per plant and grain weight per ear. Significant correlations were obtained between yield and grain weight per ear ($r = 0.85^{**}$), yield and plant height

($r=0.53^{**}$) and yield and number of ears per plant ($r = 0.41^{**}$). The results of this trial indicate that the area in Esteli where late-maturing maizes are planted could benefit from the introduction of some of these elite materials. However, they should be first tested in a wider range of environments to see if their yield stability is comparable to that of NB-4.

1g. Agronomic evaluation of 18 late-maturing yellow maize varieties

The mean yield of this experiment in the El Triunfo site was high (5339 kg ha^{-1}). Ten varieties produced mean yields above 5500 kg ha^{-1} and were significantly superior to the NB100 but not to the NB-4 variety used as a local check. The best of the varieties were Piura 8224 and Guarare 8224 with yields of over 6000 kg ha^{-1}. These high yielding materials present considerable variability with respect to plant height, ear height, grain weight per ear, and could be used as a source of germplasm in a breeding program. The need for more germplasm is shown by the fact that there is presently only one variety, NB-4, which has shown good yield stability in the region.

1h. Agronomic evaluation of 18 late-maturing white maize variety (EVT 12-D1)

The average yield in this trial (6200 kg ha^{-1}) was the highest of all trials conducted in 1984. All of the varieties with the exception of Palmira (1) 8129 significantly outyielded the control NB-100 which yielded 4500 kg ha^{-1}, but not NB-4 which yielded 5695 kg ha^{-1}. All other varieties averaged more than 6 t ha^{-1} among these fifteen varieties. There were no statistically significant differences, but the superior performance of some of them should be noted such as Santa Rosa (1) 8243, Ikenne (1) 8243, Across 7622 RE, Catacamas 8243 and El Plantel (1) 8129.

General Summary of Maize Genotype Evaluation - Semiarid Tropics

Of the four lines of study implemented by the genotype evaluation component in Nicaragua (maizes resistant to drought, early, intermediate, and late maturing "Criollo" maizes), the most progress was made with the late maturing local varieties. Substantial progress was also made with drought-resistant maizes, which should be re-tested under more severe drought-stress conditions than the 1984 cropping season provided. Of the improved materials already available in the area (NB-4 and NB-100), NB-4 appears to perform better, showing excellent yield stability and high production with a mean yield of 5702 kg ha^{-1} over all 1984 trials. It is one of the best of the early and intermediate maturing lines. NB-100 always performed more poorly than NB-4: it would only seem adapted to specific locations.

Beans (*Phaseolus vulgaris* L.)

Genotype selection of beans for the semiarid tropics began in 1982 with introductions and evaluation of both bush and climbing bean germplasm. All testing was done in association or in relay with maize. A total of 21 varieties of climbing beans and 10 of bush beans were evaluated in 1982. The bush germplasm was reevaluated in 1983 and a new group of 16 varieties from CIAT was tested in the second planting period (see 1983 report). The climbing bean types were also evaluated further in association with maize.

In 1984, the work with bush beans, included not only new lines and improved varieties but also local varieties collected in the area of study. A total of 133 acquisitions (20 new lines in 3 sites; 31 local varieties in three sites, and 82 advanced lines in El Guapinol) were evaluated in the first planting period of 1984. Based on these results, the trials for the second planting were as follow:

1. The sixteen genotypes of local selection were tested in four sites

2. A trial consisting of nine improved varieties and five advanced lines were the same in two sites and different in the three other sites

Climbing Beans

In the second planting of 1982, cultivars of climbing beans from CIAT were introduced into Nicaragua. These were evaluated in the maize-bean relay cropping system (see 1983 report), using the local variety Rama as a check. There were no significant differences in yields among material and few of the cultivars performed better than the local check. In 1983, the best of these cultivars and new introductions were tested in three planting systems:

a. Traditional: three rows of bush beans between each maize row

b. Same as traditional but using a climbing variety in place of one of the rows of bush beans

c. Alternative proposed by the IDRC* project: two rows of beans between the maize rows

This experiment was set up in two sites in the township of Pueblo Nuevo: El Motolin and El Rodeo. The maize variety used was "Tuza Morada", which is tall and early. The bush bean variety was "Revolucion 81" recently released by the Nicaraguan national program.

A randomized complete block design was used with eleven treatments and three repetitions.

Considerable drought was experienced during the experiment at the El Motolin site. The modified traditional system was superior to the

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* The IDRC project was active in the Esteli area from 1977 to 1982.

traditional system for all bean cultivars. With the climbing bean variety V-7916, total bean yield was 1968 kg ha^{-1} as against 1363 kg ha^{-1} for the traditional system. The mean bean yield for all varieties in the modified traditional system was 1702 kg ha^{-1}. In the El Rodeo site, only three treatments outyielded the traditional system but the increases in yield were not as great as in El Motolin. Combining the two sites, the modified traditional system produced over 1000 kg ha^{-1} of beans as against 931 kg ha^{-1} for the traditional system as 825 kg ha^{-1} for the IDRC recommendation.

Bush Beans

a. Agronomic evaluation of 31 local varieties of bush bean, El Guapinol, Nicaragua, 1984*

The material used in this and two other sites was collected by personnel of MIDINRA and CATIE in early 1984. Yields at this site ranged from 1248 to 2177 kg ha^{-1} with a mean of 1737 kg ha^{-1}. These materials were quite early: mean flowering date was 33 days with a range of 28 days for "Rojo El Jicaro" to 40 days for Barreño Limay. The varieties which yielded over 2 t ha^{-1} were: Bayo, Barreño Esteli, Tico Rama, Esteli, Chile Rojo, Revolucion 83 and Rosado. The best material from this trial and from the other two sites was selected for use in the second planting of 1984.

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* 'A' refers to the first bean planting (May-August) and 'B' refers to the second planting (September-December).

b. Agronomic evaluation of 20 improved varieties of bushbean, El Guapinol, Nicaragua, 1984A.

Results are reported on one of the three trials using this material, which came either from CIAT, other Central American national programs, or common local varieties. Mean yield (1652 kg ha^{-1}) was quite similar to that of the 31 local varieties also evaluated at this site (see previous section) but this material was much later. Mean flowering date was 39 days after germination. The two highest yielding materials (over 2 t ha^{-1}) were BACO 90-1 and BAT 1554 but they did not yield significantly higher than the local checks Revolucion 79 and Rojo Nacional. Even the poorest yielding variety in the trial, Rojo de Seda, another local check, produced 1035 kg ha^{-1}, some 400 kg ha^{-1} higher than average yields in the area.

c. Evaluation of yield stability of 16 local varieties of bushbean, 1984B

This experiment was carried out at four different sites (El Guapinol, El Rosario, La Lomilla and the Esteli Experiment Station) in the Department of Esteli. The varieties used had performed well in previous trials. A completely randomized design with three repetitions was used at all sites.

The best varieties were Chile Rojo, Rojo Pando, Mono (Esteli), Rojo Seda, Chile Ligero, and Rojo Musuli, all of which produced yields of over 1 t ha^{-1}.

The controls Rojo Nacional and Revolucion 79 showed little yield stability in the different sites. The lack of statistical significance in the differences in the variables studied is evidence of the uniformity of the material and reflects that it was all selected using the same criteria. The materials which performed best in the trials are being retested, following which the national program of MIDINRA will conduct large scale validation trials.

d. Agronomic evaluation of 14 varieties and improved lines of bushbean 1984B

As noted earlier, there were four trials, all with the same nine improved varieties, two (El Guapinol and La Lomilla) with the same five advanced lines. In the other two sites, the advanced lines were different. The combined analysis for the nine tested varieties is shown in Table 23. As can be seen from the table, the variety H772202-62CMCM produced the highest average yield over all sites. Even though it did not yield significantly higher than several other varieties in the combined analysis it yielded well in all sites, showing better yield stability than Rojo Nacional, Revolucion 79A, Revolucion 79 and Revolucion 83. The variety BAT 1514 showed similar stability to H-772202-72CMCM. One of the advanced lines, #71, outyielded H-772202-72CMCM at one of the sites but the difference in yield was not significant and was not maintained at the other sites.

Sorghum

Genotype research with sorghum for the semi-arid tropics includes both the traditional photoperiod sensitive material and the improved photoperiod insensitive material. Much of the research is carried out in collaboration with ICRISAT which maintains a Latin American regional office in Mexico.

1. Photoperiod Insensitive Sorghum

Testing of sorghum lines began with the introduction of 52 varieties of white sorghum, suitable for human consumption, in the second planting of 1982. This material was received from the ICRISAT program in Mexico. Promising lines were tested for acceptability among farmers in the region and a selection of forty nine lines was

TABLE 23. Combined analysis for 4 sites of the nine improved varieties of bushbean common to all sites. 1984B.

Variety	Yield (kg/ha)	Plant Height (cm)	Pods per Plant (cm)	Seeds per pod. (No.)
H-772202-72CMCM	1102a	78.5a	6.9	5.9a
Bat 1514	992ab	77.1ab	7.8	5.2cd
Rojo Nacional	983ab	73.8abc	7.2	5.8abc
Revolucion 79A	940ab	71.8abc	7.5	5.4cd
Bat 1577	937ab	77.0ab	6.7	5.8a
Revolucion 83	910ab	64.8d	8.1	5.6abc
Revolucion 79	887b	71.2bcd	6.5	5.4cd
Bat 1217	801b	70.9bcd	6.1	5.5bcd
Honduras 46	795b	69.5cd	6.0	5.4cd
Mean	927	72.7	7.0	5.6
Range	795-1102	64.8-78.5	6.0-8.1	5.2-5.9

Values followed by same letter do not differ at $p \leq 0.05$ by Duncans Multiple Range Test.

made from among and within families. These were evaluated in both the first and second planting of 1983. Also in 1982, 111 experimental lines were introduced from ICRISAT in India which were planted, observed, and selected in that year.

From these two acquisitions, material was selected and tested during 1983 and 1984 until a group of 10 lines and varieties was selected for testing throughout the region (12 trials in 4 different regions). From this work, one or two varieties will be selected for testing at some 40 - 45 sites in the region by the Ministry of Agriculture land reform team with the support and supervision of the CATIE-IFAD genotype program.

a. Agronomic evaluation of white sorghum

Varieties suitable for tortillas, 1983A and 1983B

These studies were the evaluation of the 49 selections made from the ICRISAT material received from Mexico in 1982. There were three sites for the first planting and three for the second planting, but two sites were eliminated from the second planting due to low rainfall (a frequent cause of loss of photoperiod insensitive sorghum in the Esteli area). In all sites, management practices were similar: no fertilizer at planting and 65 kg ha^{-1} of urea at hilling up. Weeds were controlled with atrazine 80 at 2.0 kg ha^{-1}. Rows were 0.5 m apart with about 0.1 m between plants. The first planting was made at the beginning of June and the second planting in the third week of September. A randomized complete block design was used with four repetitions per site for the first planting and three repetitions per site for the second planting.

Of the four sites used for analysis (Esteli, Santa Adelayda and El Rodeo in the first planting, Esteli in the second planting), the highest production was obtained for the first planting in Esteli, with a mean of 6560 kg ha^{-1}. Much of the material outyielded the commonly used Central American varieties, Guatecau and Intasor, as well as the hybrid W-823-A included as a check. A group of 35 materials was selected from these four trials for evaluation in the first planting of 1984 in La Grecia, Limay.

b. Agronomic evaluation of 35 varieties of grain sorghum, La Grecia, Limay, 1984

This trial was considered as a final screening before the testing of ten varieties in the second planting of 1984 (see next section). In this trial, the varieties were planted in 60 cm rows, with little spacing between seeds in the row to give a population of 167.000 plants per hectare. The trial was fertilized with 130 kg ha^{-1} of 12-30-10 at planting and 130 kg ha^{-1} of urea, 25 days later. Although there was no statistically significant difference between varieties, yields varied from 2882 to 5335 kg ha^{-1}. Nine of the thirty five varieties produced more than 4.5 t ha^{-1}, among them, Sepon 77 (DGTA); (M36285/S1080-3 x E35-1). M90075 (GPR 168 x 561760 - 17) - 1, Sepon 77 (Bulk) and 80L-27925-1. These results, as well as plant and grain charateristics, were used to select the ten genotypes used for the yield and yield stability trials planted in 12 sites in the second planting of 1984.

c. Agronomic evaluation of 10 grain sorghum varieties in the Department of Esteli, 1984B

The twelve sites used for this study were located in the municipalities of San Juan de Limay, Pueblo Nuevo, Somoto, and Palacagüina. The work was done in collaboration with MIDINRA, who recommended two of the varieties used in the trial, ISIAP Dorado and Nicasor. Results for eight sites are presented in Table 24, since in four of the sites, experiments had to be abandoned due to guerilla activity in the area. The highest yields were obtained in Unites (Esteli) and the lowest in Mateare (San Juan de Limay). The combined site analysis showed slightly significant differences among sites, among varieties and for the site x variety interaction. Although the

Table 24. Agronomic evaluation of 10 grain sorghum varieties in 8 sites of the Esteli Department. Nicaragua, 1984B.

Genotypes	GRAIN YIELD (kg ha^{-1})								Mean yield of 8 sites kg ha^{-1}
	Uniles Somoto	Guapinol Esteli	Culebras Somoto	Casa Blanca Esteli	Gualila Limay	La Grecia Limay	Lamilla Esteli	Mateare Limay	
IDIAP Dorado	4966abc	4958a	3509ab	3219	2853ab	1729bc	3125	2180	3347a
Sepon 77	5445a	4139ab	4162a	2532	2184bc	3678a	2653	1648	3286ab
(S 108-3 x E35-1)-5-IS(S 3541)deri 3-4	5246ab	4750a	3133bc	2906	2717abc	2923ab	1625	1922	3220abc
M 5009	5153ab	3639b	4231a	2833	2576abc	2389bc	2694	1962	3213abc
(T x 954063 x S3541) - 3	5223ab	3872ab	3455abc	2792	2394abc	2412bc	2208	2193	3194abc
Nicasor	4711abc	4194ab	4016a	2792	2194bc	1774bc	2708	1842	3086abcd
M 36285/S108-3 x E31-5	4599abc	4389ab	3635ab	3063	2321abc	1770bc	2042	2108	2957bcd
(IS126226 x 55) (IS36112 x 221913-5-1 x E35-1-52)	4782abc	4458ab	3120bc	2792	2225bc	1627c	2542	1522	2920bcd
CATIE - 1	4599abc	4222ab	2971bc	2333	3033a	2440bc	1819	1494	2853cd
CATIE - 2	4979c	4292ab	2680c	2125	1976c	2908ab	2236	2083	2775d
Mean	4876	4301	3491	2732	2430	2407	2364	1895	3076

Values followed by the same letters do not differ significantly by Duncan's Multiple Range Test at $p \leq 0.05$.

range in mean yields of varieties is not great (2775 to 3347 kg ha^{-1}), little of the material showed general adaptability over sites. Of the two varieties with the highest average yield over site, ISIAP Dorado showed more stability over site than Sepon 77. The best overall yield stability was shown by the selection (S108-3 x E35-1)-5-15 (S3541) Deri 3-4 y M5009, although it produced lower than the average site yield in two of the eight sites. This line is a little later than ISIAP Dorado but showed the advantage of short stature. These two genotypes would appear to be the most promising for an overall recommendation for the Department of Esteli. In specific sites, such as Culebras (Somoto) and La Grecia (Limay), Sepon 77 outyielded these two materials.

2. Photoperiod-Sensitive Sorghum (Millon)

There are few breeding programs dedicated to the improvement of photoperiod sensitive sorghum, known locally as millon; and those that exist in the region, such as that of CENTA in El Salvador and of PNIA-INTSORMIL in Honduras, were started relatively recently. As the extent of genetic variability present in local matrices was unknown, a collection of materials in the Esteli Department was begun in 1982. Unfortunately material collected in 1982 and 1983 was lost so a new collection was made in 1984. This material was planted for observation in 1984 and will be harvested in early 1985. Some of the lines seem quite promising.

Other work with maize-millon association included studies on the interaction of spacing, fertilization and phenotype, in collaboration with the Latin American Commission of Sorghum Researchers (CLAIS) and the ICRISAT office in Mexico. Some of these results are presented in the cropping systems section of this report. More results will be presented in the 1985 report.

Pearl Millet

Because it matures more rapidly than sorghum, pearl millet was considered to be an alternative for sorghum for both grain and forage production in the areas of the region where rainfall is lowest and most erratic such as the Limay valley. Material introduced from Georgia (USA) was tested in 1982 and 1983.

However, this line of research was abandoned in 1983 because little interest had been stimulated in the crop.

Cowpea

Work on the introduction and evaluation of cowpea lines began in 1982 and continued in 1983.

