CATIE

Serie
Institucional

CATIE 1985
FINAL REPORT
1980-1985
(IFAD TA A-D GRANT)

La preparación y publicación de este trabajo ha sido financiada por el Fondo Internacional de Desarrollo Agrícola, FIDA.

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA

Departamento de Producción Vegetal

1986

PREFACE

This report summarizes the progress made by the Plant Production Department of CATIE under IFAD TA 38 A-D Grants to CATIE. During the period convered by the Grants, 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 personel of the IFAD Support Team, who were responsible for the activities described. The editorial committee consisted of Dr. Franklin E. Rosales, of the support research team and Ms. Susan Shannon, who edited previous IFAD reports. They are also responsible for the English translation. Typing and loyout were done by Maricela Chaves and Edith Bermúdez, and graphics by Hector Chavarria and Andrés Núñez, 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 Central American region. This support has produced

important contributions in all of the Project components as is reflected in this final report.

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FINAL REPORT 1980-1985 (IFAD TA 38 A-D GRANT)

PRINCIPAL ACCOMPLISHMENTS OF THE PLANT PRODUCTION DEPARTMENT OF CATIE UNDER IFAD ASSISTANCE

INTRODUCTION

The CATIE/IFAD Project (Grants TA 38 A-D) initiated in June 1980, ended on March 30, 1986. It was designed to support CATIE's activities in research and technology development for food crops as well as to provide training for national personnel and technical assistance to national research and teaching organizations.

The work, led by the Plant Production Department (PPD) of CATIE, was implemented in the countries of the Central American Isthmus. The main bulk of activities was carried out in three representative ecological zones: the Lowland Humid Tropics (LHT), the Semiarid Tropics (SAT); and the Wet-Dry Tropics (WDT). The LHT, which covers more than half of Central America but contains less than 40 percent of the population, is the area with the most potential for relieving population stress. The SAT comprise more than one third of the population area for maize and sorghum production systems. The WDT is not as extensive or highly populated as the other two zones but its potential is less limited by the problems which pose constraints in the LHT and SAT.

The Project components were key elements in the PPD and allowed the strengthening of CATIE's work through five lines of action: 1) "Prototype Teams", for the above mentioned ecological zones; 2) Support Research, to back up Prototype Teams and to provide training and technical cooperation to national research and teaching organizations; 3) Training Unit, to coordinate training activities of the PPD and to develop visual aids and teaching materials for project beneficiaries; 4) Outreach Coordination, to improve communication and links between the PPD, national organizations and Prototype Teams; and 5) Operational Support to reinforce CATIE's different institutional activities in Central America.

The technical personnel carrying out project activities consisted of 7 Senior and 14 Junior professionals located in Costa Rica, Nicaragua and Panama. The Senior staff formed the Support Research Unit and included specialists in soil management, weed management, genotype evaluation, crop physiology, farming systems, agricultural economics and outreach coordination. This Unit reinforced work at farm level by the Prototype Teams which were formed by three Junior scientists in the areas of crop production, crop protection and agricultural economics.

The main body of this document summarizes the principal accomplishments of CATIE's Plant Production Department during 1980-1985 under IFAD assistance through Grants TA 38 A-D; it also covers the 1985 technical activities and results supported by the Grant TA 38 D presented in Annex 1.

BACKGROUND

The first formal contacts between CATIE and IFAD were in 1979. In December of that year CATIE submitted to IFAD the "Proposal to help small farmers increase food production in the Central American Isthmus"; this Proposal, for US$2.2 million, was intended for the period of 1980-1982. IFAD restructured it and approved the TA-38 Grant for US$560 000 for the period of June 1980 to June 1981. In April 1981 an IFAD evaluation committee visited CATIE and the first technical Report (TA 38 Grant) was presented to IFAD; at this time the project was extended to September 31, 1981. Based on the evaluation, CATIE submitted a new proposal titled " A proposal to support research and training for developing crop production technology for small farms in CATIE's mandate region". The proposal was approved as TA 38-A Grant for US$1.1 million for the period October 1, 1981 to December 31, 1982.

In 1982 two supervision visits (April and June) were made by IFAD teams; this initiated a new project extension for 1983 know as TA 38-B Grant ("A proposal to continue support of research and training for developing small farm crop production technology in CATIE's mandate region") for the amount of US$1.4 million.

In 1982 CATIE presented to IFAD the "Final Technical report to the International Fund for Agricultural Development on the use of TA Grant No 38, June 1980 to September 1981".

In 1983 IFAD made two visits to CATIE's project; a supervisory one in February and an evaluation in June. A detailed report ("Evaluación de mitad de período del Convenio de Asistencia TA Grant No#38, 38-A y 38-B CATIE/FIDA") was produced. After the evaluation, CATIE prepared "A proposal to continue support of research and training for developing small-farm crop production technology in CATIE's mandate region during 1984" which was approved for the amount of US$1,246 000 plus the use of the remainder of 1983's grant.

In September of 1983 the "Summary Progress Report; TA Grant No#38, IFAD/CATIE" was send to IFAD and in January 1984 the "Progress Report to the International Fund for Agricultural Development on the Use of TA Grant No# 38-B CATIE" was also presented.

In 1984 IFAD assigned to CATIE US$850 000 to support the continuation in 1985 of the Project activities, subject to the evaluation of the working plans. These plans were sent to IFAD in January of 1985 as "Planes de trabajo para 1985 del Departamento de Producción Vegetal del CATIE con apoyo de FIDA mediante el TA Grant 38D-CATIE".

RESEARCH AND DEVELOPMENT OF TECHNOLOGY

Two project components, the Prototype Teams and the Research Support Unit, were responsible for the work of research and technology development in the 3 selected ecological zones. The two components were complementary elements with different activities but the same objective; to produce farming technology for specific Central American sites and to train technical personnel and similar workers situated in the Project areas.

Their work included tasks such as: area diagnosis; identification of the principal production systems and their problems; programation and development of research necessary for solving the problems encountered; formulation of production alternatives and assistance in the spreading and transference of results, achievements and knowledge development by the project. The principal achievements in research are summarized below for each of the three ecological zones mentioned previously.

Lowland Humid Tropics.

For the humid tropics site, the Canton of San Carlos, Costa Rica (10o19'-35' N and 44o 18'-80' W) was chosen, occupying 3371 km2 in the northeast part of the country. Most of the canton is below 500 meters above sea level and receives 2500 to 6000 mm of annual precipitation. The area is classified as having no dry season but in February, March, and April, as little as 100 mm of rainfall per month may be recorded. Like much of Central America, the soils have received a certain input of volcanic ash but as this amount varies from site to site, Paleudults, Dystropepts, and Tropudalfs are found in the area as well as the expected Dystrandepts.

All of the farmers who participated in the project had obtained 10 ha plots through various land reform schemes. No work was done with the extensive cattle producers who occupy more than 75% of the area of the Canton. The most important crops produced by the 5000 small holders in the Canton are maize, cassava, beans, rice, papaya, pineapple, cacao, and edible aroids. With the exception of maize and rice, most of these products are sold off the farm as there is an extensive, if poorly maintained, road system in the area.

Legume - Maize Associations.

A simple, low-cost method was developed to identify species and varieties adapted to the association with maize of different growth habits through the use of screens of dissimilar light transmission capacities. The method also permits the separation of the effect of above and below ground competition through different crops (sweet potatos, adzuki beans, rice and soybeans) identified and used as biological indicators.

Both maize and associated crops (soybean and cowpea) were found to have altered growth rates when associated; the nature of the alteration depends upon the crop phenotype (both maize and legume) and the relative planting dates. Maize growth rates were affected most by indeterminate cowpeas, less by determinate cowpeas, and least by soybeans. Later planting of the legumes reduced these effects. Growth rates of associated crops were principally affected by the reduction of photosynthetically active radiation by the maize -hence growth habit of the maize and time of association affected the growth rates of the associated legumes, soybeans being less affected than cowpeas. Soybeans would therefore be more suitable for association with maize than cowpeas.

Maize Monoculture

Monoculture maize responded markedly to phosphorus fertilization on a soil quite extensive in the humid tropics of Central America, a Typic Humitropept, fine, halloystic, isohyperthermic, with the following chemical characteristics: pH 5.6, P (Olsen) 14.8 ug/ml; exchangeable K, 0.17 (p+) cmol/l, exchangeable Ca, 1.67 (p+) cmol/l, exchangeable Mg, 0.55 (p+) cmol/l, aluminium saturation, 35.2%, organic matter, 5,5%. Maize yields increased from 2765 to 5642 kg/ha ha when 250 kg/ ha of P_2O_5 and 75 kg/ha of K_2O were applied. There was no response to zinc but an application of 461 kg/ha of Mg SO_4 $7H_2O$, the only form of magnesium locally available, increased maize yields by 700 kg/ha, although this increase was not statistically significant. Increased fertilization with phosphorus, potassium and perhaps magnesium and sulfur would contribute significantly to increased maize yields in the humid tropics of Central America; if pricing structure made these materials more readily available, then a better option to production is open to low income farmers.

Of 40 genotypes evaluated, five (Ferke (1) 8128, Across 7728, Poza Rica 8121, Across 8042 and Ferke (1) 8129) were selected with yield production of 4 to 6 ton/ha and recommended for farmers' use.

In 1985 the cultivars previously selected (Guaymas (1) 8022, Ferke (1) 8129, and Across 7929, outyielded local varieties under low management conditions by as much as 150% (local cv. yielded 1.0 ton/ha). The same varieties, using technology recommended by government agencies, outyielded the local check variety by 80% (local cv. yielded 1.6 ton/ha). Government's technology was not more economical than farmer's .