In 1982, thirty-five varieties were introduced from IITA. The yields were very promising even in San Juan de Limay where high temperatures and evapotranspiration rates contribute to frequent failures of the Phaseolus bean crop. The best material from the 1982 introduction were tested in the first and second plantings of 1983. In the first planting of 1983, problems were encountered due to photoperiod sensitivity and a heavy attack of virus which resulted in the complete loss of several experiments. New introductions were made and many of these problems were overcome in the second 1983 planting. Nevertheless, the line of research was abandoned at the end of 1983. It was felt, that in spite of the adaptability of the cowpea to areas marginal for beans, no interest had developed in the crop and market possibilities were practically non-existent.

Pigeon Pea

Pigeon pea was thought to have potential as a food and feed crop in areas too dry for other food legumes. Material obtained from the

U.S. was tested in 1982 but did not survive. At the same time, a heterogeneous bulk population was also sown to find material adapted to the region. Some selections were made and seeded in 1983 for observation. No work with pigeon pea was continued in 1984.

Maize - Bean Systems

As was pointed out earlier, the maize-bean system is more characteristic of the mid-elevation wet-dry areas of Central America where the present IFAD program does not operate. At the time that IFAD began collaborating with CATIE, the Plant Production Department was doing research in various areas where the maize-bean system predominated. It was decided at the time that the IFAD project should provide genotype support to this research. This work continued into 1984.

It was the idea of the first genotype specialist supported by IFAD, Dr. Jonathan Woolley, that a maize plant with less foliage would be of benefit to the maize-bean system. This would permit earlier planting of the beans as they would not be shaded by the maize. The beans would mature earlier, overcoming problems of lack of water at the end of the growing period. An experiment in which maize plants of different leafiness were associated with beans sown at the regular sowing date and 20 days before the physiological maturity of the maize, was carried out in 1982-83 and 1983-84. The ability of maize to support the climbing beans was also studied.

a. Evaluation of climbing bean genotypes in association with maize genotypes of differing plant height

Climbing bean genotypes characterized by a not overly vigorous habit (1-2.5 m in height, CIAT Growth Habit IVa) with uniform distribution of leaves and pods, have shown good potential for medium elevation locations, with lower incidence of foliage and pod diseases than bush types. A trial with 12 genotypes of this growth habit (IVa

- CIAT) in association with maize genotypes of 3 growth habits, was planted at the Montaña Experiment Station of CATIE, Turrialba, in August 1983. A split plot design was used with maize genotypes in the main plots and bean genotypes in the subplots. Maize was sown at 40.000 plants ha^{-1} and beans at 80.000 plants ha^{-1}. Beans were sown when the Tuxpeño C-7 maize reached physiological maturity (125 days after seeding).

There were significant differences among bean genotypes with respect to yield but the bean genotype x maize genotype interaction was not significant. All bean varieties produced best when associated with the Tuxpeño C-12 maize, which offered the best support for the beans. The best yielding bean genotypes were V7920, V7919, V7918, all of which yielded over 1 T ha^{-1}, a highly acceptable yield as the final bean population was only 70,000 plants ha^{-1} and no fertilizer and low levels of other inputs were applied to the trial. The line V7919 was one of the latest (44 days to flowering) while V7918 was one of the earliest (38 days to flowering).

b. Multiplication and evaluation of 20 genotypes of climbing beans in association with maize

Also, in October of 1983, 19 levels of climbing beans, mostly obtained from CIAT, and a local variety were planted at the Montaña experiment station. Maize stalks from a previous experiment were used to support the beans. Besides evaluation of the material, it was hoped to obtain sufficient seed for planting several trials in different sites at a later date.

There were differences among lines with respect to the incidence of web blight (*Thanetephorus cucumeris*) (Frank) Donk. Line G-3910 was not afected while others such as G5653, G2333, and V7920 only showed small lesions. In general, lines of growth habits II and IIIB showed greater severity of web blight than those of the IVA growth habit. The greater concentration of leaves and pods in the lower part of the plant in the lines with growth habits II and III should lead to higher humidity and better conditions for the spreading of the fungus causing web blight. Due to excessive rainfall, yields of this trial were extremely variable.

c. Evaluation of maize and bushbean genotypes grown in relay

It was noted that the Central American maize-bean production system is adapted to double maxima rainfall distribution. It has been observed that earlier maizes allow earlier bean plantings, reducing risk of drought, although yields are often reduced. Another means of reducing drought risk is to plant beans before physiological maturity of the maize, using maize genotypes which do not shade the beans excessively. A split-plot experiment was planted in Turrialba in 1984 to test these hypotheses: as main plots, there were eight maize varieties, as subplots, 2 dates of bean planting, and as sub-subplots, 8 bean bush-type variety.

The maize variety showed the expected differences in plant height, leafiness, and maturity. Shorther stature maizes produced lower yields. Beans planted 20 days before the physiological maturity of the T-PB-15 maize had more water available from germination to flowering, which favored both vegetative development and grain production, as compared with the beans planted at physiological maturity. The more favorable rainfall distribution also favored the development of web blight (see previous section), however, leading to a reduction of leaf area of 41% in the earlier planted beans as compared to 12% in the later planted beans. Nevertheless, yields for the earlier planting were always about 50% higher than for the later planting. The varieties Huetar, Brunca and ICTA Tamazulapa showed the greatest difference in this respect with yields in the first planting exceeding those of the second by 95, 90 and 72% respectively.

Although the maize genotype x bean genotype interaction was not significant at either planting date, there was a tendency of beans to produce more with shorter stature maizes. What is most notable is that the more favorable rainfall distribution obtained through earlier planting always led to higher yields, even with increased incidence of web blight. This result indicates the importance of using materials resistant to web blight to obtain the highest yields.

WEED MANAGEMENT

Weeds are the principal constraint to crop production in 40% of the area of Central America ecologically denominated as the lowland humid tropics. In these areas, the cropping systems generally include the production of a tropical root or tuber. One of the principal aims of the weed management component during its first year of research was to develop weed management alternatives for the principal or potential systems of production in the area, as a support to the prototype team operating in the LHT. Research was conducted in the cassava+bean, cassava+maize, cassava+ginger systems, and in the monocultures of cocoyam (Xanthosoma), yam (Dioscorea) and rice.

The weed management team began field work in 1984, two years after the establishment of the prototype, and three years after some of the other components of the IFAD project. In order to provide immediate support to the prototype, effective weed management alternatives had to be developed in less than two years. Taking into account the economic resources of the growers, their interest in the chemical control of weeds and the requests of the prototype team, four lines of research were determined. They include pre and post-emergence herbicide evaluation, studies on the critical periods of weed competition and soil tillage systems. In the pursuit of these lines, the principal weeds associated with the systems of production under study were identified.

The wet-dry tropics is the ecological zone of Central America where 40% of its population lives. The region is characterized by the intensive use of the land, and high land values. The principal systems of production frequently include a vegetable crop. Research in support of the Panama prototype team was conducted in tomato in the maize-fallow or pasture-tomato system, in sweet pepper in the rice-fallow or pasture-sweet pepper system, rice in the rice-fallow or pasture-tomato system and in yam in monoculture.

The semi-arid tropics is an area with a high concentration of small growers whose principal systems of production include the basic grains. Support was given to the Nicaraguan prototype team through research in the bean-bean system of production.

The weed management component of IFAD is a service component for all of CATIE and for the national institutions of Central America, Panama and the Dominican Republic. Therefore, the research conducted has been in support of other Departmental projects, such as IDRC financed Systems of Production based on the Plantain, Tropical Root and Tuber Project, and of a prototype of the University of Costa Rica at Rio Frio which is also financed by IDRC. Support through research has also been given to IDIAP in Panama and to MAG in Costa Rica.

LOWLAND HUMID TROPICS

Cassava + Beans

Eight herbicides at various concentrations by themselves or in mixtures were evaluated. They were linuron, alachlor, oxyfluorfen, pendimethalin, chloramben, DPCA, fluometuron and fluazifop - butyl. These herbicides were compared to a hand weeded and to a non weeded control. Treatments are shown in Table 25.

The predominant weeds in the trial were Eleusine indica, Spananthes paniculata, Sida rhombifolia, Digitaria sanguinalis, Cynodon dactlyon, Eclipta alba, Euphorbia heterophylla and Paspalum fasciculatum.

The highest bean yields were obtained in plots treated with pendimethalin 1.3 or 0.78, chloramben 2.0, DCPA 10.5, alachlor 1.0 or 1.5 and fluometuron 1.0 kg ai ha^{-1} (Table 25). However, no significant differences were found between these treatments and the

TABLE 25. Yield of bean (15% humidity) and cassava in a preemergence herbicide evaluation experiment. San Carlos, 1984-85.

Herbicide	Concentration kg ai ha^{-1}	Yield	
		Bean kg ha^{-1}	Cassava ton ha^{-1}
Linuron	0.5	1364 abcd	20.00
Linuron	1.0	1302 bcd	22.73
Linuron	1.5	1519 abcd	25.46
Alachlor	1.0	1528 abcd	28.88
Alachlor	1.4	1565 abc	24.31
Alachlor	2.9	1044 d	23.43
Oxyfluorfen	0.2	1435 abcd	22.00
Oxyfluorfen	0.4	1315 bcd	28.53
Oxyfluorfen	0.6	1426 abcd	28.18
Pendimethalin	0.7	1557 abcd	21.53
Pendimethalin	1.0	1337 bcd	22.65
Pendimethalin	1.3	1795 a	21.84
Chloramben	2.0	1648 ab	16.18
Chloramben	4.0	1484 abcd	21.67
Chloramben	6.0	1404 abcd	25.43
Chloramben + Pendimethalin	2.0 + 0.7	1511 abcd	20.28
DCPA	10.5	1601 ab	22.34
Fluazifop-Butyl	1.0	1533 abcd	18.82
Fluometuron	1.0	1596 abc	23.72
Fluometuron	2.0	829 e	25.30
Fluometuron	4.0	1173 cd	29.58
Hand weeded check		1428 abcd	24.71
Non-weeded check		1380 abcd	24.31
Grower's check (weeding at 30 DAP)		1507 abcd	23.53

Values followed by the same letter do not differ significantly by Duncan's multiple range test at $p \leq 0.05$

hand weeded control. The yield in these treatments ranged from 1528 to 1795 kg ha^{-1} of beans at 14% humidity.

Fluometuron 2.0 to 4.0, alachlor 2.9 and oxyfluorfen 0.2, 0.4 or 0.6 kg ai ha^{-1} caused phytotoxicity to the beans, and resulted in lower yields than the highest yielding treatments.

The highest cassava yields were obtained in plots receiving fluometuron 2.0 or 4.0, alachlor 1.0 and oxyfluorfen 0.4 or 0.6 kg ai ha^{-1} and in the hand weeded control treatments. In general, the highest cassava yields were found in plots where the herbicides caused phytotoxicity to the bean.

White Cocoyam

Two field trials were established in May, one at Sonafluca, San Carlos and the second one at Turrialba. The cultivar known as Blanco was used.

The predominant weeds at both sites were *Melampodium divaricatum*, *Melampodium perfoliatum*, *Digitaria sanguinalis*, *Eleusine indica*, *Cynodon dactylon*, *Mimosa pudica*, *Borreria laevis*, *Phyllanthis niruri*, *Richardia scabra*, *Commelina diffusa*, *Emilia fosbergii*, *Asclepias curasavica*, and *Lantana camara*. At both sites, the most important weed was *Melampodium divaricatum*.

The fresh and dry weight of weeds at 12 weeks after treatment application, the percent ground cover at 8 weeks after application, and the phytotoxic effects of the herbicide were recorded.

At San Carlos, treatments resulting in the smallest dry weight of weeds were ametryn 3.4, metolachlor 3.6, oxyfluorfen 0.5, diuron 2.8, prometryn 4.5 and the mixtures of ametryn 3.4 + TCA 5.6, and ametryn 3.4 + pendimethalin 1.0 kg ai ha^{-1}. These treatments had less than

21% of the plot surface covered by weeds at 8 weeks after treatment application.

At Turrialba, the same treatments had less than 25% of the plot area covered by weeds at 8 weeks after treatment, except for linuron at 3.4 kg ai ha^{-1}. Other treatments with less than a 25% ground cover included the mixtures of ametryn 3.4 + alachlor 1.0 and ametryn 3.4 + metolachlor 1.8 kg ai ha^{-1}.

Six weeks after treatment application, no visual phytotoxicity symptoms in cocoyam were found in any of the treatments at San Carlos. Phytotoxicity data from Turrialba are not reliable due to a dry rot disease which affected the crop. The Turrialba trial was abandoned at 12 weeks after planting and the one in San Carlos at 24 weeks after planting due to disease problems. The line of work on cocoyam will be discontinued until a method for the control of the "mal seco" disease is found.

Cassava + Ginger

Nine herbicides at various concentrations by themselves or in mixtures were evaluated. They include ametryn, diuron, linuron, oxyfluorfen, alachlor, atrazine, pendimethalin, metolachlor, and TCA, as well as a hand weeded and a non weeded treatment. Treatments are shown in Table 26.

At ten weeks after treatment application plots having the smallest dry weight of weeds were in the diuron 2.8 or 3.9, ametryn 3.4 or 4.5 and the mixtures of ametryn 3.4 + alachlor 1.0, and diuron 2.8 + alachlor 1.0 kg ai ha^{-1} treatments (Table 26).

The most important weeds at the experimental site were *Ipomoea* sp., *Paspalum conjugatum*, *Cyperus* sp., *Borreria laevis*, *Ludwigia decurrens*, *Lantana camara*, *Drymaria chordata*, *Digitaria sanguinalis*,

TABLE 26. Dry weight and percent of ground covered by weeds in a preemergence herbicide experiment on the cassava + ginger system. San Carlos, 1984-85.

Herbicide	Concentration kg ai ha^{-1}	Dry weight of weeds at 2.5 months kg ha^{-1}	% ground covered by weeds (months) after planting 1.5	2.5
Ametryn	2.25	1689	55	92
	3.40	947	34	70
	4.50	595	28	77
Diuron	1.70	1103	33	88
	2.80	630	26	62
	3.90	527	19	47
Linuron	3.40	1255	35	82
	4.50	1035	35	85
Oxyfluorfen	0.49	1139	30	72
	0.73	1209	36	92
	0.97	804	30	68
Alachlor	0.96	1040	42	88
	1.44	1171	40	85
	2.88	1516	50	92
Atrazine	3.40	882	33	88
Pendimethalin	0.66	1123	37	87
	0.99	930	33	75
	1.32	958	40	78
Metolachlor	1.80	1321	41	92
	3.60	905	36	75
T.C.A.	5.60	1171	34	80
Ametryn + Alachlor	2.25 + 0.96	825	27	70
Ametryn + Alachlor	3.40 + 0.96	588	26	73
Ametryn + T.C.A.	3.40 + 5.60	950	40	87
Ametryn + Pendimethalin	2.25 + 0.66	1214	37	85
Ametryn + Pendimethalin	3.40 + 0.66	992	34	72
Ametryn + Metolachlor	2.25 + 1.80	895	43	85
Ametryn + Metolachlor	3.40 + 3.60	879	32	68
Linuron + Alachlor	3.40 + 0.96	1044	29	80
Linuron + T.C.A.	3.40 + 5.60	921	30	75
Linuron + Metolachlor	3.40 + 1.80	1370	38	82
Linuron + Pendimethalin	3.40 + 0.66	739	41	90
Linuron + Alachlor	2.80 + 0.96	663	24	58
Hand weeded control		459	17	47
Non weeded control		1405	47	94

Melampodium divaricatum, *Panicum trichoides* and *Mimosa pudica*. The predominant weed was *Ipomoea* sp.

None of the treatments caused visual symptoms of phytotoxicity.

The highest yields of ginger (grade A) were found in metolachlor 3.6, diuron 1.7, oxyfluorfen 1.0, ametryn 2.3 + alachlor 1.0, metolachlor 1.8, linuron 3.4, ametryn 3.4 + pendimethalin 0.7 kg ai ha^{-1} and in the weed free control treatments. These treatments yielded significantly more than the non weeded control. Significant differences in yield were also found between the metolachlor 3.6 kg ai ha^{-1} treatment and all the other treatments.

A negative correlation was found between the dry weight of weeds and the grade A yield of ginger.

Cassava + Maize

Seven herbicides at various concentrations by themselves or in mixtures were evaluated. They included alachlor, atrazine, linuron, pendimethalin, oxyfluorfen, metolachlor and diuron as well as a hand weeded and a non weeded control.

Plots with less than 30% weed cover at ten weeks after planting were found in the oxyfluorfen 0.8 or 1.3, metolachlor 2.5 or 3.3, diuron 2.0, linuron 1.5 or 2.0, atrazine 1.3 or 1.6, linuron 1.5 + oxufluorfen 0.3, linuron 1.5 + alachlor 0.9, linuron 1.5 + pendimethalin 0.7, atrazine 1.6 + metolachlor 1.7 and atrazine 1.6 + alachlor 0.9 kg ai ha^{-1} treatments.

Severe phytotoxic effects were found in both crops when the linuron 1.5 + oxyfluorfen 0.3 kg ai ha^{-1} mixture was used. The atrazine 2 kg ai ha^{-1} treatment caused phytotoxicity to cassava.

At twelve weeks after treatment application, plots having the lowest dry weight of weeds were the oxyfluorfen 0.7, atrazine 1.63 +

alachlor 0.86, atrazine 1.63 + metolachlor 1.68, metolachlor 2.5, linuron 2.0 kg ai ha^{-1} and the weed free treatment. The dry weight of weeds in these treatments ranged from 215 to 413 kg ha^{-1}.

The maize was harvested in December 1984. Yield data is not reliable due to bird damage prior to harvest. The cassava will be harvested in July 1985.

PRE AND POSTEMERGENCE HERBICIDE EVALUATION

Rice

Six herbicides at various concentrations by themselves or in combinations applied pre and at postemergence were evaluated. They included oxyfluorfen, pendimethalin, oxadiazon, bentazon, propanil, 2,4-D, propanil + pendimethalin, propanil + 2,4-D as well as a hand weeded and a non weeded control.

The trial was established at Rio Frio under the ecological classification of very humid tropical forest with a mean annual rainfall of 4194 mm, a mean annual temperature of 25.4 C and at 150 masl.

Preemergent herbicides were applied to a soil under minimum tillage conditions. Soil preparation consisted of hand hoeing to break the soil surface, and planting in furrows at 85 kg of seeds per hectare.

The predominant weeds at the experimental site were Eleusine indica, Digitaria sanguinalis, Panicum maximum, Paspalum paniculatum, Cyperus ferex, Killinga pumila and Pilea haylina.

Visual evaluation of the percent of the plot surface covered by weeds was made at 20, 40 and 60 days after planting and preemergent herbicide application.

Treatments showing the smallest percentage of ground cover were oxyfluorfen 0.24, 0.29 and 0.34, and oxadiazon 0.88, 1.00 and 1.13 kg ai/ha.

They ranged from 15% to 30% at 60 days after herbicide application.

The same treatments showing the smallest percentage of ground cover had the lowest dry weight of weeds at 18 weeks after planting (immediately after harvest). The dry weights of weeds ranged from 304 to 401 kg ha^{-1} and from 278 to 374 kg ha^{-1} for the oxyfluorfen and oxadiazon treatments, respectively.

A significant difference in the dry weight of weeds, and in yield of unhulled rice was found between the non weeded control and all the other treatments.

CRITICAL PERIOD OF WEED COMPETITION

Yams

The trial was planted in Guapiles, under a very humid tropical forest ecological classification. The rainfall during the life cycle of the crop was 3200 mm, the mean maximum monthly temperature ranged from 26 to 30 C and the minimum from 19 to 21 C and at 80 masl.

Dioscorea rotundata cv. Antillano was used. The crop was grown, as is the custom in the Atlantic region of Costa Rica, under high input agriculture. Stakes 2.3 m above the ground, complete fertilizer formula, and disease control with fungicides were used.

The predominant weeds in the experimental area were grasses. These included *Digitaria sanguinalis*, *Panicum fasciculatum*, *Paspalum conjugatum*, *Panicum trichoides* and *Eleusine indica*. The principal broad-leaf weeds were Melanthera aspera and Momordica charantia (Table 27).

Reductions in yield due to weeds accounted only for 35% of total yield. Yields ranged from 29.15 t ha^{-1} to 44.77 t ha^{-1}. No differences in yield were found between the treatment where weed competition was permitted for the first four weeks after planting, and the one where the crop was hand weeded until harvest (Table 28). No differences in yield were found between the treatment which was hand weeded until the 10th week from planting, and the one hand weeded throughout the season. Therefore, the critical period of weed competition for D. alata under tne environmental conditions of the weed pressure at Guapiles was between the 4th and the 10th week after planting. The highest dry weight of weeds was 5100 kg/ha.

TILLAGE SYSTEMS

Rice

A field trial to compare tillage systems in rice was established at Bataan, Costa Rica on November 15, 1984. Treatments included zero tillage in which seeds were broadcast, or in which seeds were planted in holes; minimum tillage, using a rotavator to incorporate rice seeds; conventional tillage when one or two cuts with a rotavator were carried out.

The soil at the experimental site is a Typic Tropaquept of clay texture, pH of 6.33 and 5.75% organic matter content.

Predominant weeds in the area are Digitaria sanguinalis, Eleusine indica, Ixophorus unicetus, Cyperus rotundus, Mimosa pudica, Rottboelia exaltata, Paspalum conjugatum and Cenchrus echinatos.

Observations were made with regards to the number of tillers per plant at 40 days after planting; weed counts prior to planting, and at

TABLE 27. Weeds present in a critical period of weed competition study in yams (Dioscorea alata). Guapiles, 1984.

Scientific Name	Common name in Costa Rica	Incidence[1/]
Digitaria sanguinalis	Digitaria	Very high
Panicum fasciculatum	Granadilla	High
Paspalum conjugatum	Zacate amargo	Medium
Melantera aspera	Paira	Medium
Momordica charantia	Sorisi	Medium
Panicum trichoides	Ilusión	Medium
Eleusine indica	Pata de gallina	Medium
Borreira laevis	Botoncillo	Low
Phytollacca spp.	Jaboncillo	Low
Erechtites hieraciifolia	Hierba de cabro	Low
Paspalum paniculatum	Zacate de burro	Low
Solanum nigrum	Hierba de mora	Low
Phyllanthus niruri	Tamarindillo	Low
Pennisetum purpureum	Gigante	Low
Ipomoea spp.	Churristate	Low
Ochoroma piramidale	Balsa	Low
Emilia sonchifolia	Clavelillo	Low
Mimosa pudica	Dormilona	Low

[1/] Very high = 85 = 100%
High = 70 - 85%
Medium = 35 - 70%
Low = Less than 35%

TABLE 28. Total and commercial yield in a study of critical periods of weed competition in yams (*Dioscorea alata*). Guapiles, 1984

Treatments without weeds (WAP)1/	Total Tuber Weight (t ha^{-1})	Number of total tubers ha^{-1} X10^3	Weight of commercial tubers (t ha^{-1})	Number of commercial tubers ha^{-1} X10^3
4	33.39 bcd	29.91 ab	18.39 bc	14.20 abc
8	34.92 bcd	30.72 ab	20.70 abc	15.93 abc
10	39.93 abc	29.33 b	19.08 abc	15.24 abc
12	41.25 abc	29.91 ab	27.89 a	18.82 ab
14	41.64 ab	29.91 ab	19.29 abc	15.59 abc
16	40.80 abc	32.56 ab	19.67 abc	15.22 abc
20	36.87 abcd	28.52 b	14.92 c	12.82 c
Throughout the cycle	44.77 a	32.79 ab	77.62 a	18.59 ab
With weeds (WAP)				
4	44.10 a	27.83 b	22.17 abc	15.01 abc
8	33.28 cd	29.21 b	18.05 bc	16.40 abc
10	35.44 bcd	36.49 a	21.32 abc	17.90 abc
12	36.62 abcd	32.79 ab	24.33 ab	18.60 ab
14	34.88 bcd	32.45 ab	17.69 bc	15.70 abc
16	36.83 abcd	31.52 ab	24.90 ab	19.17 a
20	40.44 abc	32.33 ab	21.06 abc	15.47 abc
Throughout the cycle	29.15 d	32.91 ab	13.94 c	13.40 bc

1/ Weeks after planting

Numbers in a column with a letter in common do not differ significantly according to Duncan's Multiple Range Test $p \leq 0.05$

10 to 35 days after planting; rice plant height at 45 and 80 days after planting, insect counts at 100 days after planting and cost production.

The experiment will be harvested in April and yield data taken and analyzed.

VEGETATION MANAGEMENT

Gramalote

The evaluation of growth characteristics and propagation of gramalote (*Paspalum fasciculatum*), an important weed, continued during 1985.

Production of biomass from cuttings of the apical, central or basal parts of its branches (stolons) was evaluated at 20 day intervals. Results show similar development (not significant) among the types of cuttings with respect to total biomass and stems, a function of age (Figure 9).

For total above ground biomass,

$$Y = 18.227^{0.03178X} \qquad R^2 = 0.97$$

For stem biomass,

$$Y = 6.3676^{0.03748X} \qquad R^2 = 0.96$$

Significant differences were found among the types of cutting with respect to leaf biomass. The highest production of leaves were found using apical cuttings. They followed an experimental function.

$$Y = 14.273e^{0.02616X} \qquad R^2 = 0.97$$

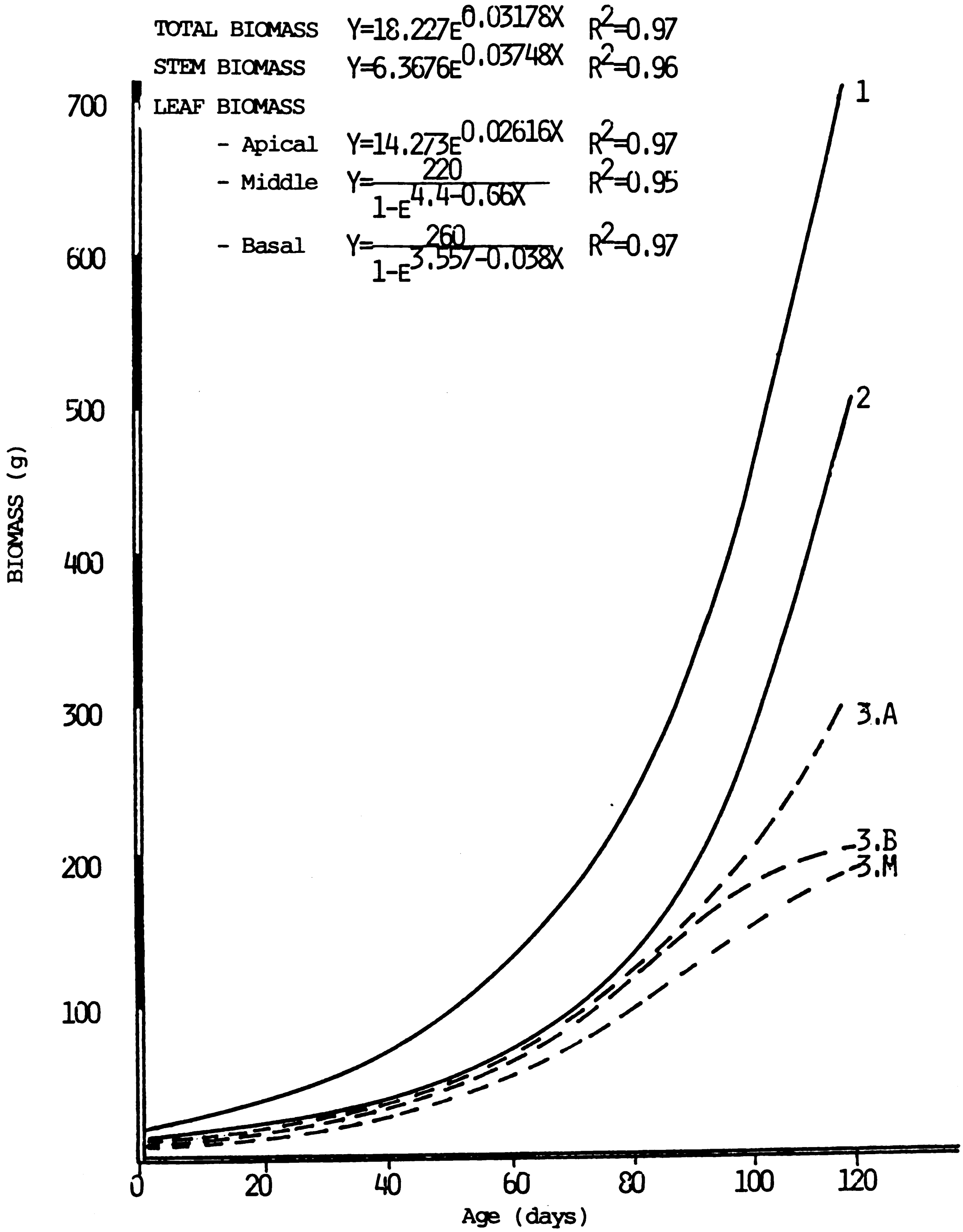

Figure 9. Gramalote (<u>Paspalum fasciculatum</u>) biomass with age

The basal cuttings produced less biomass than the apical, but more than the central ones. The biomass follows a logarithmic function.

$$Y = \frac{260}{1 + e^{3.557 - 0.038X}} \qquad R^2 = 0.97$$

The production of leaves from leaf cuttings for the central part of the stem was low. It follows a logarithmic function:

$$Y = \frac{220}{1 + e^{4.4 - 0.66X}} \qquad R^2 = 0.95$$

Velvet Bean

The regulated growth of velvet bean (*Mucuna* sp.) was evaluated as a live cover in maize. In addition, evaluations were made of *Mucuna* sp. mulch, produced through physical or chemical means, and weed control through manual or chemical means (no cover).

Live covers were planted 40 and 55 days before planting maize. To ease the planting of maize, paraquat (0.5 kg ai ha^{-1}) was applied in strips over the 55 day old cover. The same day, maize was planted between strips of the 40 day old cover. Some treatments with covers received dicamba applications at 150 g ai ha^{-1} at 3 days after the maize emerged. Forty days later, part of these treatments received a second application of dicamba at 755 g ai ha^{-1} to regulate the growth of the cover crop.

Evaluation were made at four sampling dates (25, 40 55 and 120 days after the planting of maize) and at harvest.

The results show major incidence (No. weeds m^{-2}) and weed biomass production in plots with mulch obtained through manual cuttings, followed by treatments with live covers which were established 40 days before the maize planting. The highest incidence and biomass of weeds was obtained in treatments with mulch (with paraquat applications). They did not differ significantly from the chemical control.

The variations in the velvet bean biomass are presented in Figure 10. A tendency for greater growth in older covers (55 days) is shown (curves 3 and 4) in comparison to those at 40 days (curves 1 and 2). For each age, the effect of competition due to weeds may be observed.

The effect of the growth regulations on velvet bean biomass (curves 5 to 8) in comparison to those where no growth regulation was used can be observed. Among the curves regulated with dicamba application, the effect of one application (curves 5 and 6) and two applications (curves 7 and 8) over the two times of planting can be observed.

The effect of one or two applications of dicamba over the leaf area index of the covers of both ages are shown in Figure 11. The effect of the age on the leaf area index of the cover in the treatments without growth regulator (curves 1 and 2) can be observed. The LAI of the cover planted 55 days before planting maize reached a value of 5 (curve 1) and the 40 day cover reached a value of 3 to 3.5 (curve 2).

The effect of dicamba applications as a regulator can be observed in the differences between curves 1 and 2 (without regulator) and curves 3, 4, 5 and 6 (with regulator).

An application of dicamba (curves 3, 4) at 10 days after maize planting has a deleterious effect on maize in the cover of higher age. Both covers were recipients at 40 to 60 days after the maize planting.

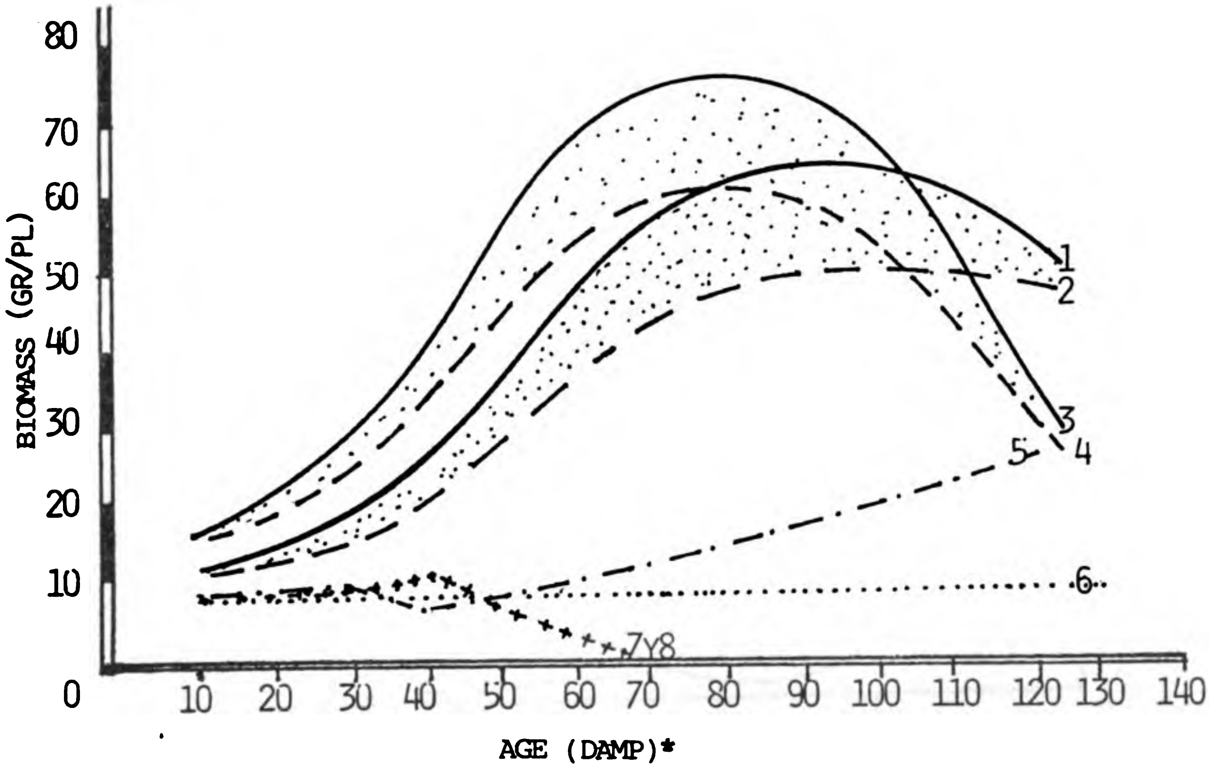

Figure 10. Biomass ranges in velvet bean (Mucuna sp.) with and without growth regulators, for maize planted at 40 and 55 days after the velvet bean live cover.