Maize - Beans

It was found that the proposed alternative (planting beans 20 days before physiological maize maturity) reduced possibility of drought stress during bean flowering, leading to increased bean yields.

Economic analysis identified the proposed alternative as the best crop arrangement, especially when low leafiness maize type (such as " Compuesto Blanco 2" and "ETO Blanco") are used. Yield increase of beans were 20-25% above the traditional system which is to plant beans at physiological maturity of maize.

In none of the experiments were significant interactions between maize and bean genotypes detected, indicating that in the maize-beans relay cropping systems selection of maize and beans can be done independently.

Investigations with maize of different plant heights associated with climbing beans, determined that maize phenotypes shorter than 2.5 m with strong stalks led to the highest yield of beans. The best bean lines in the system were V7920, V7919 and V7918 with production of grain above 1.0 ton/ha.

Maize - Cucurbits

Yield of Central American cucurbits (*Cucurbita mixta* and *Cucurbita moschata*) in maize-cucurbit systems can be increased 60% by association with double rows rather than single rows of maize. Maize yield is reduced 47% in this planting pattern.

Maize - Cassava System

Maize yields were not increased by hand-weeding or by use of preemergence herbicides in a well-fertilized soil, tilled previous to planting.

Cassava yields were increased over those obtained by hand weeding with metolachlor at 2.5 kg/ha, alachlor at 2.6 kg/ha and a combination of linuron at 1.5 kg/ha and alachlor at 0.89 kg/ha. A combination of 1.5 kg/ha of linuron with 0.25 kg/ha of oxyfluorfen caused severe toxicity to both maize and cassava. Atrazine at 1.25, 1.63 or 2.0 kg/ha caused light phytotoxic symptoms to cassava which soon disappeared, indicating that further work might be done with this product in the system.

Cassava and maize phenotypes were identified for the cassava + maize intercropping pattern. The most desirable cassava plant type is one of intermediate height (1.7 m), medium to low leafiness (like M Col 22 or CM 342-180) and first branching at approximately 1.3 m above ground. The best maize phenotype would be one of intermediate height (2.2 - 2.3 m) and leafiness (50-55 dm2) and good husk cover.

The presence of a significant maize genotype-by-system interaction, emphasized the importance of considering the cropping system before selecting maize genotypes. Cassava selection for intercropping can be made in monocrop systems regardless of phenotype.

The best maize cultivars recommended for the intercropping system are Guaymas (1) 8022 and Ferke (1) 8129, with yields of 1.2 to 1.4 t/ha even under conditions of low fertility and plant population (18000 plants/ha) in which local materials only produced 0.4 t/ha.

The cassava variety most recommended for sowing in association with maize is "Criollo zamorano", because of its high potential productivity and great ability to with stand maize competition.

For the maize+cassava system, the most economical fertilization was 37, 40, and 37 kg/ha of N, P_2O_5 and K_2O, respectively, applied only to the maize. Higher fertilization rates did not bring about sufficiently higher yields of either maize or cassava to compensate for higher costs of fertilizer. Both maize and cassava showed a greater response to fertilization as well as higher overall yields in La Fortuna than in Pital, due principally to differences in soil types. The experiments in La Fortuna were run on Tropudalfs of high base status while the experiments in Pital were located on Paleudults with high levels of aluminium saturation.

Cassava - Bean System

Grain yield of the Talamanca bean cultivar (local) did not respond to hand weeding or to the application of various preeemergence herbicides when the soil was tilled prior to planting. A factor in this finding may be the rapid maturity of this cultivar, which takes less than 70 days from planting to harvest.

The best alternatives for weed control in the cassava bean system were chloramben at 2.0 kg/ha, alachlor at 1.5 kg/ha or linuron at 1.5 kg/ha which did not cause phytotoxicity to either crop and resulted in a yield of over 30 t/ha of cassava. Similar yields could be obtained with hand weeding but this alternative depends on labor availability. Certain herbicides (oxyfluorfen 0.4-0.8 kg/ha and alachlor at 2.9 kg/ha and fluometuron at 2.0 - 4.0 kg/ha were phytotoxic to beans.

Bean varieties differ in their adaptability to this cropping pattern. Best recommended varieties for this system are R-675, ICTA Tamazulapa and ICTA 8164 with yields between 0.9 and 1.0 t/ha, 52% higher than the local cultivar "Chimbolillo".

When beans were associated with cassava, bean yields were reduced proportionally as bean populations were reduced while cassava yields were not significantly affected by association with beans at any population. It would seem best to use the higher plant population, 150 000 pl/ha when beans are associated with cassava as this produced the highest L.E.R. (Land Equivalent Ratio) independent of soil type.

Neither beans nor cassava responded to increases in fertilization from 0 to 6 qq/ha of 12-24-12 fertilizer (55 kg/ha of N, 110 kg/ha of P205 and 55 kg/ha of K20), indicating that such a level of fertilization of the bean-cassava system constitutes an uneconomical practice.

Plantain - Maize

Association of maize with plantain was shown to be a beneficial alternative for small farmers. Maize yields were reduced by less than 25% in comparison with monoculture maize. Plantain yields only decreased significantly in association in the first year when the traditional planting pattern was used. An economic analysis of the results for the first year of the association showed that the association in the hexagonal planting pattern would produce 75% more income per hectare than if the hectares were equally divided between maize and plantain monocultures. In the second year, there were also no detrimental effects to plantain production, with the association in the traditional planting pattern producing sufficiently more to compensate for its poor performance in the first year. It was shown that this association could help low income farmers offset the cost of plantain establishment.

Bean Monoculture

Five elite cultivars were selected, multiplied and reevaluated in on-farm trials. Yields above 1.6 t/ha were obtained with ICTA 8164, Negro Huasteco and Compuesto-1. These three genotypes outperformed the improved variety "Talamanca" (recommended in this zone) by 13% and the local cultivar "Chimbolillo" by 29%.

Moderate applications (2 t/ha) of lime to soils with aluminium saturation levels of 15-50%, increased bean yields by more than 80% (from 600 to over 1000 kg/ha); producing a greater economic return than fertilization with phosphorus, nitrogen, or potassium, or than inoculation with selected strains of rhizobium. Bean yield was more correlated with levels of aluminium saturation than any other soil factor; including levels of exchangeable water or soluble or readily reducible manganese, indicating the importance of correcting this factor before applying other amendments.

Massive applications of phosphorus (200 kg/ha of P205) increased bean nodulation in the field but brought about smaller yield increases than liming in a soil with moderate levels (30%) of aluminium saturation. The high cost of phosphorus fertilizer in Central America is the major constraint to using this method as opposed to liming to overcome soil deficiencies which limit crop production. However, in soils with low levels of phosphorus and exchangeable aluminium, liming did not improve phosphorus availability.

In a greenhouse study, using a soil with high levels of aluminium saturation, nodulation and total nitrogen recovery was improved more by high levels of liming than by applications of lower levels of lime with phosphorus and molybdenum, There was an interaction of rhizobium strain with treatments, indicating that certain strains are more effective than others when soil deficiencies were not corrected.

Sorghum Monoculture

A sorghum genotype ICRISAT M 91057 was selected for tolerance to conditions of high soil moisture and high levels of soluble manganese as often occur in the lowland humid tropics.

Alley Cropping

Four years of data (a total of eleven crop harvests), were obtained from an experiment to determine the possibility of using woody legumes as a nutrient source for annual crops. Yields of maize and beans could be maintained at over 2.5 and 1.0 t/ha, respectively, using only prunings of a leguminous tree (*Erythrina poeppigiana*) as a nitrogen source. Using ammonium nitrate as a nitrogen source resulted in significantly lower yields of both crops.

Cassava (*Manihot esculenta*) was associated with the maize and beans in the first three years of the experiment. Yields of commercial roots of this crop, declined over the three years regardless of the types of mineral or organic amendments employed. However, total biomass production declined only slightly when mulches of leguminous or non-leguminous trees were applied twice yearly. It would seem that deterioration of soil structure rather than decline in nutrient levels was responsible for the trend in cassava yields.

Growing the leguminous trees on the same plots as the crops (Alley-Cropping), produced about similar yields as a mulch of the tree prunings in the case of *Erythrina poeppigiana*. However, alley cropping with *Gliricidia sepium* at a somewhat higher density (6666 trees/ha), considerably reduced yields of maize and cassava but not of beans. It would seem that beans are much better adapted to alley cropping systems than maize or cassava.

Total biomass production and crop nitrogen recovery, was significantly higher than the control treatment only when a mulch of *Erythrina poeppigiana* was applied or the nitrogen contained in the prunings of the alley cropping system were included in the calculations. The latter finding could imply that the leguminous trees were contributing considerable nitrogen to the system, since total biomass in the alley cropping treatments contained over 200 kg/ha/yr. more nitrogen than the control treatments.

Efficiency of recovery of all applied nitrogen was low; less than 20%, whether mineral N or organic N sources were used. This low N efficiency is typical of volcanic-ash derived soils, however, applying organic amendments increased the recovery of mineral N.

Benefits of the leguminous trees was not confined to nitrogen nutrition. Potassium recovery was also higher in plots receiving a mulch of leguminous tree prunings; analysis showed them to contain almost 2% potassium. Significant increases in Olsen extractable potassium were observed after three years in both 0-20 and 20-40 cm depths when mulches of leguminous trees were applied. Exchangeable aluminium and extractable manganese increases are less with leguminous tree prunings than with mineral nitrogen applications. Thus, the prunings would appear to produce less undesirable effects of acidification which is a problem with mineral nitrogen sources.