* DAMP = Days after maize planting

1. Cover for 40 days without weeds
2. Cover for 40 days with weeds and maize
3. Cover for 55 days without weeds
4. Cover for 55 days with mulch
5. Cover for 40 days, one growth regulator application
6. Cover for 55 days, one growth regulator application
7. Cover for 40 days, two growth regulator applications
8. Cover for 55 days, two growth regulator applications

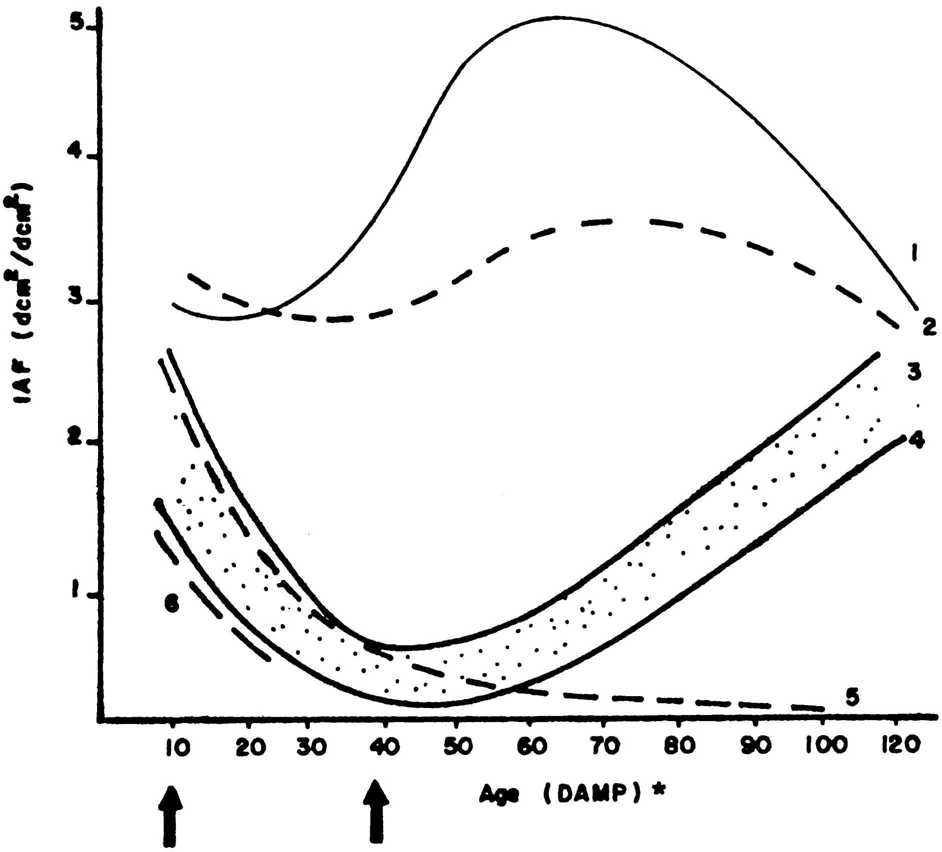

Figure 11. Leaf area index (IAF) variations of Mucuna sp. as a function of age and dicamba applications, during the growth cycle of maize.

* DAMP = Days after maize planting

1 = Cover for 55 days
2 = Cover for 40 days
3 = Cover for 40 days + 1 application of dicamba
4 = Cover for 55 days + 1 application of dicamba
5 = Cover for 40 days + 2 aplications od dicamba
6 = Cover for 55 days + 2 applications of dicamba

Two applications of dicamba (curves 5,6) at 10 and 40 days after the maize planting do not allow for a recovery of Mucuna sp.

The covers without dicamba application showed the highest values for leaf area and biomass, provoking a drastic decrease in the height of the plant, biomass and yield of maize.

In the mulched treatments, a tendency could be observed to improve maize yields. The treatment with mulch (paraquat) adequately controlled weeds, especially grasses.

SEMI - ARID TROPICS

PREEMERGENCE HERBICIDE EVALUATION

Beans

Three herbicides at various concentrations by themselves or in combinations were evaluated. Treatments are presented in Table 29. One of the objectives of the trial was to demonstrate whether pendimethalin was phytotoxic to beans as has been previously reported in the region. The other herbicides studied were linuron and alachlor.

The trial was established at the Experimental Center of MIDINRA at Esteli, Nicaragua. Revolucion 79, a red grain variety was used.

A month after planting, a visual evaluation of phytotoxicity was made. None of the treatments showed any sign of phytotoxicity.

The predominant weed species were Bidens pilosa, Melampodium divaricatum, Cyperus rotundus, Ipomoea sp., Melanthera aspera, Portulaca oleracea, Euphorbia heterophylla, Amaranthus dubius, Mimosa pudica, Malachra capitata and Hyparrehnia rufa. Since the weed

Table 29. Yield of black bean in preemergence herbicide evaluation experiment. Estelí, 1984.

Herbicide	Concentration kg ai ha^{-1}	Yield kg ha^{-1}
Linuron	1.0	1783
Linuron	1.5	1375
Linuron	2.0	1793
Alachlor	1.0	1828
Alachlor	1.4	2061
Alachlor	2.4	1653
Pendimethalin	0.7	1818
Pendimethalin	1.0	1793
Pendimethalin	1.3	1788
Linuron + Alachlor	1.0 + 1.0	1939
Linuron + Pendimethalin	1.0 + 0.7	1860
Linuron + Pendimethalin	1.5 + 0.7	1667
Hand Weeded Check		3302
Grower's Check		2842
Non Weeded Check		2575

species were mainly broadleaves, two of the herbicides, pendimethalin and alachlor which are effective mainly against grasses, were not effective in weed control. None of the herbicide treatments yielded more than the non weeded treatments. Only the hand weeded treatment and the treatment where the grower's hand weeding practice was applied, yielded significantly more than the non weeded control.

Treatments with the least weed cover were linuron 1.0 + alachlor 1.0, and linuron 1.5 + pendimethalin 0.7. The experiment should be continued, using as treatments more herbicide combinations.

WET - DRY TROPICS

PREEMERGENCE HERBICIDE EVALUATION

Rice - Fallow - Tomato

A preemergence and early post-emergence herbicide evaluation experiment in rice was established at IDIAP's experimental farm in Los Santos, Panama on July 18, 1984. The objective of the experiment was to control *Rottboelia exaltata* and *Cyperus rotundus*, the two most important weeds in the region. Pendimethalin was used as a preemergence treatment, while oxadiazon, bentazon (Basagran M-60) and propanil, at three concentrations each or in combination were used in early post-emergence (2 weeks after planting).

Certified seed of the Anayansi variety was planted in furrows and covered with a light layer of soil. Rainfall was very irregular during the first few weeks after planting and germination of the rice was poor. Even after replanting, less than 10% of the rice germinated (including the control treatments).

After an evaluation of weed control at six weeks after planting, the experiment was abandoned. An excellent control of *Rottboelia exaltata* was found at all the concentrations of pendimethalin studied.

At the time of early post-emergence herbicide application, *Cyperus rotundus* plants were at the 5 or 6 leaf stage. The mixtures of bentazon + MCPA (Basagran M-60) were not effective in controlling *Cyperus*, neither were any of the other treatments effective.

Yams

Support was given in the selection of treatments and in all the evaluations in a preemergence herbicide experiment of non staked *Dioscorea alata* yams in Ocu, Panama. The objective of the trial was to control *Rottboelia exaltata* and *Cyperus* sp., the two most important weeds in the region. Treatments included linuron 3 and 4, pendimethalin 0.7, 1.0 and 1.7, ametryn 3 and 4, oxadiazon 0.8 and 1.3, and combinations of ametryn or linuron 3 + pendimethalin 1.0, linuron 3.0 + alachlor 1.4 and diuron 1.0 + alachlor 1.4 kg ai ha^{-1}. A grower's treatment (1.6 kg ai ha^{-1} of ametryn) as well as a hand weeded and a non weeded control were also included (see Table 30).

At five weeks after planting the linuron 3 or 4, linuron 3 + pendimethalin 1, oxadiazon 0.8 or 1.3 and linuron 3 + alachlor 1.4 kg ai ha^{-1} treatments had less than 10% of their plot surface covered by weeds (Table 30). At seven weeks after planting, only the treatments with linuron 3 or 4 kg ai ha^{-1} had less than 25% of their surface covered with weeds. At this date, the pendimethalin treatments had from 35 to 45% of the plot's surface covered by weeds, while the oxadiazon treatments had from 68 to 73% weed cover.

None of the treatments caused visual phytotoxicity symptoms in yams.

Table 30. Visual evaluation of the percent ground covered by weeds in a preemergence herbicide experiment on yam (Diocorea alata). Ocú, Panamá, 1984.

Herbicide	Concentration kg ai ha^{-1}	% Ground Cover by Weeds Weeks after planting 5	7
Linuron	3.0	5	12
Linuron	4.0	4	24
Pendimethalin	0.7	19	47
Pendimethalin	1.0	27	35
Pendimethalin	1.7	14	46
Ametryn	3.0	14	47
Ametryn	4.0	20	48
Linuron + Pendimethalin	3.0 + 1.0	9	47
Ametryn + Pendimethalin	3.0 + 1.0	18	43
Oxadiazon	0.8	8	73
Oxadiazon	1.3	7	68
Linuron + Alachlor	3.0 + 1.4	7	64
Diuron + Alachlor	1.0 + 1.3	10	51
Grower's Check			
Ametryn	1.6	17	50
Hand Weeded Check		0	0
Non Weeded Check		55	57

At ten weeks after treatment application, the growth of Rottboelia exaltata was so aggressive, that the experiment was discontinued.

Results of the trial indicate that due to the large quantity of Rottboelia seeds per unit area and to the diversity in sprouting time of the seeds, an adequate weed management requires: a) proper soil preparation methods, b) use of inexpensive contact herbicides when the weeds are small, and c) use of residual herbicides.

Sweet Pepper - Fallow - Maize

Six herbicides applied postransplanting to sweet pepper at one or more concentrations each and in various combinations were evaluated at Las Zatras, Sabana Grande, Panama. They included chloramben, devrinol, oxyfluorfen, linuron + alachlor, and linuron + pendimethalin, as well as a hand weeded and a non weeded check. Treatments are presented in Table 31. They were applied eight days after transplanting. The main species in the experiment were Amaranthus spinosus, Eleusine indica, Digitaria sanguinalis, Echinocloa colonum, Momordica charantia, Malachra alceifolia, Melampodium divaricatum, Priva lapulacea, Rottboelia exaltata, Cynodon dactylon, Spilanthes americana, Lantana camara, Cenchrus brownii, Ipomoea sp., Sida rhombifolia, Cassia tora, Euphorbia hypercifolia, Cassia occidentalis and Calotropium muconoides. The two predominant species were Digitaria sanguinalis and Echinocloa colonum.

Oxyfluorfen and the combinations of linuron + alachlor or linuron + pendimethalin caused severe phytotoxicity to sweet pepper.

Results indicate that devrinol, by itself or in combination with chloramben could be an effective alternative for postransplanted weed control in sweet pepper. However, devrinol is primarily a grass killer, and results would have been different had the grass population

Table 31. Early post-transplanting herbicides evaluated in a sweet pepper (*Capsicum annuum*) experiment. Los Santos, Panama, 1984.

Herbicide	Concentration kg ai ha^{-1}	Yield kg ha^{-1}
Chloramben	3.5	2564
Chloramben	4.0	1795
Chloramben	4.5	2308
Chloramben + Devrinol	3.5 + 5.0	5641
Chloramben + Devrinol	3.5 + 8.0	8589
Devrinol	8.0	6795
Oxyfluorfen	0.6	321
Linuron + Alachlor	2.0 + 1.4	128
Linuron + Pendimethalin	2.0 + 1.0	0
Hand Weeded Check		4102
Non-Weeded Check		769

been greater. In addition, the sweet pepper yields were too low to support a preliminary herbicide recommendation.

Adaptative research on preplanting and postransplanting herbicides in sweet pepper is needed at Los Santos, Panama. However, due to the reduction of funds, the weed management component will only be able to offer technical support to the prototype team and to the national program, but will not be able to conduct any additional trials in Panama in 1985.

Tomato - Fallow - Rice

Five herbicides at various rates applied at postransplanting by themselves or in one combination were evaluated in tomato at a grower's field in La Jagua, Sabana Grande, Panama. The herbicides included metribuzin, chloramben, alachlor, prometryn and fluazifop-butyl.

Tomato seedlings were transplanted to the field on September 3, 1984 and the herbicides applied on September 19, 1984. The soil at the experimental site had a loamy clay to clay texture, was slightly acid and had 2.5 to 3.5% organic matter content.

The predominant weed species were *Amaranthus spinosus*, *Eleusine indica*, *Digitaria sanguinalis* *Momordica charantia*, *Rottboelia exaltata*, *Achyrantes indica*, *Malachra alceifolia*, *Priva lapulacea*, *Melampodium divaricatum*, *Lantana camara*, *Echinocloa colonum*, *Cyperus* sp., *Brachiaria rigurosa* and *Leptocloa* sp.

Prometryn at all application rates evaluated caused the death of the tomato seedlings. Chloramben at 2.5 kg ai/ha was not phytotoxic, at 3.5 kg ai/ha it caused severe phytotoxicity but did not kill the plants, while at 4.5 kg ai/ha it caused the death of the seedlings.

Among the treatments which did not cause phytotoxicity, the plots receiving metribuzin 1.2 or alachlor 1.0 kg ai/ha produced the least dry weight of weeds. Those treated with chloramben 3.5 or metribuzin 0.4 kg had the next lowest weed dry weights. Treatments receiving prometryn, those where no weed control was carried out, or where chloramben 2.5 kg ai/ha was used had the highest weed weights.

The experiment was discontinued after the evaluation due to poor growth of the tomato plants.

CROPPING SYSTEMS

Research in cropping systems was carried out in both the humid tropical zone in Costa Rica and in the Semiarid ecological zone in Esteli, Nicaragua.

HUMID TROPICS

The work in the humid tropics consisted of experiments with yams (*Dioscorea alata*), plantains (*Musa* AAB, BBA) and tanier (*Xanthosoma sagittifolium* Schott), carried out in San Carlos, Talamanca and Turrialba, Costa Rica. All of these crops are well adapted to the humid tropics and there is good export potential for yams, cassava and tanier. Work with plantains is justified by the importance in the diet, a stable local market, and a long tradition of production by limited resource farmers in the lowland humid tropical areas of Central America. Research was designed to increase the productivity of land planted to longterm crops such as plantains by associating a more quickly growing crop with the plantains or cassava. Such systems could provide income and opportunity for labor during the establishment stage of the long-term crop, hopefully without affecting its yield. A total of four experiments were harvested in 1984.

Table 32. Populations and yield of plantains and white tanier in association and in monoculture at 2 sites in San Carlos, Costa Rica.

Treatment	Populations plants ha^{-1}		LA PERLA			SONA FLUCA		
			Tanier yield (kg ha^{-1})		Plantain yield	Tanier yield (kg ha^{-1})		Plantain yield
	Plantain	Tanier	10 mos.	12 mos.	fruits ha^{-1}	10 mos.	12 mos.	fruits ha^{-1}
Farmer's (traditional system)association	1111	10928	5331b	9315b	39491b	7495b	7171b	34308c
Association in hexagonal pattern	1723	12750	4115b	7646b	57866a	6000b	6523b	47560b
Association in double rows	1732	11070	4406b	7463b	59340a	7288b	7525b	46707b
Plantain monoculture (hexagonal pattern)	1723				58703a			
Tanier monoculture (hexagonal pattern)		10752	10303a	15795a		12321a	15060a	52147a

Values followed by the same letter do not differ at 5% significance level by Duncan's Multiple Range Test

Table 33. Yield of maize, yield components of plantains and land equivalent ratios of different patterns of association and in monoculture at Hone Creek, Talamanca, Costa Rica.