When the experiments were set up it was not thought that the prunings would be able to supply sufficient potassium, phosphorous and magnesium for crop production. All plots, therefore, received 88, 130 and 17 kg/ha/yr. of P_2O_5, K_2O and MgO as triple superphosphates, KCL, and magnesium sulfate. Extra plots were included, however, which received only either prunings of *Erythrina poeppigiana* or dairy manure at a rate of 40 t/ha/yr. over the four years of the experiment. In the fourth year of the experiment, yields of maize and beans in these plots were higher than in the ones receiving complete N-P_2O_5-K_2O-MgO fertilization each year. Soil nutrient levels were not lower in these extra plots. It would seem that the need for mineral fertilization on these soils has been over estimated.

Application of mulch of *Gliricidia sepium* to maize and beans in a farmers field in the lowland humid tropical zone, increased yields of both by 25%. Thus, a low cost alternative to nitrogen fertilization exists.

Living Mulches

Use of velvetbean (*Mucuna pruriens*) to control weeds in maize was highly successful, if velvetbean was seeded 40 days before maize planting and cut back or killed with herbicide following maize planting. Later use of herbicide as a growth regulator of the velvetbean in this system was less successful because of unfavorable effects on the maize.

Growth Analysis of *Paspalum fasciculatum*

Growth analysis of *Paspalum fasciculatum*, a particularly problematic weed in the lowland humid tropics of Central America, showed that it has to be controlled within the first 8-9 weeks because at later stages, stolon production makes its control more difficult.

Rice Monoculture

In a minimum tillage system, two products (oxadiazon or oxyfluorfen) provided good weed control. Oxadiazon at 1.13 kg/ha produced 3038 kg/ha of rice and only 278 kg/ha of weeds, while the lower priced oxyfluorfen at 0.24 kg/ha produced 2652 kg/ha of rice. Non-weeded rice produced 1100 and the hand weeded check produced 2267 kg/ha. The oxadiazon 1.13 kg ai/ha treatment had the least ground cover by weeds, the lowest weed dry weight and the highest rice yield of all the treatments studied.

Rural Credit and Grain Storage

It was found that in the San Carlos area of Costa Rica, banks were the most important source of credit because they offered the lowest nominal interest rates. Although, when additional costs were considered, real costs of credit was frequently higher for banks than for other sources (friends, relatives and private lenders). Predictive curves for the demand of credit in the area could be determined from the relationship between the amount loaned and the real cost of credit and between the amount loaned and the extra cost of credit. Additional costs affected the total cost of small loans more than of large ones because they tended to be independent of the amount of capital.

A study of grain storage practices was realized in the San Carlos area. Sixty-four farmers were interviewed with the following results:

1. Ninety seven per cent of the farmers store beans, 31.3% store maize, and 7.2% store rice
2. Farmers store an average of 230 kg of beans, 240 kg of maize, and 80 kg of rice
3. All of the rice and maize and 94% of beans stored are consumed by the farmers
4. Eight percent of the farmers who store beans, sell part of the production (156 kg, average) either to neighboring farmers or middlemen
5. Twenty nine percent of the farmers who store beans use some of their production (21 kg as average) for seed

Most farmers (67%) use oil drums for storage, 39% use cloth bags, while 11% use plastic bags inside cloth bags.

Twenty eight percent of the farmers reported having losses in storage. The average maize loss was 14.0%, while the average bean loss was 6.0%. No farmers reported losses of rice in storage. Fourteen percent of the farmers attributed the losses to insects, 7-8% to unfavorable climate, 3% to disease and 3% to rats.

TROPICAL ROOTS, CORMS AND TUBERS

Cassava Monoculture

From thirty eight local and improved cassava varieties, thirteen were selected based on superior agronomic qualities for further evaluation according to sensory testing and quality demanded by export markets.

This work, started by the Project in 1982, resulted in the recommendation of the following varieties: Tilaran-1, Brasil 14-47-70, Mex-59 and P 77-14. All of them yielded above 27 t/ha of commercial roots of equal or superior quality to the local cultivar "Valencia" which yielded 18.8 t/ha. The variety P 77-14 (27.2 t/ha) and Tilaran-1 (37.8 t/ha) are (in this order) the best in appearance, color, shape and root flavor for export market according to farmers testing study.

Differences in management practices were evaluated according to whether cassava was the first crop planted following clearing (Class A) or whether another crop preceded the cassava (Class B). The following differences were observed:

1. Land preparation costs for cassava as a first crop were 50% higher than for cassava following other crops

2. Planting practice is similar for both systems (A and B): stakes planted horizontally, using 9000 to 9300 per hectare

3. None of the farmers using Class A system fertilized, while only 20% of those in Class B practiced fertilization

4. Farmers practiced more pest control in cassava planted immediately following clearing

5. Cassava yields in Class A were 1.5 times higher than cassava followed by another crop

In an experiment with low levels of inputs (no fertilizer, disease or insect control), the highest yields of cassava (21.2 t/ha) were obtained when cassava was weeded 4, 8 and 10 weeks after planting. Beginning weeding after the 10th week significantly reduced yields; a single weeding four weeks after planting resulted in lower yields (15.5 kg/ha). It was concluded that the period 4-10 weeks after planting is the most critical one for weed control in cassava.

Cassava - Yam

In an effort to combine a crop with export potential with a traditional food crop of the low elevation humid tropics, an association of true yam with cassava was tested at the Turrialba experiment station. It was shown that only by planting both crops in May and using supports for the yam, could acceptable production of both crops be obtained (13 000 kg/ha of commercial quality cassava and 13 972 kg/ha of export quality yams).

Plantain - Cocoyam

Increases in productivity could be realized by associating cocoyam with plantains in the year of establishment as this practice did not affect plantain yield with respect to monoculture. The economics of the practice would depend on relative plantain and cocoyam prices with the critical ratios being 2.9:1* and 2.4:1 based on production data over the first two years. When relative prices are above 2.9:1, it is most economic to produce monoculture cocoyam; when relative prices are less than 2.4:1, the more economic practice would

* Ratio of price of 1 kg cocoyam: 1 fruit plantain.

be monoculture plantain. When relative prices are between 2.9 and 2.4:1, the association is the most favorable practice.

Ginger Production Systems

In a cassava-ginger production system, yields of export quality ginger were quite poor (4396 kg/ha) when no weed control was practiced. Yields were increased to 70% by hand weeding at monthly intervals and by 101 and 95% respectively with preemergence applications of diuron at 1.7 kg/ha and oxyfluorfen at 0.97 kg/ha. However, disease incidence in ginger associated with cassava was greater than in monoculture ginger under high rainfall conditions (3200 mm/yr).

Under monoculture, the most effective weed control treatments which produced the highest ginger yields were ametryn 4.0 + metolachlor 0.7, ametryn 4.5 and 4.0 kg ai/ha. The diuron 2.8 kg ai/ha treatment produced the next highest ginger yield, but was not as effective as the other three treatments with respect to weed control. None of the treatments evaluated caused phytotoxicity to the ginger.

Yam (Dioscorea) Monoculture

When yams are grown under high input conditions (fertilization, nematode and disease control, and use of stakes), loss in yields due to weed competition principally from grasses was 35% (yields were reduced from 44.8 to 29.2 t/ha). In the 9 month yam cycle, the most critical period for weed control was 4-10 weeks after planting when low growing grasses are the principal weeds.

Different weed control experiments indicate that the best alternative for chemical weed management in yams could be found in the diuron 2.5 + paraquat 0.26 kg ai/ha treatment and the linuron (3.5) or ametryn (4.5) combination with pendimethalin (1.0) kg ai/ha.

Aroids

Use of large planting pieces produced higher yields of edible aroids Taro (*Colocasia esculenta*) and cocoyam (*Xanthosoma sagittifolium*) but was uneconomic because a high proportion of the production is thus used for seed. Removal of apical buds can regulate the size and number of cormels produced, enabling farmers to adjust production to market preference.

Sweet Potato Monoculture

Two outstanding sweet potato clones (8523 and 8467) were selected and multiplied. Yields over 55 t/ha with 82% marketable tubers were obtained with clone 8523 as compared to only 23% marketable tubers in local varieties. A relationship between skin color and commercial root production was established. Red skinned varieties had 94% marketable roots while dark and light skinned varieties had only 75% and 69%, respectively, marketable roots. Another clone 7170 was selected for animal feeding since it produced more than 50 t/ha of above ground biomass.

OTHER PROMISING CROPS FOR THE LOWLAND HUMID TROPICS

Soybeans

Greenhouse and field studies showed that soybean genotypes differ in their ability to withstand unfavorable conditions associated with flooded soils.

The yield of several varieties increased when the soil was saturated rather than at field capacity.

Continuous flooding reduced yields of all varieties but this reduction was only 25% of yields at field capacity for the varieties SIATSA 194-A and Baru, with production of 1.7 and 1.2 t/ha, respectively. The latter was also the best adapted to intermittent flooding (1.1 t/ha).

Under saturated soil conditions, the best varieties were Jupiter and PK 7394 with yields above 2.5 t/ha.

Four cultivars (Papillon, SIATSA 194-A, TEX 297-192C and TGX 536-100C) under normal (non-saturated) conditions, yield above 3.0 t/ha, showing good potential for LHT conditions.

A seed storage method for small farmers (sealed containers) was tested and identified as a viable alternative; it maintains seed viability up to 6 months, being equally efficient as cold room storage at 15oC and 60% relative humidity.

Three genotypes with superior seed storage capacity were identified (TGX 307-047D, TGX 342-356D and TGX 742-02D), all with yields above 2.9 t/ha. Local varieties do not store well.

Interaction between soybean genotypes and storage methods was detected, indicating that finding an easy screening technique for improving selection for storage capacity will be difficult.

Winged Beans

Forty eight lines of winged beans were tested for grain and root production; the best line was UPM-207 with a yield of 4.0 t/ha.

Groundnuts

Thirty two lines from ICRISAT with high potential for the LHT were introduced to be tested in soils with low pH; six lines were selected (ICGS (E)-2, -22, -8, -15, -5 and Robust 33-1) with experiment station yields above 4.0 t/ha and high levels of resistance to *Cercospora*.

Flooded Soils

A study of adaptation of different crops to flooded soil conditions showed significant differences in performance. Only rice was completely unaffected by negative redox potentials associated with flooding. Taro and soybean showed a moderate yield reduction, confirming the need of Taro for high oxygen levels when grown under flooding. Liming, to offset Mn toxicity, only improved tolerance to flooding in sorghum. Cocoyam showed no ability to tolerate even moderate levels of flooding.

SEMIARID TROPICS

The area selected to represent the semiarid ecological zone was the department of Esteli, Nicaragua, located between 12°58' and 13°22' N latitude and 86°14' and 86°36' W longitude. The department includes the townships of San Juan de Limay, Pueblo Nuevo, Condega, Esteli, and La Trinidad, with a total area of 2173 km^2. There is considerable variation in climate and soils in the department; some areas receive less than 800 mm of annual rainfall, while others receive more than 1500. Six soil orders occur in the department, accounting for the following percentage of the total area: Mollisols (31%), Entisols (22%), Alfisols (19%), Inceptisols (13%), Ultisols (13%) and Vertisols (2%).

There are presently over 100.000 hectares of farms in the department: there are 33 081 hectares of state-owned farms; 67 814 hectares of small farms, of which 80.6% are smaller than 35 hectares; and 5 042 hectares of privately-owned large farms. Basic grains are produced on some 19 704 hectares, with the predominant production systems being: maize associated with photoperiod sensitive sorghum (Millon), maize in monoculture, two successive crops of bean monocultures, and maize relay cropped with beans. Most of the research in the areas was carried out with these systems or proposed modifications of them, such as substitution of photoperiod sensitive sorghum by non-photoperiod sensitive sorghum.

Millon (Photoperiod Sensitive Sorghum)

A collection of local varieties of photosensitive sorghum was made in the Esteli region. This material was compared with introductions from other areas where this crop is grown. In monoculture, the best materials were Criollo (local), Peloton (Honduras), and Esteli 4 (local). For association with maize, the best materials were Esteli (local), Criollo Sapo (El Salvador), and Chaparro (El Salvador), all of which yielded over 3 t/ha.

Photoperiod Insensitive Sorghum

Work with this crop began in 1982 with the introduction of 52 varieties from the ICRISAT program in Mexico, as well as 111 experimental lines from ICRISAT in India. From this material, 10 lines were selected in 1983 for testing in 12 sites in 1984. From these trials, 4 genotypes (Sepon 77, ISIAP Dorado, Selection SC-108-3XE and M5009) with yields of over 3 t/ha were selected for validation trials in 1985 under the supervision of the Nicaraguan land reform and rural development agency. Sepon 77 is the most stable variety of the material evaluated and has been recommended for use in the whole region of Estelí. The other lines, especially ISIAP Dorado, are ideal for the favorable climates of Uniles, Guapinol and Culebras.

Maize Monoculture

NB-4, a late maturity variety, is recommended for monoculture due to its excellent stability over a wide range of environments (mean production of 5.7 t/ha). Other recommended late maturity varieties (white and yellow grains) for the Esteli region of Nicaragua are: Ilonga 8043, Across 8024, Piura 8224, Across 7622-Re, Los Baños 8027 and Santa Rosa (1) 8243; all of them with production above 6.3 t/ha at research trial level.

While several local varieties, collected by the project, such as Esteli #2 and #6 and Jalapa #2, #8, #9, (all with yields over 5.6 t/ha), also performed well in trials in the Esteli area, it would seem that higher yields could be obtained through the use of improved maize, which demonstrated greater yield stability, uniformity, and consumer preference.

CIMMYT drought selection C-4 produced over 6 t/ha in a trial in a dry area of Esteli; although rainfall was somewhat higher than average in the year of the trial.

Maize - Photoperiod Insensitive Sorghum

Fertilization of improved (photoperiod insensitive) sorghum following maize, was studied in three typical soils of the Central American semiarid tropics (Vertic Haplustolls, Typic Ustorthents, and Typic Hapludalfs). In all cases, application of 30 kg/ha of N was highly economic. Higher levels were not economical. Phosphorus response differed according to soil type, being highest on the Entisol where 60 kg/ha of P_2O_5 was economically justifiable, smaller on the Hapludalf, where the response was significant but not economically viable, and statistically insignificant in the Haplustoll. Response to potassium was only observed in the Entisol. For photoperiod insensitive sorghums following maize, 30 kg/ha of N can be recommended for all soils of the area while applications of phosphorus and potassium can only be recommended in the Typic Ustorthents which occur in the municipality of Pueblo Nuevo.

An economic study of this system, which is practiced on some 200 000 hectares in Central America, produced the following results: average profit was $141.24 per hectare. Labor represented 54.7% of the costs, followed by 22.0% for services, 13.2% fixed costs and 10.1% for purchased inputs. The cost benefit ratio for the system was 1.24. The return per day of labor was $3.47, much higher than the average labor cost in the area ($2.72 per day). Return for capital invested in inputs was $1.04.

Maize - Photoperiod Sensitive Sorghum

Substitution of the traditional varieties of maize and photoperiod sensitive sorghum (Millon) by materials introduced by CATIE from El Salvador (the improved maize variety M3B and the sorghum cultivar Criollo Sapo) and an increase in the N-P_2O_5-K_2O fertilization from 45-39-13 kg/ha to 51-58-4 kg/ha, resulted in a total grain yield of 4433 kg/ha; 35% higher than that obtained in the traditional system. The improved system had a cost-benefit ratio of 4.7:1 as compared with 3.7:1 for the traditional system.

Phosphorus response was most consistently observed in maize and photoperiod sensitive sorghum in soils derived from volcanic material (Typic Ustorthents). In mollisols, maize exhibits a small response, while in those with more vertic properties, response to phosphorus was smaller. There was no response to sulfur in the entisols but in the mollisols there was some evidence of a P x S interaction.

Several important aspects of plant competition in the maize-photoperiodic sorghum system used extensively in the Pacific zone of Central America, were investigated. Later planting of sorghum increased maize yields but decreased sorghum yields. Replacing of photoperiod sensitive sorghum by photoperiod insensitive sorghum, which is planted later, increased maize yields but may result in no sorghum yield at all if rainfall is inadequate in the latter part of the rainy season, as it often is. Another advantage of photoperiod sensitive sorghum is its greater biomass production, used in animal feeding.

As a result of experiments in which competition was reduced by eliminating maize and sorghum plants at different stages of development and in which water was supplied by irrigation, it was concluded that much of the adaptability of photoperiod sensitive sorghum is due to its ability to accumulate dry matter slowly over a long period, even under conditions of low moisture availability. Thus, its biomass and grain production could not be increased by later planting or with supplemental water even though these practices increased maize production. Cutting off the sorghum at ground level, 45 days after planting increased maize yields and the sorghum recovered to produce almost 2 t/ha of grain.

Photoperiod Insensitive Sorghum - Bean

Research on the sorghum-bean association, less frequently-practiced than the maize-sorghum system but more adapted to drier areas, revealed advantages for the traditional photoperiod sensitive sorghum in terms of biomass and sorghum grain production. Two plantings of beans invariably produced more beans than a single planting, but sorghum yields were always reduced by a second bean planting. The first planting of beans and sorghum invariably produced more grain than the second plantings indicating the importance and greater reliability of the early rains even though late rains may bring more total precipitation.

Bean - Bean System

Use of 1.5 qq/ Mz of 12-44-3 fertilizer and 0.5 qq/ Mz urea in place of 2 qq/mz of 12-44-3, the traditional practice in the area, reduced production costs by $44.50 per hectare with the Revolution 79 bean variety. This system had a cost-benefit ratio of 6:1 compared with 3.4:1 for the traditional fertilization with the Chile Rojo variety.

Average profit of the system was $166.62 per hectare. Labor represented 53.7% of the total cost, followed by 17.2% for services, 16.8% for purchased inputs and 12.3% for fixed costs, the cost benefit ratio was 1.33. The return per day of labor has doubled the average labor cost in the area where the study was made. Return of capital invested in inputs was $1.24.

None of the preemergence herbicides at the rates and combinations studied (linuron 1.0 to 2.0 kg/ha, alachlor at 1.0 to 2.4 kg/ha, pendimethalin 0.7 and 1.3 kg/ha and combinations of linuron 1.0 and alachlor 1.0 or pendimethalin at 0.7 kg/ha and linuron at 1.5 kg/ha) caused phytotoxicity to bean cultivar, Revolution 79, planted in a Vertic Haplustoll irrigated soon after planting. However, these herbicides failed to control the broadleaf weeds, especially *Bidens pilosa*, which predominated in the system.