		YIELD COMPONENTS OF PLANTAIN			
	Maize yield kg ha^{-1}	Weight of raceme kg ha^{-1}	Weight of raceme without rachis kg ha^{-1}	Fruits per hectare	Land equivalent ratio (L.E.R.) based on maize yield and plantain fruit per hectare
Traditional association plantain at 3m x 3m, maize at 0.5 x 1m	2178.3b	15473b	13864b	35009b	1.575
Hexagonal association plantain at 2.58 x 2.24 m maize at 1 x 0.5 m	1915.7c	21605a	20316a	49256a	1.752
Double rows plantain in double rows 4.57 m between double rows; 0.92 between rows within the double row, 2.13 m between plants. Maize at 0.5 x 1 m	2059.0cb	21285a	18916a	48705a	1.798
Monoculture maize 0.5 x 1 m	2476.0a				
Monoculture plantain in hexagonal pattern		22124a	20577a	50347a	

Values followed by same letter do not differ at 5% level by Duncan's Multiple Range Test.

a. Spacing of plantain (*Musa* AAB, BBA) and white tanier (*Xanthosoma sagittifolium* Schott) in San Carlos, Costa Rica

An experiment was planted at two sites in La Fortuna district, San Carlos canton, to test three plantings (traditional, hexagonal and double row) for association with white tanier. With the corresponding monoculture treatments, there were a total of 5 treatments. Results are given in Table 32. From the Table it can be seen that yields of tanier did not differ significantly in any of the associated systems but in all cases (both sites and both harvest dates), yields were significantly lower in the associated treatments than in monoculture. In the La Perla site, associations of tanier with plantains, in either traditional or hexagonal pattern, did not bring about significant reductions in plantain yields in comparison with monoculture. At the Sona Fluca, reductions were larger and were statistically significant at the 5% level.

The double row would appear to be the better method for association since it required fewer tanier plants to obtain the same yield as the hexagonal association.

b. Spacing of plantain (*Musa* AAB, BBA) in association with maize

The plantain-maize system is used occasionally by producers of the Atlantic zone of Costa Rica. An experiment with this association was established in 1983, in the town of Hone Creek, Talamanca, Costa Rica, where plantain is an attractive alternative to the traditional cultivation of cacao which has been severely attacked by Monilia pod rot. Three planting patterns for the association (traditional, hexagonal and double rows) were tested along with the respective monocultures. The results are presented in Table 33. The reduction in maize yields, although significant, were never more than

25% of the monoculture yields, while plantain yields only decreased significantly in the association when the traditional planting patterns were used. An economic analysis of the data showed the association in the hexagonal plantain planting pattern to increase net income per hectare by more than 75% over plantain or maize monoculture.

c. Effect of planting date and use of supports on production of true yam grown in association with cassava

Despite the fact that both true yam (*Dioscorea alata*) and cassava (*Manihot esculenta*) are well adapted to the humid tropics, the possibilities of growing these crops in association appears to have been little studied. While cassava is a well-established crop in the Atlantic zone of Costa Rica, prices vary considerably. The true yam enjoys more stable prices due to export possibilities. Association of the two crops, hopefully, would provide a more stable income to a small farmer of the humid tropical zone. Possibilities for association were studied in an experiment planted at the Montaña experiment station of CATIE in Turrialba in 1984. The treatments and results are given in Table 34. Yam population was 8100 plants/ha and cassava population was 10.000 plants/ha in all treatments. Cassava yields were reduced by 17 to 56% by the association with yam, while yam yields were reduced by more than 75% by any planting later than May, whether in monoculture or in association with cassava. The only treatment which showed any promise was the simultaneous planting of cassava and yam in May which produced 13.000 kg ha^{-1} of commercial quality cassava and 13.972 kg ha^{-1} of export quality yam, or 44% and 52% of the respective monoculture yields. Nevertheless this represents a L.E.R. of less than unity, which would generally be grounds for not recommending the association.

Table 34. Yield of marketable roots of cassava, export quality yams, and land equivalent ratios when associated at different planting dates.

	Yield of marketable cassava kg ha^{-1}	Export quality yam kg ha^{-1}	Land Equivalent Ratio
Cassava[1/] planted in May, yam[2/] in July	24361 ab	0 c	0.822
Cassava planted in May, yam in June	17941 bc	1164 c	0.648
Cassava planted in May, yam in May	13001 c	13972 b	0.955
Monoculture cassava planting in May	29627 a		
Monoculture yam planting in May		27079 a	
Monoculture yam planting in June		5415 c	
Monoculture yam planting in July		941 c	
Cassava planted in May and yam planted in July without stakes	22192 abc	0 c	0.749
Cassava planted in May and yam planted in June, without stakes	21906 abc	167 c	0.745

1/ Cassava planted in double rows 2.5 x 0.8 x 0.75 m

2/ Yam planted at 8100 pl ha^{-1}

Values followed by the same letter do not differ significantly by Duncan's Multiple Range Test at 5% level.

SEMIARID TROPICS

In the area of northeastern Nicaragua where the IFAD project has research and outreach activities, the principal cropping systems are maize associated with photoperiod sensitive sorghum, a sequence of two monoculture crops of common beans (*Phaseolus vulgaris*) and common beans associated with photoperiod sensitive sorghum (millon). These systems are of great importance in the drier zones of Central America, where most of the population is concentrated. The area planted to the maize-millon association in Guatemala, El Salvador, Nicaragua and Honduras, has been estimated at more than 200.000 hectares. Much effort has been spent by international (ICRISAT, INTSORMIL) and national research organizations in replacing the photoperiod sensitive sorghum with improved non-photoperiod sensitive varieties and hybrids. These have the advantages of higher grain yield potential, shorter stature, shorter growing period, and higher harvest index. Such efforts have met with limited success due to the advantages the traditional varieties offer in terms of biomass production for livestock feeding and lower risk due to their growth during a peroid of more reliable rainfall. Research effort of the IFAD project in the semiarid tropics have been dedicated to manipulation of the available materials to maximize grain and biomass production, reduce risk, and to understand the interactions involved which appear to favor the traditional systems and materials. The greatest part of the experimentation was with maize-sorghum systems due to their greater importance, but some research was also done with the bean-sorghum system, which involves less drought-susceptible crops than maize. Some of the experimentation was carried out in collaboration with the Latin American Commission of Sorghum Researchers (CLAIS) supported by ICRISAT through its Mexican office.

a. Aspects of competition in maize-photosensitive sorghum association

In one of the experiments, repeated at three sites in the Department of Esteli, maize populations were varied from 25,000 to 50,000 plants per hectare by varying seeding rates, planting arrangements and cutting-off plants 45 days after seeding. Populations of photoperiod sensitive and insensitive sorghums growing in association with maize were varied from 62,500 to 250,000 plants ha^{-1}. Treatments and yields are detailed in Table 35. Values followed by the same letter do not differ at the 5% level by Duncan's Multiple Range Test.

Maize yields were significantly reduced in all sites and treatments by reduction of population or clumping. Only by cutting off all sorghum plants at ground level, 45 days after planting could maize yields be maintained at the level obtained when 50,000 plants per hectare were planted at 0.8 x 0.5 m spacings with 2 plants per hill. Photoperiod sensitive sorghums outyielded non-photoperiod sensitive sorghum in all cropping arrangements, even when photoperiod sensitive populations were 25% of photoperiod insensitive population. Two succesive plantings of photoperiod insensitive sorghum outyielded one planting of the photoperiod sensitive sorghum in only one of the three sites.

It is rather difficult to estimate the economic consequences of replacing a system which favors maize with one which favors sorghum, since relative prices of maize to sorghum have declined from 4:1 to almost 1:1 in the 1983-1985 period. The treatment that maximized yields of both crops was that in which all photosensitive sorghum was cut off at ground level 45 days after planting. Maize yields were slightly increased over the monoculture system (treatment 1) in this system while the millon produced a rattoon crop which averaged 1869 kg ha^{-1} over the three sites. This treatment would appear to avoid

Table 35. Competition in maize - photosensitive sorghum and maize - photoinsensitive sorghum systems. Esteli, Nicaragua.

SORGHUM YIELDS

TREATMENTS		SORGHUM YIELDS KG/HA			$\bar{X}$
First Sowing	Second Sowing	Esteli	Trinidad	Limay	kg/ha
1. Maize 0.8 x 0.5 m. 2 plants/hill 50,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	1335	1338	1361	1344.7 c
2. Maize 1.6 x 0.5 m. 2 plants/hill 25,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	2068	2033	1001	1700.7 c
3. Maize 1.6 x 0.5 m. 3 plants/hill 37,500 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	2161	1524	1571	1752.0 c
4. Maize 1.6 x 0.5 m. 4 plants/hill 50,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	1890	1880	860	1543.3 c
5. Traditional system. Maize 0.8 x 0.8 m. 2 plants/hill - 50,000 pl/ha PPS* 0.8 x 0.5m - 2 plants/hill 125,000 pl/ha. Simultaneous alternative sowing		3198	3006	3101	3101.7 ab
6. Traditional system. 45 d.a.s. every other maize plant removed leaving 25,000 pl/ha + 125,000 pl/ha PSS		2973	2780	2905	2886.0 ab
7. Traditional system. All maize removed 45 d.a.s.		3398	2895	2946	3079.7 ab
8. Traditional system. 45 d.a.s. every other PSS plant removed leaving 62,500 pl/hill + 50,000 pl/hill maize		2639	1978	3526	2714.3 b

*PIS = Photoperiod Insensitive Sorghum
PSS = Photoperiod Sensitive Sorghum

Table 35. (cont).

T R E A T M E N T S		SORGHUM YIELDS KG/HA			
First Sowing	Second Sowing	Esteli	Trinidad	Limay	kg/ha $\bar{X}$
9. Traditional system. All PSS removed 45 d.a.s.		2346	1338	1024	1869.3 c
10. Fallow. Weed control with Gramoxone	PIS 0.4 x 0.1 m - 250,000 pl/ha	1502	1611	1446	1519.7 c
11. One row PIS 0.8 x 0.1 m. 125,000 plants/ha		3939	2619	3922	3493.3 a
One row maize 0.8 x 0.1 m. 125,000 plants/ha					
12. PIS 0.4 x 0.1 m - 250,000 pl/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	2410	2003	4213	2875.3 ab
LSD 5%		942	815	876	
MAIZE YIELDS					
1. Maize 0.8 x 0.5 m. 2 plants/hill 50,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	2338	1594	1181	1704.3 ab
2. Maize 1.6 x 0.5 m. 2 plants/hill 25,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	1325	1554	1272	1383.6 bc
3. Maize 1.6 x 0.5 m. 3 plants/hill 37,500 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	1564	1071	948	1194.3 cd
4. Maize 1.6 x 0.5m. 4 plants/hill 50,000 plants/ha	PIS 0.4 x 0.1 m - 250,000 pl/ha	1549	1225	1171	1315.0 bc
5. Traditional system. Maize 0.8 x 0.5 m. 2 plants/hill - 50,000 plants/ha PPS 0.8 x 0.5 m. 5 plants/hill 125,000 pl/ha. Simultaneous alternative sowing		719	764	335	606.0 e

Table 35. (cont.)

TREATMENTS		SORGHUM YIELDS KG/HA			
First Sowing	Second Sowing	Esteli	Trinidad	Limay	kg/ha $\bar{X}$
6. Traditional system. 45 d.a.s. every other maize plant removed leaving 25,000 pl/ha + 125,000 pl/ha PSS		963	1047	149	719.6 de
7. ----					
8. Traditional system. 45 d.a.s. every other PSS plant removed leaving 62,500 pl/hill + 50,000 plants/hill maize		1307	1249	757	1104.3 cde
9. Traditional system. All PSS removed 45 d.a.s.		2449	1796	1514	1919.6 a

Values followed by the same letter do not differ at $p \leq 0.05$ by Duncan's multiple range test.

competition between the species at the most critical stages of development of each.

An auxiliary study was carried out at the Esteli experiment station, in which photoperiod sensitive sorghum was planted with and without maize, on four successive planting dates, with and without irrigation. The trial was designed to separate water stress from other aspects of the competition between species. Results are presented in Figure 12. Photosensitive sorghum yields decreased with late planting dates even with irrigation and in the absence of maize.

Maize yields increased with later planting dates of sorghum. At the earliest planting date of the sorghum, irrigation affects yields of both maize and sorghum only slightly. Thus, sorghum established in June has probably developed a sufficiently deep and extensive root system to not respond to supplementary irrigation later in the season. But this vigorous growth adversely affects maize yields, and the competitive effect can not be wholly offset by supplemental irrigation. Later planted sorghum competes less with maize but both species respond to supplemental irrigation. At the latest planting date, response to irrigation was less, reflecting the sorghum's inability to compete with maize for other environmental resources when planted a month after the maize. The fact that July precipitation was 61.6 mm in comparison with 119.2 mm for August probably is responsible for the drop in the yield of sorghum at the third planting date.

b. Experiments on maize-sorghum systems in collaboration with Latin American Commission of Sorghum Researchers (CLAIS)

In 1983, the genotype specialist of the IFAD project participated in planning meetings of the commission in Mexico. Two types of trials were designed and the IFAD project assumed responsibility for the work in the Esteli area, which represented the Nicaraguan site for a five country (Mexico, Guatemala, Honduras, Nicaragua and Haiti) network. In one trial, five different

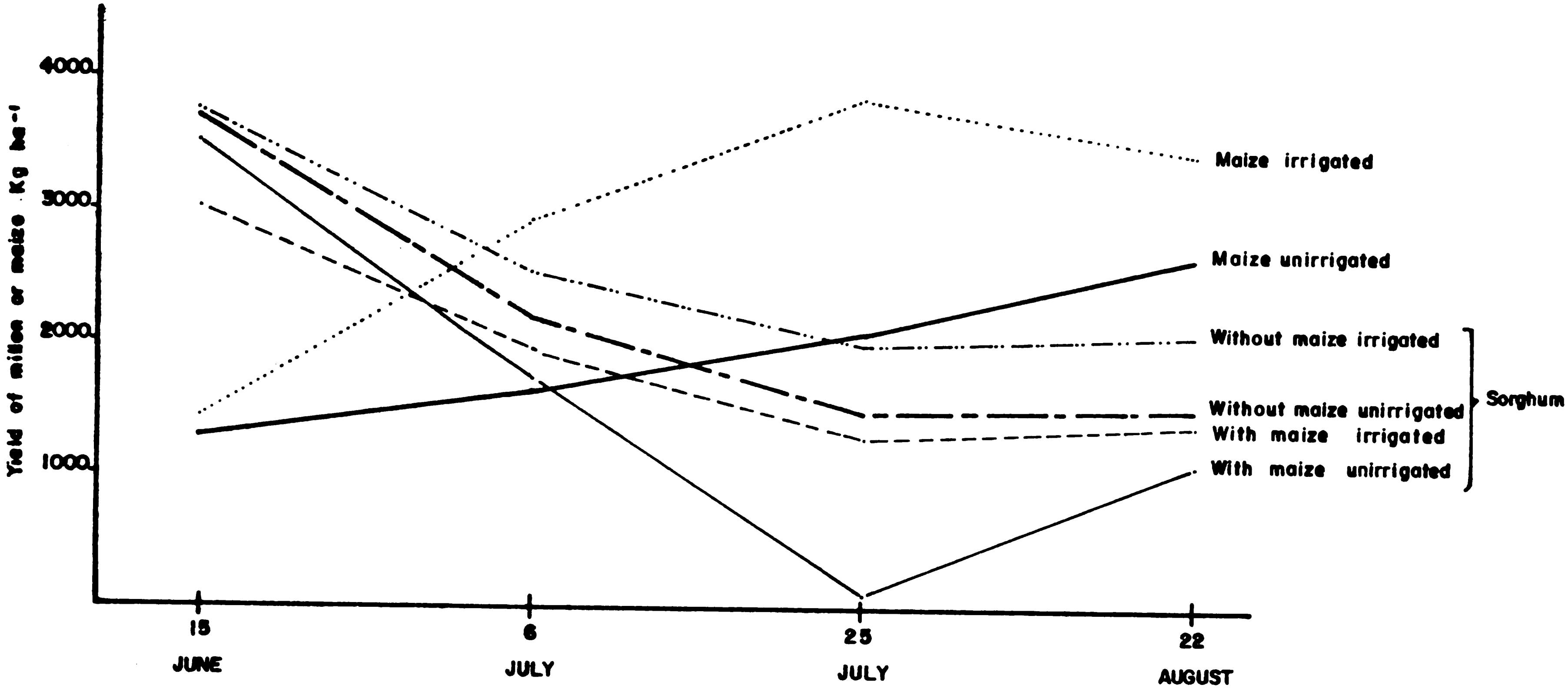

Figure 12. Effect of planting date of millon, association with maize, and irrigation on yields of maize and millon (photoperiod sensitive sorghum). Experiment Station, Esteli, Nicaragua (Vertic Haplustoll).

photosensitive sorghum varieties were planted with maize in different planting arrangements, simultaneous planting same row, simultaneous planting alternative rows, sorghum planting at hilling of maize in alternate rows. There were an additional 5 treatments with different non-photoperiod sensitive sorghum varieties planted following doubling over of maize ears. As in the previous trials, sorghum yields decreased while maize yields increased with late plantings. None of the photo-insensitive sorghums outperformed the best photoperiod sensitive sorghums planted at the same time as maize. Some of the photosensitive materials brought from El Salvador and Honduras outperformed the local materials and have since been multiplied for further testing. In the second trial, which apparently suffered from lack of water, there was a difference among varieties of photoperiod insensitive sorghum but no response to higher planting densities or nitrogen fertilization.

c. Sorghum-bean system

The sorghum-bean system is practiced less extensively than the maize-sorghum system but the characterization of the Esteli area showed it to occupy as much as 14% of the area planted to annual crops in certain communities in the Department of Esteli. CATIE made a recommendation for improving this system in a previous project in the Samulali area of Nicaragua. To test this recommendation and compare other alternatives, a trial was carried out in the Esteli station in 1983 and harvested in early 1984. Results are presented in Table 36. Planting in the first rains (June) always produced higher yields than in the second rains (September), even for photoperiod insensitive sorghum. Bean yields in the first planting were reduced by associating the sorghum in alternate rows, as in the CATIE alternative, but not by planting the sorghum in hills as is the local practice. As in the trials with maize, the photoperiod sensitive sorghums outyielded the non-photoperiod sensitive sorghum, except where there was no harvest of the latter. It would seem that planting

Table 36. Yields for beans and sorghum in systems experiment, Estelí, Nicaragua, 1983.