Genotype selection in beans was a major activity of the project since its initiation in 1982. Material was brought from CIAT and Central American National Programs and compared with materials collected in the Project area.

In 1984, 133 materials were tested and a selection of local and improved materials was made for on-farm testing in the second planting. Of this material 6 local varieties (Chile Rojo, Rojo Pando, Mono Esteli, Rojo Seda, Chile Ligero and Rojo Musuli) and two improved lines (H772202-62CMCM and BAT 1514) were selected, all of which yielded over 1.0 t/ha and showed better yield stability than the previously recommended materials, Rojo Nacional and Revolution 79. These selections are presently recommended to the land reform and rural development agency for validation.

Analyses of stability indicate that Revolucion 79 is the most unstable variety with respect to yield. Another local check (Rojo Nacional) was identified as the most stable but was associated with low yields. The "improved" varieties proved to be more unstable or more site specific than "criollo" varieties.

Pearl Millet

Introductions of pearl millet made in 1982 did not prove an attractive alternative to farmers in the region. In terms of biomass production, the pearl millet was comparable to the photoperiod sensitive sorghum traditionally used in the area. However, it could not accumulate dry matter over a long period of erratic rainfall as could the photoperiod sensitive sorghum and the grain was not an acceptable substitute for sorghum.

Soil Conservation

Higher yields of beans, maize, and sorghum were obtained on a Typic Hapludalf with 14% slope when barriers of different materials were constructed along the contours. The best barriers were agave, leucaena, and stone walls.

The use of stone walls following the contour not only increased yields of maize, beans, and sorghum but provided a guide for ploughing and planting along the contour and reduced stoniness. It was readily accepted by farmers who constructed such barriers on their own initiative in areas adjacent to the experimental plots.

WET DRY TROPICS

The area selected to represent the wet-dry tropics ecological zone was the districts of Los Santos and Guarare in the Los Santos province of Panama. It extends from N latitude $7^{o}15'$ to $8^{o}15'$ and from $79^{o}45'$ to $81^{o}41'$ W longitude. Altitude varies from 100 to 300 meters above sea level, and rainfall varies from 1000 to 1500 mm annually, with 5 dry months. Most of the soils are Tropepts.

The two districts occupy a total of 534 km^2 and contain 4772 farms. About half of the area is used for agriculture. The principal crops are maize, tomato for processing, rice and onions. Most of the farmers in the area try to produce vegetables with irrigation but both the marketing and irrigation infrastructure are poorly developed.

A total of 19 crop production systems were identified in the characterization of the area; of these, four were selected for improvement: 1) tomato or onion followed by maize for fresh ears; 2) monoculture maize for grain; 3) rice-vegetable rotations and 4) rain-fed onions.

The chief problem in the tomato or onion maize rotation are excessive fertilization for the vegetables and a general lack of knowledge of how to manage the maize crop following vegetables. Similar questions about land preparation appear to be limiting to the monoculture maize system. The chief problems in the rice-vegetable systems are weed control and lack of adequate irrigation. The main justification for producing rain-fed onions is the low availability in local markets during the month of August.

Tomato - Maize System

Planting maize without tillage, following harvest of the processing tomato crop, reduced land preparation cost by 40% as compared with traditional practices and did not affect yield or fertilizer response of the two recommended maize varieties (Across 7728 and X-304-C). Highest yields and returns were obtained using the hybrid X-304-C with 68 kg/ha of urea.

Rice - Vegetable System

Of eight locally used rice cultivars tested, Gorila and Melena are recommended because of their higher yields, resistance to lodging, and earliness, which leaves more time for the vegetable crops.

If the rice crop follows vegetables, the only fertilization necessary is 68 kg/ha of urea at seeding and an additional 68 kg/ha 60 days later.

Doubling the presently used plant density by planting the rice at a row spacing of 0.3 to 0.35 m, leaving 0.3 to 0.35 m between hills, is recommended.

In dry years, 3 supplementary irrigations: during vegetative development, at flowering, and during grain fill are recommended to reduce risk and increase cost benefit ratios.

Herbicide studies on rice show that an excellent control of *Rottboelia exaltata* can be achieved with different concentrations of pendimethalin. The mixtures of bentazon + MCPA (Basagran M-60) were not effective in controlling *Cyperus*, neither were any of the other treatments.

Rain - fed Onions

The recommended production alternative for rain-fed (non-irrigated onions) is to use Granex 429 variety, transplant either in

May or from September to November, and plant in two rows per bed (60 cm wide, leaving 10 cm between plants).

The recommended weed control practice is an application of pendimethalin (3.5 l c.p./ha) pre-transplant and an application of oxyfluorfen (1-2 l c.p./ha), which will control the grassy weeds, Rottboelia exaltata and Echinocloa colonum as well as the broadleaves (Melampodium divaricatum and Caperonia palustris).

Maize - Pasture System

For maize to be alternated with a grazing system, where a previous vegetable crop is not planted, the method of land preparation used for the tomato-maize system is recommended, but the fertilization for the maize hybrid X-304-C should be increased to 182 kg/ha of 12-24-12 and 90 kg/ha of urea.

Sweet Pepper - Fallow - Maize System

Highest yields of sweet pepper and lowest dry weight of weeds were found in plots treated in early postransplanting with chloramben 3.5 + devrinol 5 kg/ha, or with devrinol 8 kg/ha by itself when the predominant weed species were grasses (Digitaria sanguinalis and Echinocloa colonum).

The herbicide oxyfluorfen 0.6 kg/ha and the combinations including linuron 2 kg/ha, applied at early postransplanting over the crop caused severe phytotoxicity to the sweet pepper plants. However, the sweet pepper yields were too low in this study for herbicide recommendation to be formulated yet.

TRAINING

IFAD support enabled the expansion of the CATIE graduate program to include courses in soil physics and management, plant breeding, and agroecosystems not previously offered.

Eight of the 33 graduate theses produced by the Plant Production Department from 1982 to 1985 received IFAD support.

A total of 1200 professionals received training from IFAD during the period of the grant (53 short-courses). Sixty five percent of these courses were given outside of Turrialba.

IFAD support enabled the PPD to offer three 12-14 week courses in farming systems research. A total of 65 professionals from Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Peru, Panama, Bolivia, Brazil, Dominican Republic, Paraguay and Colombia, completed these courses.

The IFAD support to the PPD, in the form of specialists paid by the grant, experience gained in grant activities, and the presence of a training coordinator, permitted the formation of a graduate curriculum with four areas of specialization (soils, plant protection, plant science, and production systems) in the PPD.

A three week intensive course on weed management in Production systems of small farms was offered to professionals of national institutions from nine Central American and Caribbean countries. Professors from 12 different nations taught in the course which was jointly financed by FAO, the International Plant Protection Center of Oregon State University and CATIE.

In 1985, 83 audiovisuals for use in seminars or short courses were produced and/or acquired. Their length varied from 15 to 40 minutes and covered topics such as: calculator operation; area characterization and selection; bean, cassava and rice production;

agricultural mechanization; weed control; soil management and experimentation on farms.

CATIE/IFAD Project personnel produced more than 150 publications in the form of work reports and formal documents (see Annex 2) The Documentation Unit accounted for the distribution of 16155 documents in 1079 shipments to more than 10 countries during the final years of the project.

The Project organized and financed the creation and publication ofa data base for the Central American Cooperation Program for Improvements of Food Crops (PCCMCA) covering 28 years of information. Most of the research on food crops carried out in Central America is reported at these meetings and having this data systematized has made the results readily available for the first time to researchers within and outside the region. A specialised production systems bibliography was also prepared and an accumulative list of all documents prepared by the PPD is being maintained. A library specializing in vegetable crops containing 4476 references to 30 crops was developed and co-financed.

Institutional support

The work in tolerance to flooded soils required the realization of certain analyses not previously carried out at CATIE. Thus a capacity was developed to determine exchangeable manganese, water soluble manganese, readily reducible manganese, redox potentials and oxygen diffusion rates.

Several pieces of equipment were acquired by CATIE under the IFAD grant to improve its research capability in areas where rainfall is limited. These included a plant water status console, an infrared thermometer, pressure plate aparatus, electrical resistance blocks and meters, standard evaporation tanks, recording rain gauges, and pyranographs.

Data processing was also improved by the purchase of two microcomputers. Equipment for slide reproduction and preparation of audiovisuals increased capability for training and outreach activities. Training, documentation and the information system of the PPD were greatly benefited by IFAD grants and are now well established and running properly.

Seed Multiplication and Distribution

The genotype evaluation component has also collaborated in the conservation, multiplication, and distribution of the material which performed best in trials or in which there was research interest either at national or international level. Seed has been supplied for research to CATIE personnel not involved in the IFAD project. The genotype component has served as a linkage between national programs and international organizations for obtaining and distributing germplasm of different crops. A small germplasm bank exists, containing presently some 600 introductions of various crops. The principal objective of this bank has been the conservation, multiplication and distribution of material to researchers. Seeds are available of *Phaseolus vulgaris*, *P. lunatus*, *Dolichos* sp., *Canavalia* spp., *Vigna* spp., *Psophocarpus tebragonolobus*, *Arachis hypogaea*, *Glycine max*, *Cajanus cajan*, *Sorghum bicolor*, *Zea mays*, *Oryza sativa*, and *Manihot esculenta*. During 1984-85, more than 200 shipments of planting material were made to countries in the area. The germplasm bank is now part of the Plant Genetic Resources Project of CATIE.