	Beans 1º kg ha^{-1}	Beans 2º kg ha^{-1}	SORGHUM PIS 1º kg ha^{-1}	SORGHUM PIS or PSS 2º kg ha^{-1}	Total Beans kg ha^{-1}	Total Sorghum kg ha^{-1}	L.E.R.
Bean - PIS in relay*	1221 a			1917 ab	1221 b	1917 b	0.988
Bean - PSS in relay*	1384 a			539 d	1384 b	539 c	0.777
Bean - PIS/Bean - PIS (rattoon) in alternate strips	779 b	735 c	1620 b	384 d	1514 b	2005 b	1.15
Bean/bean/PIS in alternate strips	1218 a	1194 a		464 d	2117 a	484 c	1.10
Bean/bean/PIS in hills 1 x 1 m	1305 a	867 bc		550 d	2171 a	550 c	1.14
Traditional system bean/PPS in hills 1 x 1 m	1306 a			2292 a	1306 b	2292 b	1.11
Bean-PIS/bean-PIS (rattoon) in hills 1 x 1 m	1308 a	787 bc	1419 b	282 d	2095 a	1701 b	1.35
PIS/PIS			3370 a	1253 c		4623 a	
Beans-beans	1357 a	1025 ab			2126 a		
PSS				1471 bc		1471 b	

*PIS = Photoperiod Insensitive Sorghum

PSS = Photoperiod Sensitive Sorghum

photoperiod insensitive sorghum in hills with beans in rows in first planting followed by allowing a rattoon of the sorghum when the second crop of bean is planted is the best method of combining photoperiod sensitive sorghum with beans. While producing more beans and value per hectare than the traditional system, it produces slightly less sorghum grain and considerably less sorghum biomass.

d. Stability of cropping system

Due to the year to year variability in rainfall, it was decided in 1984 that systems should be tested over several years to evaluate their stability over different conditions. Experiments were set up at two sites in 1984 and produced promising results, especially for sesame, a drought resistant crop with which the IFAD program had not previously worked. However, the degenerating political situation prevented the repetition of these trials in 1985, making the fulfillment of the objectives of this research impossible.

SOCIOECONOMIC COMPONENT

During 1984, the Socioeconomic Component of support research was involved in support to the other units of IFAD and one research project.

Research activities were conducted at Turrialba and in the specific work area of the Prototypes (San Carlos, Esteli and Los Santos). They included support activities and direct socioeconomic studies.

1. Support Activities

1.1 Support to Prototype Teams

Lowland Humid Tropics

Support was given to the Costa Rican group in follow-up studies on the predominant systems of production in San Carlos (cassava + maize, cassava + beans), economic analysis of experiments and in the planning of research for 1984-85.

Semi-Arid Tropics

Cooperation was given in Nicaragua in planning, follow-up studies (bean-bean, maize + sorghum and maize-potato), economic and statistical analysis of experiments, a diagnostic study of the potato introduction to the region and in training of the agricultural economist who began working for the Prototype Team at the beginning of the year.

Wet Dry Tropics

The Prototype Team in Panama received support of the socioeconomic component in follow up studies (data processing) in industrial tomato and onion. Statistical and economic analysis has been made of all field trials conducted since the beginning of the prototype team activities. Support has also been given in the planning of research for 1984-85.

1.2 Support to the PPD

Relatively limited support was given to the other components of IFAD or to other departmental projects. Support was given to the soil management component in economic analysis of experiments. In addition, two technicians were trained in survey design and implementation.

A partially documented joint publication was prepared in cooperation with the genotype specialist. The manuscript will be published during the first semester of 1985. It will serve as a basis for future research work by national institutions and the prototype team on cassava variety evaluation.

2. Socioeconomic Component Research

- Real cost of agricultural credit for small scale farmers in San Carlos

Results of this study have been discussed in the IFAD Annual Report for 1984 (pages 99-105). Further analysis has been carried out during 1984 and the following manuscript has been prepared in a preliminary way:

Meseguer, M., Navarro, L.A. and Rodriguez, A. Costs of agricultural credit and its relation to characteristics of small farms in Pital and Fortuna, San Carlos, Costa Rica, 1984. 34 p.

- Marketing Study for Cassava Varieties

Results of this study have been discussed in the 1983 IFAD Annual Report (pages 105-108) and the following manuscript has been repared:

Meseguer, M., Herrera, F. and Smith, M. Cassava quality pre-selection and evaluation based on variety trials. Preliminary report. CATIE, Turrialba, Costa Rica, 1984. 18 p.

Results of both publications were discussed in the IFAD Annual Report for 1983.

- Characterization of cassava cultivation systems in Fortuna San Carlos, Costa Rica

As support to the San Carlos prototype team and as a source in information to complement their area characterization, a study was made of cassava cultivation systems in Fortuna. The objectives of this work were as follows: a) to describe, both agronomically and economically, the cassava cultivation systems in the area; b) to determine their importance in relation to the whole farm; c) to distinguish two categories of farmers (those starting a cassava system and those who already cultivate a system) and to compare them agronomically and economically.

The work was carried out in the field during November 1983 and its subsequent analysis during 1984 formed the basis for the thesis of a student at the University of Costa Rica's Faculty of Agronomy.

A sample of 38 farmers, each with at least 50 ha of land, were interviewed to gain information about their farms in general and, specifically, about their current cassava cultivation practices. Fifteen of these farmers formed Category 1 (starting cassava cultivation) and the remaining 23 Category 2 (already cultivating cassava).

An initial general analysis was made to relate, at farm level, production resources characteristic of the farmer and his family, physical infrastructure and limiting factors to the categories established.

A more detailed analysis was made to describe and compare the cassava monocrop systems within these categories with respect to resource use, agricultural practices and economic indices.

Various characteristics of the farmers, their families and farms are summarized in Tables 37, 38 and 39. The average age of the farmers was 44 in both categories. However, variations appear between the categories where other characteristics are considered.

Mean labor availability was higher for Category 1 farmers, a characteristics related to the number of children.

In both categories, available land was mainly used for annual crop production and raising cattle. However, Table 38 shows that Category 1 farmers use a higher percentage of land area for annual crop production than Category 2 farmers.

Cassava and pasture were considered by both groups to be the most important crops, both as regards percentage of land use and number of farmers interviewed (Table 39).

Table 40 gives a summary of the characteristics of cassava system management as a monoculture for both categories of farmer.

Table 37. Characteristics of farmers, their families and farms from interviews carried out in La Fortuna, San Carlos, Costa Rica, 1984.

CHARACTERISTICS	CATEGORY 1	CATEGORY 2
Available labor (as man equivalent)	9.33	7.03
Number of children	5.3	4.7
Investment in farm (d)	1816.035	1663.806
Average farmer age	44	44
Average no. years in area	13.8	16.6
No. years in posession of land	5.3	6.4
Years of secondary schooling	2.6	3.1
Average farm size (ha)	10.4	8.8

Table 38. Average land distribution according to use. La Fortuna, San Carlos, Costa Rica, 1984.

Land Use	n = 15 CATEGORY 1 ha	n = 15 CATEGORY 1 % total	n = 23 CATEGORY 2 ha	n = 23 CATEGORY 2 % total
Annual Crop	4.8	43.8	3.4	39.3
Permanent Crops	2.4	22.2	1.5	16.9
Woodland/fallow	0.2	2.1	0.3	2.9
Cattle	3.0	27.6	3.2	36.2
Rented	0.03	0.3	0.2	1.7
	0.1	1.2	0.03	0.3
Buildings	0.3	2.8	0.2	2.6
	10.8	100.0	8.8	100.0

Table 39. Land utilization according to cultivation. La Fortuna, San Carlos, Costa Rica, 1984.

Crop	CATEGORY 1 (n=15)			CATEGORY 2 (n=23)		
	% area	% n	IIR	% area	% n	IIR
Cassava	26.8	100	26.8	17.7	100.0	17.7
Pasture	17.9	80	14.3	23.3	82.6	19.3
Taro	6.7	20	1.3	10.8	17.4	0.8
Cocoa	8.9	20	1.8	19.1	17.4	3.3
Maize	8.9	40	3.6	5.4	21.7	1.2
Plantain	11.4	60	6.8	8.3	34.8	2.9
Papaya	11.1	20	2.2	7.0	17.4	1.2
Rice	5.0	13	0.7	5.4	13.0	0.7
Banana	3.3	7	0.2	3.1	4.3	0.1

IIR = (% n x % area/100)

Table 40. Characteristics of cassava system management as monoculture practiced by farmers in La Fortuna, San Carlos, Costa Rica, 1984.

Practice	Category 1 (n = 15)	Category 2 (n = 23)
Soil Preparation:		
% use of machinery	93.4	87.0
Method of planting:		
Horizontal stakes (%)	80.0	82.6
Ave. no. stakes/ha	9333.0	9086.0
Distance between plants (cm)	83.0	83.0
% use of fertilizer	6.6	8.7
% controlling pests	56.0	33.0
Yields (kg/ha)	9545.00	8262.8

TRAINING UNIT

The training unit includes all the teaching activities and the preparation and distribution of PPD teaching aids. Its function within the project is to promote the use of information developed by the research component. Its general objective is to strengthen the technical capacity of the national institutions of the region through training events according to priorities established by the countries.

Its specific objectives are to:

- Support the educational activities of graduate school
- Train technicians from the national research and development teams
- Coordinate and obtain resources for the training activities of the PPD
- Develop documents and audiovisuals for use in training and technology transfer activities
- Document and distribute information related to project activities, research methodology and technology development

To meet these objectives, the following lines of action have been adopted: a) Support of graduate training and providing courses, b) Production of audiovisuals and c) Documentation and information.

SUPPORT OF GRADUATE TRAINING AND COURSES PROVIDED

Graduate Training

Graduate training operates through an agreement between the UCR and CATIE. The PPD mainly contributes with the graduate training in crop production. The department's participation in the Graduate School has been one of its principal activities since its founding by IICA.

Support to the Graduate School includes cooperation in curriculum formulation, cooperation in the formation of a thesis committee for each student and participation in all committees which contribute to the day to day running of the Graduate School.

1. Curricular Aspects

Twenty two graduate courses were offered to students during 1984. Seven were conducted by PPD personnel of whom three were members of the IFAD project. The four main areas of the courses were: background courses, general preparation, specific preparation and integration (see Table 41).

2. Thesis Advisory Committee

An advisory committee of four members was formed for each graduate student. Table 42 shows the major professor and members of the advisory committee for each student within each class. Eighty percent of the students have at least one committee member belonging to IFAD and 25% have a major professor belonging to IFAD.

3. Master's Thesis

During 1984, IFAD personnel participated in the following committees:

a. Qualifying exam

b. Interdepartmental teaching

c. Candidate evaluation for admission to the graduate program

During 1984 there were 28 students, four of whom received scholarships from IFAD funds. A total of eleven theses were prepared

Table 41. Graduate courses offered during 1984.

IV. Trimester December - February, 1983-84		
1.	Soil management and soil physics	D. Kass
2.	Physiology of Crop Production	E. Villalobos
3.	Thesis seminar	M. Meseguer
4.	Soil genesis and classification	A. Alvarado
5.	Soil chemistry	E. Bornemisza
I. Trimester March-May, 1984		
6.	Advanced general mathematics	F. Quesada
7.	Technical english	A. Erickson
8.	Use of scientific literature	A.M. Arias
9.	Soil fertility and productivity	A. Cordero
10.	Crop Seminar: Pest management	J. Saunders
11.	Plant breeding	G. Enríquez
12.	Agrosilvopasture systems	R. Borel
13.	Thesis seminar	
II. Trimester June-August, 1984		
14.	Systems of agricultural production, I	T. Schlichter
15.	Soil microbiology	C. Ramírez
16.	Statistics	M. Baldares

17.	Ecology	G. Budowski
18.	Technical writing	R. Borel and M. Gutiérrez

III. Trimester September - November, 1984

19.	Systems of Production, II	J. Arze
20.	Weed control	A. Soto
21.	Disease control	J. Galindo
22.	Experimental design	M. Baldares
23.	Phytoclimatology	J. Heuveldop

Table 42. Thesis committees for graduate students class of 1983-85.

Students	Major Professor	THESIS COMMITTEE		
		1º	2º	3º
Araya Sánchez, J.F.*	D. Kass	J. Heuveldop	T. Schlichter	J. Arze
Cajar Sierra Araiz*	M. Rodríguez	R. Díaz-Romeu	A. Alvarado	W. Bejarano
Carmona Solano, A.**.	L. Müller	J. Galindo	J. Fargas	J. Arze
Castañeda Cowoh, A.**	A. Soto	J. Saunders	A. Beale	M. Rodríguez
Fuenmayor Fuenmayor, E.*	J. Arze	J. Fargas	R. Moreno	J. Henao
Gómez Flores, M.A.**	L. Navarro	J. Arze	R. Moreno	G. Escobar
González Orellana, A.E.	G. Enríquez	E. Valverde	R. Salazar	
Martínez Salazar, G.	E. Bornemisza	J. Henao	A. Alvarado	R. Díaz-Romeu
Morera González, N.M.**	J. Fargas	G. Enríquez	J. Arze	D. Kass
Palmieri Reymond, V.**	T. Schlichter	J. Henao	A. Cordero	J. Arze
Phillips Mora, W.**	J. Galindo	G. Enríquez	J. Saunders	J. Arze
Porras Humaña, V.H.	L.C. González	G. Enríquez	J. Galindo	J. Soria
Ramírez Obando, P.**	R. Hawkins	T. Schlichter	J. Heuveldop	D. Kass
Rodríguez Fuentes, H.**	J. Saunders	M. Rodríguez	J. Henao	R. Díaz-Romeu
Treviño, Ramírez, J.E.**	G. Enríquez	M. Rodríguez	H. Heinze	J. Echeverri
Yañez Méndez, H.,R.**	C. Burgos	J. Saunders	M. Rodríguez	R. Díaz-Romeu
Zelaya Blandon, D.*	J. Arze	D. Kass	A. Beale	M. Meseguer

*Major professor from IFAD

**One or more members of the committee from IFAD

TABLE 42 (cont). Thesis committees for graduate students class of 1984-86.

Student	Major Professor	THESIS COMMITTEE 1º	2º	3º
1. Berrios Pérez, A.	L. Müller	J. Fargas	G. Enríquez	G. Sánchez
2. Morales Sánchez, M.A.*	A. Cordero	M. Rodríguez	C. Ramírez	D. Kass
3. Herrera Murillo, F.*	A. Beale	F. Rosales	J. Galindo	J. Fargas
4. Pardo Tasies, J.**	G. Enríquez	J. Galindo	M. Rodríguez	R. Martínez
5. Jiménez Otárola, F.**	J. Fargas	J. Arze	R. Díaz	M. Rodríguez
6. Marenco Mendoza, R.	J. Saunders	T. Schlichter	J. Fargas	E. Somarriba
7. Heer Arana, C.*	J. Arze	J. Fargas	C. Burgos	D. Kass
8. Nieto Cabrera, C.**	J. Fargas	J. Arze	G. Enríquez	R. Borel
9. Barón Ramírez, J.E.*	D. Kass	J. Arze	G. Sánchez	J. Fargas
10. Quirós Conejo, Ś.**	G. Enríquez	J. Arze	J. Fargas	J. Galindo
11. Jiménez Mora, J.M.**	G. Enríquez	J. Galindo	J. Saunders	M. Rodríguez

*Major professor from IFAD

**One or more members of the committee from IFAD and approved for the M.Sc. degree in the PPD. Of these 64% were directed and financed by IFAD (see Table 43). A further 17 thesis projects are in progress, six of which are directed and/or financed by IFAD (see Table 44).

In addition to graduate student support, personnel supported and directed 29 Licenciatura thesis in agronomy at the University of Costa Rica, the National University of Costa Rica, the Technological Institute of Costa Rica and the University of Panama. Of these twenty six (90%) had both technical and financial support from IFAD.

Courses Provided

During 1984, 30% of the training events carried out had technical/financial support from IFAD while an additional 10% had partial support. A summary of short term training offered during 1984 is shown in Table 45.

Most of the events were short courses with an average of 18.5 participants per event, for a total of 203 participants. A summary of short courses provided by the PPD during 1986 appears in Table 46. Just over half of the events related to cocoa production (48%) and coffee production (4%). There were 133 participants -34% in cocoa and 5.6% in coffee production. Seven events related to research methodology in production systems and had 147 participants. Crop protection, plant breeding and soils amounted to 18% of the events with 56 participants.

In addition to short courses, a second intensive twelve week course on research and technology Development for Crop Production Systems was held in Turrialba from August to October, 1984. The course was financed 60% by IFAD and 40% by the Kellogg Foundation. It included:

Table 43. Master's theses completed during 1984.

Student:	Georges Bruno Bolívar
Thesis Title:	Methodology to evaluate the effect of Meloidogyne exigua Goeldi in coffee
*Student:	Jorge Aldunate Deromedis
Thesis Title:	Establishment and management of velvet bean (Mucuna sp. L.) as a live cover for weed control in maize (Zea mays L.)
*Student:	Milton Geraldo Ramos
Thesis Title:	Sorghum (Sorghum bicolor L. Moluch) germplasm tolerance to oxygen deficiency resulting from water saturation of the soil
*Student:	Mary Quinlan
Thesis Title:	An evaluation of tropical tree species, the leguminous Erythrina poeppigiana and non-leguminous Gmelina arborea, as sources of nitrogen for production of maize (Zea mays L.)
Student:	Jorge A. Arce Portuguez
Thesis Title:	Characterization of 81 achiote (Bixa orellana L.) plants from CATIE's collection from Honduras and Guatemala, and vegetative propagation through slips
Student:	Orlando López Báez
Thesis Title:	Heretability of some properties of cocoa (Theobroma cacao L.) seeds
*Student:	José Nilson de Melo
Thesis Title:	Effect of the maize height and distance between rows on the growth and yield in the maize (Zea mays) + vigna (Vigna unguiculata L. Walp) system

* Thesis financed or directed by IFAD scientists

Table 43. (cont.)

*Student:	Werner Rodríguez Montero
Thesis Title:	Interactions between components of a cassava (*Manihot esculenta* Crantz) - vigna (*Vigna unguiculata* L.) association on their growth habits
*Student:	Roberto Rodríguez Sandoval
Thesis Title:	Adoption of technical recommendations in the basic grains and its effect on the management and income of small farms in El Salvador
Student:	Renán Aguero Alvarado
Thesis Title:	Evaluation of various tillage systems in dry rice in rotation with forage sorghum
*Student:	José Soto Acosta
Thesis Title:	Variability in the establishment of plants and in the yield components of purple fleshed cocoyam (*Xanthosoma violaceum*) according to the type of planting material

Table 44. Thesis topics of graduate students from the class of 1983-85.

**1. Araya Sánchez, José Fernando. Effect of Gliricidia sepium in a maize-bean system in succession in Gilagueral, Puriscal.

2. Cajar Sierra, Araiz. Study of the soils from a topographical sequence from Los Santos, Panama.

3. Carmona Solano, Alvaro. In vitro culture of Elaeis guineensis and of the interspecific hybrid (E. guineensis x E. oleifera).

4. Castañeda Cowoh, Anselmo. Study of five methods of weed management on the maize and adzuki bean (Vigna angularis) system under zero tillage.

5. Fuenmayor Fuenmayor, Emérita. Influence of microclimate on the physiological behavior and yield of common bean (Phaseolus vulgaris) associated with 3 maize (Zea mays) genotypes.

6. Gómez Flores, Manuel A. Analysis and feedback of technology transfer for the first cycle maize system based on the evaluation of the results obtained in Pococi, Limón.

7. González Orellana, Aura E. Evaluation of yield and Capsaicine content of ten hot pepper (Capsicum spp.) introductions.

**8. Martínez Salazar, Guillermo. Nitrogen dynamics in a soil under the maize-cucurbit system.

*9. Morera González, Nidia M. Physiological and morphological response of several soybean varieties under various flooding conditions.

10. Palmieri Reymond, Viviana. Energy balances and some responsible factors in rural areas.

11. Phillips Mora, Wilbert. Biological control of cacao moniliasis.

12. Porras Umaña, Víctor H. Tolerance stability of cacao cultivars to Monilia roreri in two regions of Costa Rica.

13. Ramírez Obando, Patricia. Development of yield models for the maize, sorghum and vigna associations using rainfall and humidity as parameters.

14. Rodríguez Fuentes, Humberto. Relationship among soil fertility, pests and various tillage systems.

15. Treviño Ramírez, José E. Embryological studies and tissue culture of Coffea arabica and Coffea conephora.

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* Financed and directed by IFAD scientists

** Financed partially by IFAD

Table 44. (cont.)

16. Yanez Méndez, Herbert R. Soil and residue management and their effect on the physical properties and the incidence of pests in an Inceptisol.

17. Zelaya Blandón, Donald. Evaluation of root and light competition in crops associated with maize under simulated conditions.

Table 45. Participants and number of training events carried out during 1984.

Type of Event	EVENT		PARTICIPANTS	
	No.	Duration-Ave. (Days)	Total	Ave./Event
Short courses	11	15.5	203	18.5
Seminars/Workshops	3	4.7	85	28.3
Meetings	1	2.0	15	15.0
In-service training	8	18.0	33	4.1
Average		14.3		14.6
Total	23		336	

TABLE 46. Short courses provided by PPD during 1984

Title of content of the course	Participants		Place, date of initiation and duration	Financing
	Number	Type and institution represented		
Cacao Production	30	One agronomist and 29 farmers, Costa Rica	Pejibaye and Turrialba March 5 to 9	IDA-MAG
Soil Conservation	15	Agronomists from MIDINRA, Nicaragua	Esteli, Nicaragua March 9 to 23 March 26 to 30	IFAD
Research methodology and technology development for production systems	26	Researchers, extensionists and teachers. 24 from the Secretaría de Recursos Naturales and 2 from the Escuela Nacional de Agricultura, Honduras	Olancho, Honduras March 26 to 29	IFAD
Cacao Production	32	Researchers, extensionists and teachers from ANACAFE, the Coffee Rust Committee, ICTA, DIGESA and the University of San Carlos, Guatemala	Chocola, Guatemala June 11 to 15	KELLOGG
Cacao Production	7	Researchers and producers, University of San Carlos, DIGESA, BANDESA, private sector	Chocola, Guatemala June 11 to 22	KELLOGG
Fundamentals of Modern Coffee Production	19	Researchers, extensionists, teachers from MAG, universities and research institutions	Turrialba July 2 - August 10	PROMECAFE

TABLE 46. (Continued)

Title or content of the course	Participants		Place, date of initiation and duration	Financing
	Number	Type and institution represented		
Intensive course in research and development of technology for cropping systems	20	Researchers, extensionists and teachers: 5 from universities, 9 from ministries of agriculture and 6 from research institutions	Turrialba August 6 - Oct. 26	KELLOGG
Agricultural entomology training in insect taxonomy	18	Researchers and teachers from MAG, universities, CATIE	Turrialba October 1 to 12	ROCAP
Cacao Production	6	Agronomists NANI	La Lola October 15 to 19	~~NANI~~ ANAI
Weed Management in Systems of Production of Small Farms	22	Researchers and extensionists from research institutions, ministries of agriculture, and universities from Central America, Mexico, Panama and the Caribbean	Turrialba November 5 to 24	FAO, IFAD, IPPC
Cacao Production	8	Agronomists and farmers NANI	La Lola November 26 to 29	~~NANI~~ ANAI

1. Basic, concepts of methodology

2. Support, general disciplines (economics, statistics, etc.)

3. Complement for specific disciplines (crop protection, soil science, physiology, etc.)

4. Case studies on methodology applciation

5. Practical work and field visits

6. Evaluation

Twenty students participated, 12 from Central America, 3 from Panama, 4 from the Dominican Republic, and one from South America. An attempt is being made to present the course in other countries of the region, either in parts or through a work study program. Previous experience in Honduras, Guatemala and El Salvador indicate that teaching the course by parts shows promise.

PRODUCTION OF AUDIOVISUALS

The PPD began this line of work in 1983 and, with IFAD support, has been able to intensify activities throughout the year. Work has included the purchase and preparation of audiovisual aids to form a collection for teaching purposes (aids have also been prepared at other institutions).

The following material were prepared during 1984:

a. 300 slides for 10 training courses

b. Two audiovisuals: Area Selection and Methodology, CATIE

c. Layout, art work and edition of 7 documents on area characterization in the Central American Isthmus

d. Layout, art work and edition for the Forum on Soil Taxonomy

e. Layout and art work for the documents on the characterization and agricultural bibliography of San Carlos

f. Layout and art work of documents for the Documentation Center

g. Slides for training activities conducted by national groups in El Salvador, Honduras and Nicaragua

h. A guide to organizing photographic materials for the scientists working on various PPD projects

DOCUMENTATION AND INFORMATION

During the last four years, the PPD created a Center for Documentation and Information aimed at disseminating information about PPD crop production of the PPD. Its objectives are to provide documentation and information relating to crop production systems for the countries of Central America and the Caribbean and to support the maintenance of a data base for the PCCMCA.

Five hundred and eight requests for documents were received, and a total of 10147 documents were sent throughout Central America, the Caribbean and other Latin American countries during 1984.

On a monthly basis, a list of newly acquired publications is compiled and distributed to maintain a continuous service with international centers.

DOCUMENTS PRODUCED BY THE PPD

A total of eleven documents have been prepared, edited and published during 1984 with the support of IFAD funds. Of these, nine were area characterization studies resulting from the work of the Prototype Teams and two were bibliographies.

A further five documents (description of alternatives in the areas) are currently in press and eight documents are in the process of being published.

OUTREACH COORDINATION

The functions of the outreach coordinator and the general approaches adopted to fulfill the objectives of this component have already been discussed in depth in the 1983 Annual Report (see pages 132-134). An inventory of his activities during 1984 is given below.

Inventory of 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 CATIE's mandate area; 2) representation of PPD and CATIE in technical and coordination meetings, seminars and field days; 3) interviews with the professional personnel of the PPD assigned in each country, particularly the prototype teams, in order to communicate instructions and coordinate the activities; 4) project evaluation by national institutions or by CATIE; 5) participation in departmental training activities, including planning and coordination; 6) organization of a second meeting of the working group held in Guatemala City; 7)

TABLE 47. Outreach coordination and other outreach activities, not including research and training, developed by the Plant Production Department under IFAD Grant, 1984.

Activity and main purpose, by country	No. of events and representatives for PPD		Type of personnel contacted and number			Institution Contacted
			Dir./Adm.	Staff/Farm	Total	
1. Meeting for coordinator of activities with Prototype Teams						
a. Costa Rica	2	OC		5	5	CATIE
b. Nicaragua	1	OC		2	2	CATIE, DGA
c. Panama	2	OC		5	5	CATIE, IDIAP
2. Meeting with personnel from different institutions at country level and CATIE outreach staff						
a. To organize working group and committee meeting in Guatemala						
Costa Rica	1	OC	3		3	MAG, CATIE
El Salvador	1	OC	3	2	5	CENTA, CATIE
Guatemala	1	OC		2	2	ICTA
Honduras	1	OC	1		1	PNIA
Nicaragua	1	OC	2	1	3	DGEIA
Panama	1	OC	1	2	3	IDIAP, CATIE
b. Revision/evaluation of specific projects	1	OC		3	3	CATIE

OC = Outreach Coordination

TABLE 47. (Continued)

Activity and main purpose, by country	No. of events and representatives for PPD		Type of personnel contacted and number			Institution Contacted
			Dir./Adm.	Staff/Farm	Total	
c. To represent the PPD in planning evaluation meetings for national institutions						CATIE, IICA, TECNOANARG
Panama	1	OC, I	6	5	11	IDIAP, CATIE
Guatemala	1	OC	2	2	4	USC, CATIE
Nicaragua	2	OC	8		8	CIID, CATIE, DGA, DGEIA, TECNOANARG
Honduras (Annual Meeting)	1	OC, I	5	15	20	SRN, AID, CIMMYT, CIAT, EAP, CATIE
Costa Rica	2	OC	1	5	6	CIAT, EAP, CATIE, ITCR, MAG
d. Participate in the planning and coordination meeting of the PPD and national institutions						
Costa Rica	3	OC, I	15	6	21	MAG, ITCR
El Salvador	2	OC, I	14	3	17	AID, OSPA, CENTA, CATIE
Panama	3	OC, I	5	9	14	IDIAP, CATIE
3. Representation of the PPD in field days, seminars and other meetings with professionals or farmers						
Costa Rica	1	OC		4	4	MAG, CATIE
Guatemala (Consultant meeting)	1	OC, I	9	10	19	DGEIA, IDIAP, MAG, CENTA, PNIA, ICTA, CATIE
Panama (Rio Hato)	1	OC	4	10	14	IDIAP

TABLE 47. (Continued)

Activity and main purpose, by country	No. of events and representatives for PPD		Type of personnel contacted and number			Institution Contacted
			Dir./Adm.	Staff/Farm	Total	
4. Consultancy services or technical assistance based on specific demand by countries or international institutions						
Panama	1	OC		1	1	-IDIAP
5. Meetings with specific interest groups in research and development						
Mexico (sorghum+millet)	1	OC, I	6	10	16	-CIMMYT, CIAT, INTSORMIL, ICRISAT
El Salvador (system of sorghum+millet)	1	OC	8	12	20	-CENTA, ICIRSAT, ICTA, INTSORMIL
Honduras (GEPLACEA)	1	OC	8	12	20	-GEPLACEA
Hawaii (IBSNAT)	1	OC	6	15	21	-IBSNAT
6. Meeting of coordination of activities with other international institutions						
Guatemala	1	OC	4	4	8	-AID-ROCAP, CATIE
Costa Rica	1	OC, I	2	2	4	-CEE, CATIE
7. Participation in international professional meetings or courses in different disciplines						
Nicaragua, Italy, Venezuela	3	I			MANY	-PCCMCA, NATO ADVANCED STUDY INSTITUTE

motivation support and participation in meetings of professionals in Central American countries.

An inventory of these activities is summarized in Table 47. They include the participation of all of the professionals in the project. In addition to the activities reported in Table 47, members of the project have received visitors interested in different aspects of the project and the general work of CATIE.

Second Meeting of the Cropping Systems Research and Technology Development Working Group for the PPD

Participation, organization and coordination of the second 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. This meeting was held in Guatemala City, July 17 and 18, 1984.