OUTREACH

A cropping systems working group was formed for the six Central American Countries. This group met in September, 1983 in Turrialba and in July, 1984 in Guatemala city. The first meeting served to discuss the institutionalization of the CATIE farming systems research methodology. The second meeting focussed specifically on problems of validation and technology transference, as many of the Central American countries are presently involved in these aspects of farming systems research.

Among the resolutions of the first meeting was the encouragement of the formation and training of multidisciplinary research teams by national institutions. It was felt that they should be integrated with the rest of the public agricultural sector. CATIE could participate in such training through its graduate program and short courses.

The second meeting identified specific problems in validation and technology transfer activities. There were problems in selection of personnel, obtaining background information, selection of farmers for participation, and analysis of data obtained. It was felt that CATIE could provide guidelines for activities in these areas.

The outreach coordination activities under the IFAD grant have included:

1. Contacts and consultancies with technical personnel and authorities in different institutions of the countries of Central America and the Caribbean

2. Representation of the Plant Production Department in scientific meetings, seminars, and field days

3. Coordination of activities of the Department outside of Turrialba especially of the prototype teams

4. Evaluation of other farming systems activities of CATIE in the Central American countries

5. Organization of the cropping systems working group among farming system researchers of the area

6. Participation in support research activities in the lowland humid tropics in the area of cropping systems and soil management

ANNEX 1

CATIE 1985

ANNUAL REPORT

(IFAD TA 38D GRANT)

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA

Plant Production Department

Turrialba, Costa Rica, 1986

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INTRODUCTION

1985 may be considered as a year of transition and reorientation for the CATIE/IFAD Project. Reorientation was necessary since CATIE's lines and organization were under revision and the Project had to fit within the new framework. Another factor was IFAD's decision to reduce support for CATIE projects following the evaluation team's redefinition which took place in November 1984. It was also a year of transition since the program of activities for 1985 (based on the evaluation mentioned previously) was designed with the aiar of accumulating knowledge for the start of a new CATIE/IFAD Project directed at strengthening agricultural development or integrated rural development projects financed by IFAD in CATIE's mandate region.

The project carried out all the activities programmed for 1985 which were presented to IFAD in January of this year as "Planes de trabajo para 1985 del Departamento de Produccion Vegetal del CATIE con apoyo del FIDA mediante el TA Grant 38-D CATIE". In February and March, a consultation visit was made to the seven countries of the region. 71 government, private and international organizations were visited, 242 people interviewed and 173 documents photocopied, in keeping with the 1985 proposals of a) producing an inventory of different technology development and agricultural development programs and projects b) diagnosis of needs and priorities for support by the CATIE/IFAD Project (1986-1990) c) development of the project proposal "Desarrollo de Sistemas de Producción Tradicionales y Nuevos Sistemas de Producción" presented to IFAD in September. This proposal was revised and commented on by IFAD senior staff in Rome, who then suggested technical and financial changes for its presentation to the IFAD Board of Directors in April 1986. In February 1986, CATIE sent a new proposal "Technology and Farming Technical Assistance for

Accelerated Rural Development including comments and changes suggested by IFAD.

Updating analysis and documentation of Project results and advances also took place in 1985. The majority of research work started in 1980-81 by the Support Unit and Prototype teams was consolidated (points d and e of evaluation).

The Project was gradually restructured during 1985 to create a starting point for a new project, following indications given at the IFAD evaluation visit. The Costa Rica and Panama prototypes were wound up in June and December respectively and the Nicaragua Prototype in December 1984. No new personnel were hired, research activities were kept to a minimum, the External Cooperation Coordinator's position was closed, the last production systems course was given and only short courses were given in the countries.

The number of trips made by international personnel was cut to a minimum and only made when nescesary for consolidating plans and agreements for the new project.

In accordance with this, support was given to the Guaymi Project in Panama from the beginning of 1985. From February a CATIE specialist was posted in the Project area and technical personnel stationed in Costa Rica visited Panama at least 5 times. Their work included physical, biological and socioeconomic planning of the Guaymi area and giving a course on Area Diagnosis and Farming Research. A Guaymi professional was trained at CATIE for 3 months; and CATIE as an institution provided a vehicle for the use of national personnel attached to the Guaymi Project.

The PRODESBA Project (financed by IFAD) in Honduras also received technical and logistic support from CATIE/IFAD. On three different occasions, personnel from Turrialba visited this Project, participating in the 1986 programing and assisting reorientation of research and extension activities. One PRODESBA Scientist received three months training at CATIE.

The Dominican Republic was visited in June 1985 to make contacts and revise current and future IFAD Projects (IFAD I, II, III and IV). This initiative was maintained for the rest of the year until the beginning of 1986. Momoranda and documents were passed between IFAD-Rome, the Dominican Republic's government and CATIE personnel in Costa Rica.

The activities and progress made by the Project during 1985 and the first quarter of 1986 are presented in the following sections of this Report.

RESEARCH AND DEVELOPMENT OF TECHNOLOGY

Research, trials and validation of technology carried out by the Research Support Unit and Prototype teams were drastically reduced in 1985. It was decided as an overall strategy to cancel or finish studies that were already sufficiently advanced or so close to finishing that extra effort was not worth while in such a short time. Only those in line with the "New Project" and/or whose results could easily be obtained in 1985 were continued.

In Nicaragua only essential logistic and, supervisory support was left for technology verification and validation. The Prototype team was dismantled in December 1984.

In Costa Rica the prototype team worked until June concentrating on classifying information and formal design for production alternatives. Senior personnel of the Research Support Unit were kept on with the exception of the Project Technical Coordinator (Agricultural Economist) who left CATIE in September. The Panama Prototype was also reduced, for the most part, to two personnel. They only worked on farmer's land in the first farming cycle and on a small number of trials.

Finally, work on ecological zones and the most important production systems was concluded. The definition of each of these ecological zones is presented in the main body of this document.

LOWLAND HUMID TROPICS

Legume - Maize Associations

Two characteristic microclimates within maize + cowpea (Vigna, 288 and TVU-401 selections) and maize + soybean (PK 7394) associations were evaluated. Associations were planted at three intervals relative to the maize sowing: 0 (simultaneous), 20 and 80 days after sowing maize (DASM).

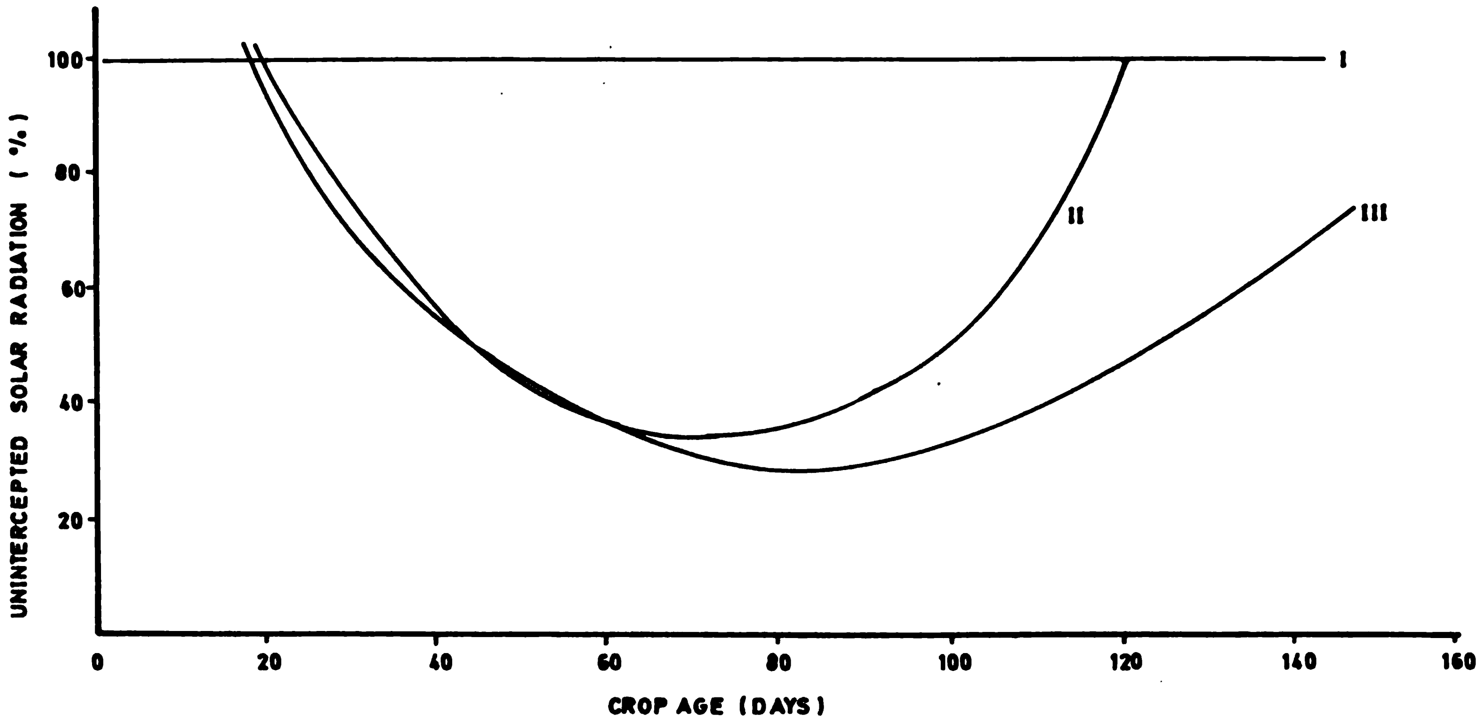
Principal microclimate variations imposed on the associated crop (soybean, cowpea) by the dominant crop (maize) were mainly related to solar radiation (27 to 37%) Fig 1 shows solar radiation not intercepted by maize foliage (and therefore available to the soybeans or cowpea). With "Maicito variety", lowest available radiation (37%) was found 60 DAS, whilst in "Tuxpeño PB C7" 27% was found 80 DAS. Solar radiation within the crop correlated with plant height (-0.91) and leaf area index (-0.91) in "Tuxpeño" maize, wheras it correlated with plant height (0.89) and biomass (-0.91) in "Maicito".

Mean variation of temperature (0.5 to 0.7) and relative humidity (90 to 91%) within and outside the maize was small. Thermal oscillation varied betwiin 6.8^{o} and 10.9^{o}C and degree days between 12.7 and 13.7 during the crop cycle.

Maize varieties Tuxpeño C7 and Maicito showed differences in their growth curves; Tuxpeño showed greater size, LAI, biomass and vegetative cycle, imposing different mocroenvironmental conditions than did Maicito.

The effect of the associated crops (cowpea and soybean) on maize biomass production and growth pattern were different for each associated crop. Greatest reduction in biomass and growth were found in indeterminate cowpea (TVU-401) associations compared to determinate (selection 288). Maize yields fell by 42% in simultaneous associations with indeterminate cowpea.

Less changes in maize growth pattern were produced by determinate (s. 288) than indeterminate cowpea (Figs 2, 3, 4 and 5). Changes were less for "Tuxpeño" (Fig.3) than



I EXTERNAL SOLAR RADIATION

II SOLAR RADIATION NOT INTERCEPTED BY MAICITO

III SOLAR RADIATION NOT INTERCEPTED BY TUXPEÑO

FIG. 1. UNINTERCEPTED SOLAR RADIATION (%) FOR MAIZE CULTIVARS TUXPEÑO pB-C7 AND MAICITO (TURRIALBA JUNE-DEC. 1984).

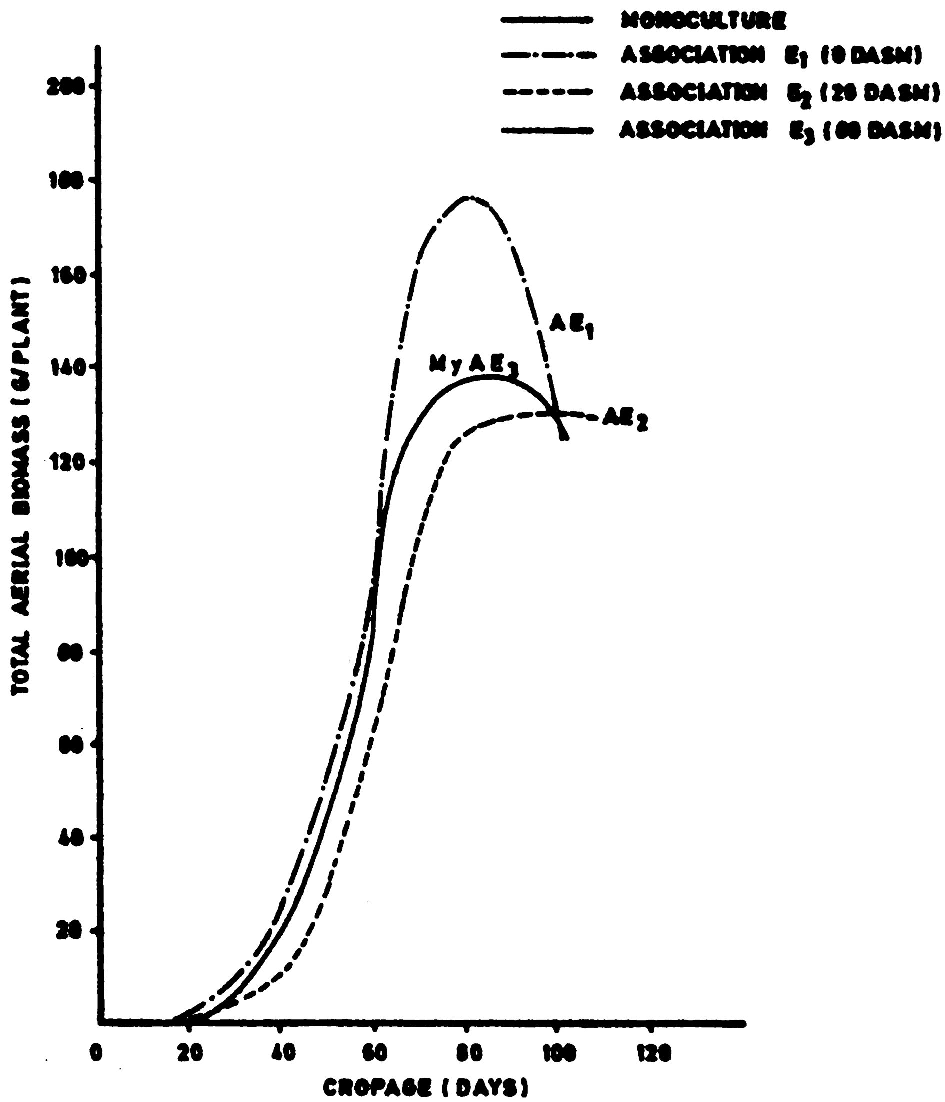


FIG. 2. VARIATIONS IN TOTAL AERIAL BIOMASS PER PLANT IN MAICITO VARIETY MAIZE IN MONOCULTURE AND IN ASSOCIATION WITH SELECTION 208 COWPEA, IN THREE CHRONOLOGICAL ARRANGEMENTS.

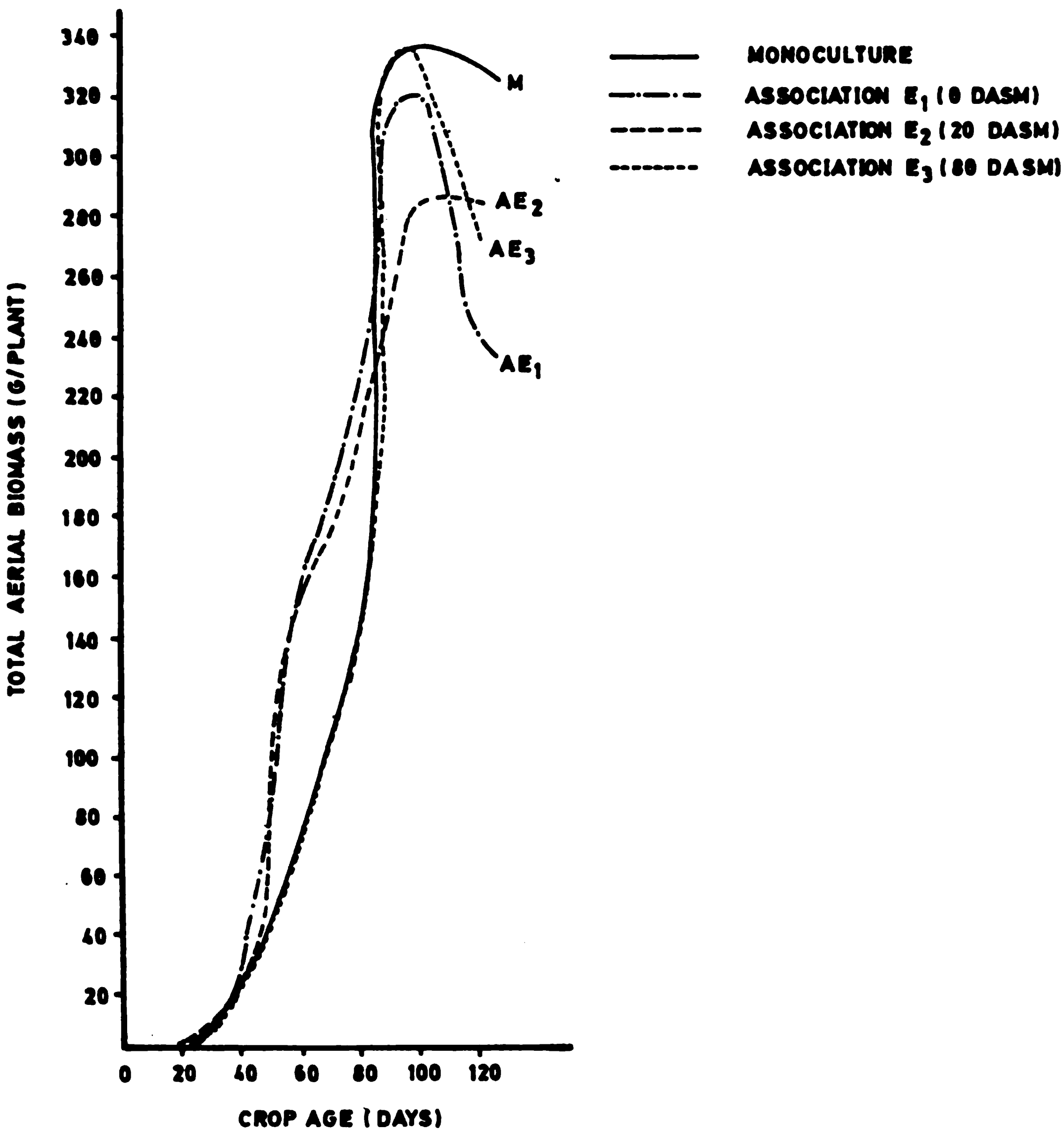


FIG. 3. VARIATION IN TOTAL AERIAL BIOMASS PER PLANT IN TUXPEÑO pB-C7 VARIETY MAIZE, IN MONOCULTURE AND IN ASSOCIATION WITH SELECTION 288 COWPEA, IN THREE CHRONOLOGICAL ARRANGEMENTS.