Participants at this meeting included directors, subdirectors and coordinators of agricultural research and extension from all of the Central American countries. The number of participants from each country was: Costa Rica 2; Panama 2; Nicaragua 1; Honduras 3; El Salvador 2; Guatemala 5. The most important objectives of this second meeting were:

1. To maintain the interest aroused by the first meeting and consolidate progress made in specific areas

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

3. To exchange experiences and comments of the group concerning the methodology used by the PPD

4. To establish the basis for the future activities of the working group

The recommendations of the group were as follows:

A. Concepts of technology validation/transfer

1. Despite the existence of some differences in terminology with respect to validation/transfer, the group agreed that validation is the last step of the research process and the first step of indirect transfer in all stages of technology development

2. After much discussion about the meaning of technology transfer the group concluded that: (a) it is a broad concept, subject to different interpretations, which could be the subject of a future meeting of the working group and (b) several different methodologies could be used in technology transference

3. Figure 13 was proposed to clarify the interrelationships of the various components of validation and technology transfer

- Validation transference has the following objectives in order to integrate the actions of the research and extension processes: (a) to compare the proposed improved technology and traditional technology in the agroecological and socio-economic conditions of the area and (b) to provide national institutions with the results which should lead to an improvement of extension methods

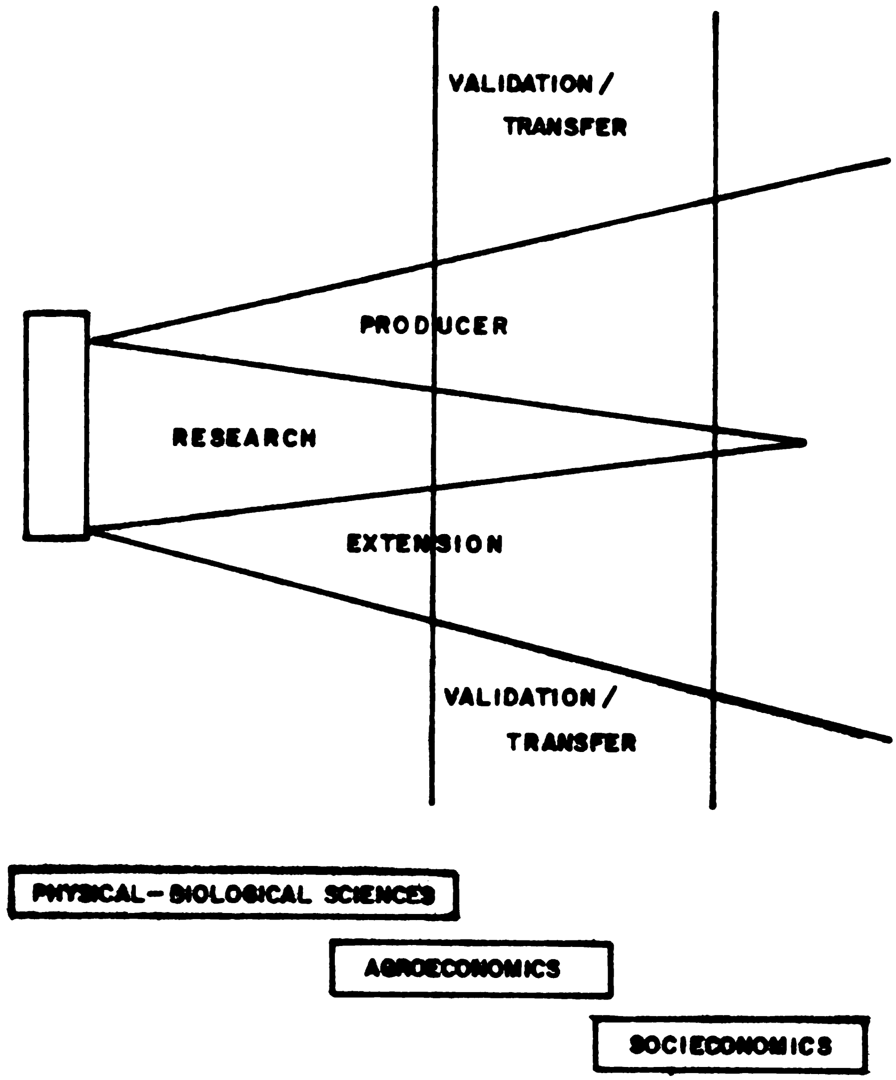

Figure 13. Position of Validation/Transfer in the process of technology development.

B. Methodology of validation and technology transfer

1. Two types of teams are needed for validation and technology transfer. A field team with an extension researcher and auxiliary personnel and a multidisciplinary support team with specialists in such disciplines as agricultural economics, statistics, plant pathology, etc.

2. Sources of innovations for validation and transference:

   a. Many researchers already have results which have not yet been validated but could be

   b. Problems identified in diagnostical surveys

   c. Experience and practices of the most progressive or innovative farmers in the area

   d. Information generated by regional programs. This leads to less duplication of effort by national institutions

3. Selection of cooperating farmers:

   a. This is a very important point in the validation technology transfer process and requires the services of professionals in anthropology and rural sociology

   b. Cooperatives and farmers' associations should also participate in the validation process so long as they are representative of farmers in the area

   c. Selection of farmers should be random and should involve a sufficient number for a good evaluation of possibilities of adoption and acceptance of the proposed technology

d. Participating farmers should have some of the following characteristics:

- They should be receptive and disposed to collaborate. Farmers should accept some kind of obligation to participate in evaluation but not be given full responsibility for the process

- They should be communicative so that the results of validation will be spread through the communities

- They should have credibility and be influential in the community

4. Obtaining and processing the required data

a. A dynamic mechanism is required which includes periodic visits and registration of significant information at all stages of the activities affected by the innovation

b. Analysis of the data should be rapid and complete so as not to constitute a bottleneck in the validation-transfer process

- Use of computers is probably necessary

- Personnel will have to be trained in analysis and interpretation

- Results will have to be published in forms accesible by researchers, extensionists, financing agencies and farmers. National programs probably need training assistance in this area

c. Types of information required by the validation process

- Basic information, which comes from the characterization of the area, research results and present farmers practice

- Information obtained during the validation process the principal results from technical and economic considerations of the innovations and the farmer reaction to them

- Information obtained after the validation transfer process. This is a follow-up procedure which measures the level of adoption by participating and non-participating farmers and determines the reason for acceptance or non-acceptance

d. Final recommendations of the working group

- A future meeting, specifically dedicated to transference of technology. This should include a seminar with participation by international experts in this area. It was felt that the help offered by international institutions in research activities has not extended to areas of validation and technology transference

- Activities of "extension", "transference", "difussion", and "adoption" should be well defined and known to researchers and extensionists

- CATIE should develop appropriate methods for technology transference and validation which could be used in Central America and the Caribbean

- Training is needed in the area of validation and technology transference at the national level. CATIE should provide this training

OPERATIONAL SUPPORT UNIT

The Operational Support Unit was established to assist the Head of Department and technical personnel of the PPD with the many administrative and logistic support activities that they had to undertake, minimizing undue delays in activities of a technical nature.

Personnel of this unit have the following functions:

1. Assistant Project Manager. To assist the Head of Department and Coordinators of PPD projects in the preparation of annual budgets for each project and the core budget. Control records of the budgeted outlay during the year so that project coordinators may make necessary modifications. Assist the technical residents in the management of the funds for activities in each country. Review monthly bank account statements sent by the technical residents, supervise their processing by the administration and arrange reimbursements to each technician.

2. Administrative Assistant. Deals with all documents referring to the hiring of personnel. In conjunction with CATIE's Personnel Office, he authorizes vacations, sick leave or other types of leave of absence. He is in charge of the paper-work involved in the extension or termination of contracts both at Turrialba and in the countries. Prepares all field and office purchasing requisitions, for material and equipment, both at the national and international level.

Continues supervision until the purchases are delivered to the technician ensuring that they arrive at the time and place where they are needed.

Secretarial Support

The PPD has twelve secretaries, each generally working for five technicians. They include receptionists, typists and documentalists. In some instances, they have additional administrative duties such as field hand payroll and petty cash control. In addition, there is a secretary in charge of filing documents, and another in charge of internal mail services and photocopying.

The year 1984 was a transition period not only for the new CATIE administration, but also for those already working at the Institute. The new administration implemented new administrative procedures to which personnel had to adjust. The new procedures are more organized and easier to control than the previous ones.

The 1985 budget was drawn up during 1984 making use of computer terminals. It was calculated in a more organized way than in previous years with greater project participation.

Reorganization of the control systems of the Unit of Commercial Relations and Building, Instalations, Vehicles and Equipment Management was begun during the year. The role of the Administrative Support Unit was very valuable, the administration informed of the problems and the benefits resulting from the new systems implemented at CATIE.

During the year, the administration organized an administrative committee in which all departmental administrative assistants participated in conjunction with all heads of unit at the Institute. The committee meets every 15 days. During the meetings, documents such as the Operative Plan for 1895, Rules of Transportation and

Guidelines for the next ten years were discussed. Attempts are made to solve problems caused by lack of familiarity with the new systems or misinterpretation of the data as they arise.

The distribution of expenditure by budget item over the 12 months from January through December 1984 is presented in Table 48. Table 49 contains a summary inventory of equipment purchased during this period and Table 50 lists the personnel financed under the IFAD Grant to CATIE.

TABLE 48. Expenditure (US$) distribution by budget item and by month during the January - December period for the IFAD Grant, 1984

	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL
100	37.428.12	35.187.22	30.675.21	31.663.16	30.991.74	44.107.98	47.089.68	43.685.37	63.361.55	44.515.54	44.949.82	109.476.09	563.131.48
200	2.067.18	2.066.89	2.869.85	4.771.76	2.765.97	3.165.79	3.414.61	8.223.32	7.653.19	6.636.36	6.701.23	24.449.63	74.785.78
300	528.81	4.104.70	2.210 25	6.868.60	5.165.30	8.712.96	6.043.14	11.970.09	17.067.99	19.252.39	6.216.13	13.015.59	101.155.95
400	32.06	837.35	930.34	2.916.06	2.513.42	2.472.72	16.293.92	2.097.42	11.830.47	1.765.59	4.482.74	134.680.01	180.851.10
500 + 700	4.857.05	4.128.65	16.257.28	6.299.83	2.932.30	13.127.95	8.523.34	8.711.90	10.238.37	6.026.76	17.730.41	52.201.24	131.035.08
600	2.613.93	2.781.63	3.042.91	4.702.29	3.985.20	3.392.66	3.228.19	9.998.16	5.408.60	6.987.56	10.273.32	24.557.12	80.971.57
800	16.666.67	16.666.67	16.726.67	16.666.67	16.666.67	16.666.67	16.666.67	16.666.67	16.666.67	16.666.67	16.666.67	16.666.67	200.060.04
900		6.119.22	900.10	650.90	1.931.69	996.53	258.39	802.13	884.11	1.508.67	1.029.51	824.60	15.905.85
TOTAL	64.193.82	71.892.33	73.612.61	74.539.27	66.952.29	92.643.26	101.517.94	102.155.06	133.110.95	103.359.34	108.048.83	375.870.95	1.367.896.85

100 = Salaries and benefits
200 = Training
300 = Travel
400 = Equipment and vehicles
500 = Communication and supplies
700 = Communication and supplies
600 = Operation and maintenance, equipment and vehicles
800 = Administrative and logistical support
900 = Miscellaneous items

Table 49. Summary inventory of equipment purchased during 1984 under the IFAD 38-C Grant to CATIE

TYPE OF EQUIPMENT	EXPENDITURE US$
Office equipment	51,000
Field and laboratory equipment	34,000
Vehicles	13,000
Audiovisual equipment	17,000
TOTAL	115,000

TABLE 50. PLANT PRODUCTION DEPARTMENT PERSONNEL FINANCED UNDER IFAD GRANT TO CATIE

GRANT COMPONENT AND NAME	POSITION	LOCATION	DATES OF ASSIGNMENT	
			INITIATION	TERMINATION
Prototype Teams				
Rolando Araya (Ing. Agr.)	Crop Protection Specialist	Costa Rica	04-01-82	
Byron Argüello (Ing. Agr.)	Crop Protection Specialist	Nicaragua	25-01-82	
Luis Barrientos (Agr. Econ.)	Agricultural Economist	Costa Rica	01-08-83	
Nivaldo de Gracia (Ing. Agr.)	Crop Production Specialist	Panama	15-05-85	
Alma Iris Moreno (Lic. Econ.)	Economist	Nicaragua	01-03-84	
Adys Pereira (MS)	Economist	Panama	01-01-83	
Alexis Rivera (Ing. Agr.)	Crop Production Specialist	Panama	01-01-83	
Orlando Torrez (Ing. Agr.)	Crop Production Specialist	Nicaragua	18-01-82	
Ulises Ureña (Ing. Agr.)	Crop Production Specialist	Costa Rica	18-01-82	
Support Team				
Alberto J. Beale (Ph.D.)	Weed Management Specialist	Turrialba	21-10-83	
Wilbert Campos (Ing. Agr.)	Assistant Plant Breeder	Turrialba	23-01-84	
Franklin Herrera (Ing. Agr.)	Plant Breeder	Turrialba	16-09-82	
William González (Agr. Econ.)	Assistant to Technical Coord.	Turrialba	01-10-84	
Humberto Jiménez (MS)	Information Specialist	Turrialba	01-08-83	28-02-84
Donald L. Kass (Ph.D.)	Soil Management Specialist	Turrialba	01-01-82	
Margarita Meseguer (MS)	Agricultural Economist	Turrialba	15-10-82	

GRANT COMPONENT AND NAME	POSITION	LOCATION	DATES OF ASSIGNMENT	
			INITIATION	TERMINATION
Carlos Ramírez (Ph.D.)	Consultant	Costa Rica	30-07-84	
Anabelly Rodríguez (Ing. Agr.)	Assistant Agronomist	Turrialba	16-04-83	
Franklin Rosales (Ph.D.)	Genotype Evaluation Specialist	Turrialba	01-07-84	
Margaret E. Smith (Ph.D.)	Plant Breeder	Turrialba	01-05-82	31-05-84
Reynaldo Treminio (MS)	Consultant	Turrialba	01-11-83	31-01-84
<u>Training Unit</u>				
José Arze (MS)	Training Officer	Turrialba	01-03-82	
Helga Blanco (Ing. Agr.)	Documentalist	Turrialba	01-06-84	31-12-84
Manuel Carballo (MS)	Assistant Training Officer	Turrialba	03-05-82	
Héctor Chavarría (Lic.)	Audiovisual Communication Specialist	Turrialba	01-06-84	
<u>Outreach Coordinator</u>				
Juan Luis Morales (Ing. Agr.)	Assistant Agronomist	Turrialba	20-01-83	
Marciano Rodríguez (Ph.D.)	Outreach Coordinator	Turrialba	01-09-82	
<u>Administrative Support</u>				
Hernán R. Rodríguez (Bus. Admin.)	Project Management Assistant	Turrialba	18-10-82	
Nubia Castillo	Administrative Assistant	Nicaragua	01-10-82	
Sergio Corrales	Assistant Cropping Systems Researcher	Nicaragua	01-01-82	
Jacobo Reyes	Research Assistant	Nicaragua	06-06-83	
Martha Ena Rodríguez	Secretary	Nicaragua	01-06-82	
Pedro Romero	Cropping Systems Specialist	Nicaragua	28-05-84	

GRANT COMPONENT AND NAME	POSITION	LOCATION	DATES OF ASSIGNMENT	
			INITIATION	TERMINATION
Juan José Tercero	Field Assistant	Nicaragua	01-04-80	
<u>Support Personnel</u>				
Luz Marina Agüero	Office Keeper	Turrialba	02-01-84	15-05-84
Urbana Aguilar	Documentation Assistant	Turrialba	01-06-84	31-12-84
José Ramón Alvarado	Office Keeper	Turrialba	20-09-84	
Carlos Araya	Field Assistant Lab.	Turrialba	01-06-84	31-12-84
Walter Bermúdez	Field and Laboratory Assistant	Turrialba	01-10-80	
Maricela Chaves	Executive Bilingual Secretary	Turrialba	07-06-82	
José Fuentes	Field Assistant	Turrialba	03-03-83	
Rose Mary Garro	Secretary	Turrialba	12-09-84	
Mario Jiménez	Field and Laboratory Assistant	Turrialba	12-04-83	
Juan Bautista Hidalgo	Documentation Assistant	Turrialba	01-08-83	31-05-84
Amyel Locatelli	Bilingual Secretary	Turrialba	01-11-81	
Oskarina León	Secretary for Systems Course	Turrialba	18-08-83	29-02-84
Jorge Madrigal	Field Assistant	Turrialba	20-11-81	
Antonio Mora	Field and Laboratory Assistant	Turrialba	26-07-82	01-06-84
Marjorie Mora	Secretary	Turrialba	01-06-84	31-12-84
Andrés Núñez	Office Assistant	Turrialba	01-06-84	
Felicia Oviedo	Documentation Assistant	Turrialba	01-06-84	31-12-84
Hannia Pereira	Office Assistant	Turrialba	18-08-83	
Oscar Portuguez	Field Assistant	Turrialba	08-08-82	
Sergio Quesada	Field Assistant	Turrialba	01-08-83	

GRANT COMPONENT AND NAME	POSITION	LOCATION	DATES OF ASSIGNMENT	
			INITIATION	TERMINATION
Lisbeth Ramos	Secretary	Turrialba	20-01-80	
Hebe Ramírez	Secretary	Turrialba	26-09-84	31-12-84
Ely Rodríguez	Data Proc. Assistant	Turrialba	16-08-83	
Ana Ligia Rojas	Secretary for the Systems Course	Turrialba	26-07-84	
Antonio Salas	Administrative Assistant	Turrialba	16-03-83	
Jesús Sánchez	Field and Laboratory Assistant	Turrialba	01-07-80	
Rigoberto Solano	Field Assistant	Turrialba	21-04-84	
Bernardita Vargas	Secretary	Turrialba	01-01-84	
Limberth Vega	Field Assistant	Costa Rica	12-11-83	

*Systems Course 1984

NOTE IN PARENTHESIS: Ph.D. Doctor of Philosophy; MS Master of Science; Ing. Agr. Ingeniero Agrónomo, Agr. Agronomist; Bus. Admin. Business Administrator; Ag. Econ. Agricultural Economist; Dr. Doctor.

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