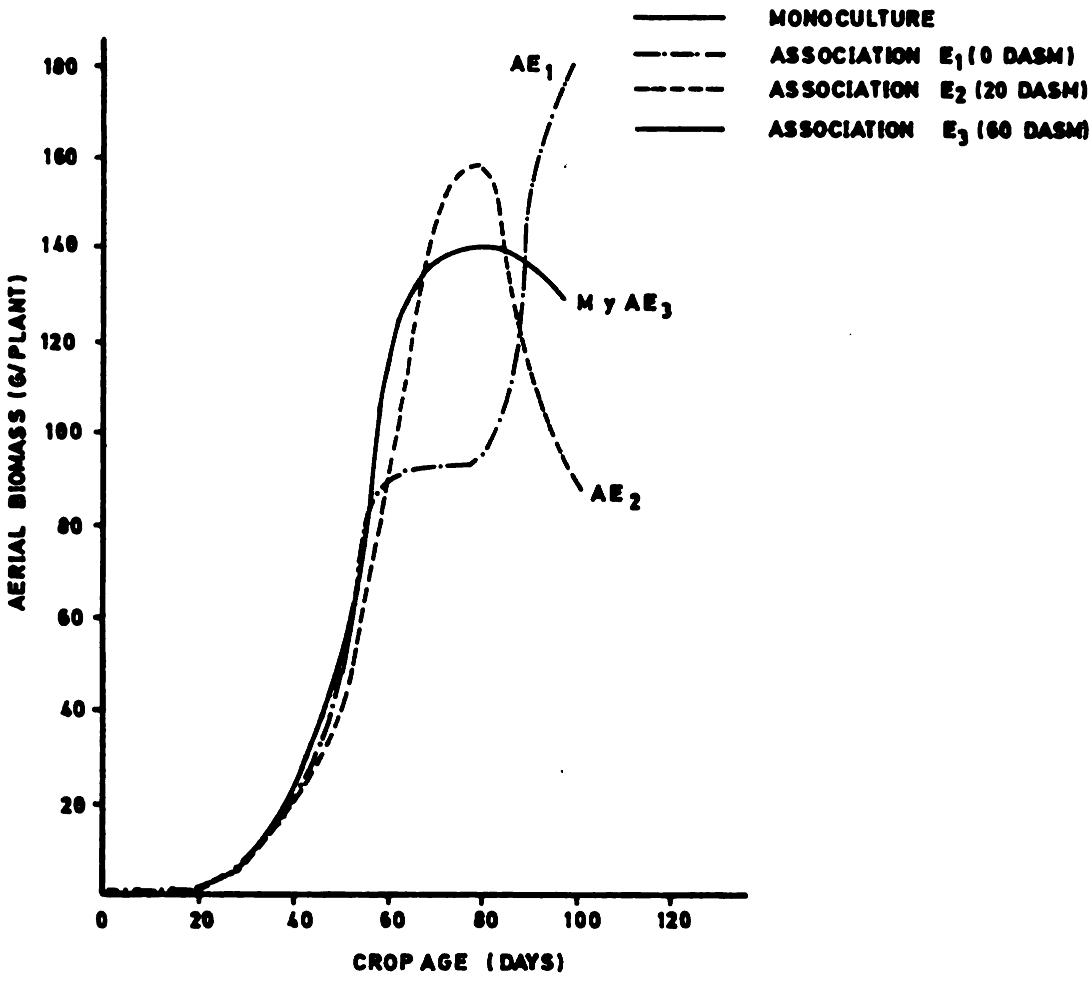


FIG. 4. VARIATIONS IN TOTAL AERIAL BIOMASS PER PLANT IN MAICITO VARIETY MAIZE IN MONOCULTURE AND IN ASSOCIATION WITH TVU-401 VARIETY COWPEA, IN THREE CHRONOLOGICAL ARRANGEMENTS.

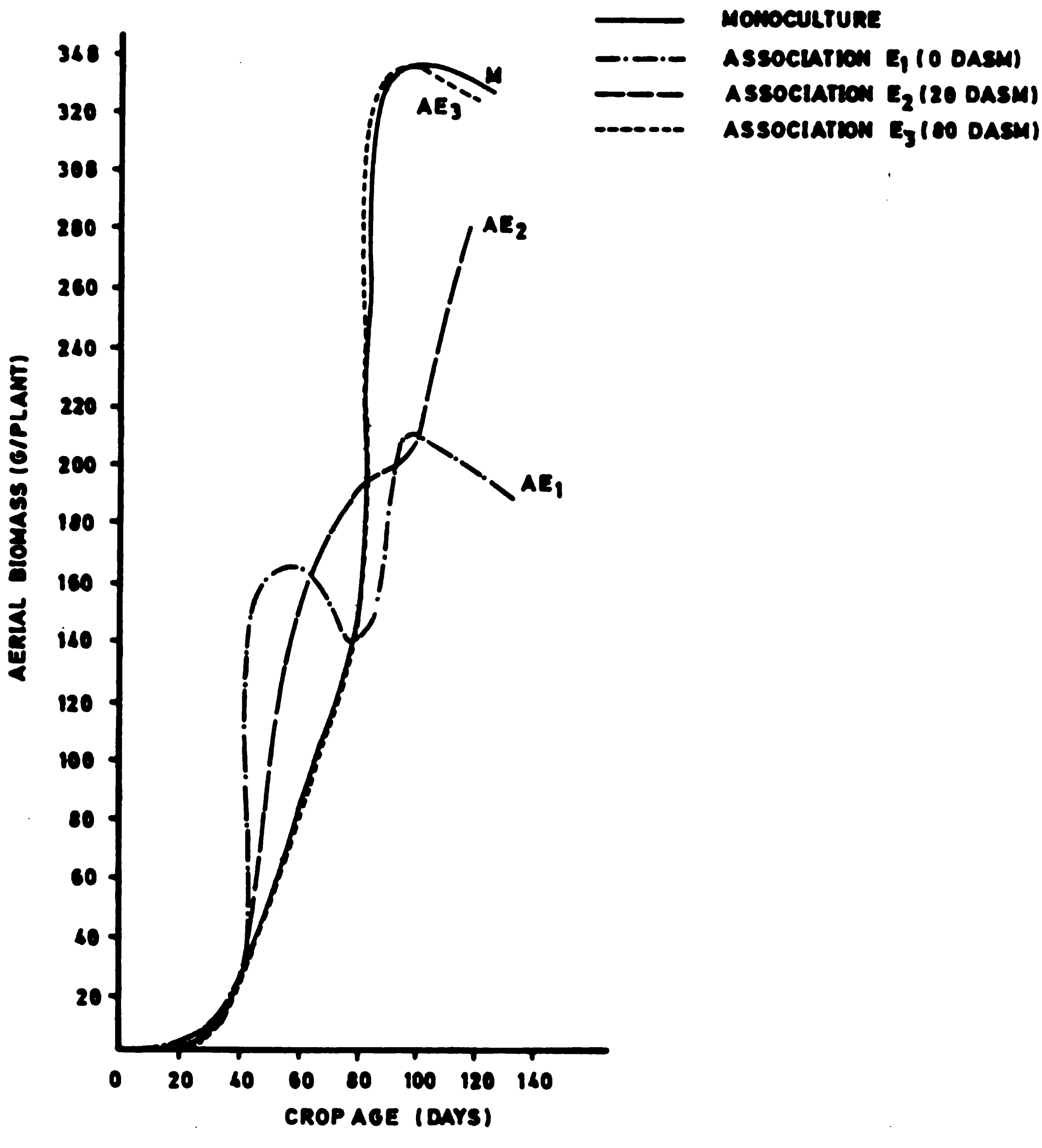


FIG. 5. VARIATIONS IN TOTAL AERIAL FOLIAR BIOMASS PER PLANT IN TUXPEÑO pB C7 MAIZE VARIETY IN MONOCULTURE AND IN ASSOCIATION WITH TVU 401 VARIETY COWPEA IN THREE CHRONOLOGICAL ARRANGEMENTS.

"Maicito" (Fig. 2) where cowpea simultaneous association stimulated "Maicito" growth comparated to monocrop growth. Cowpea (selection 288) sown at 20 DASM reduced maize growth. Tuxpeño and Maicito growth patterns are closely related to the periods of coincidence of associated crop requirements and to the opportunities they have for advantageous competition.

Almost all yield components differed within maize varieties. "Maicito" yield was 39% that of "Tuxpeño".

Growth pattern modifications were different for maize-soybean associations. Tuxpeño growth was higher in simultaneous association than in monoculture. At 200 DASM maize growth was affected by soybean competition (Fig.7).

"Maicito" monoculture growth pattern was changed by association with soybean at all sowing times (Fig 6). In the first association, maize growth seemed to be stimulated, while in the second there was a greater degree of soybean competition, due to the longer time of association.

In association with maize, cowpea showed different growth patterns, influenced by competition and microenvironmental conditions produced by the dominant crop (maize). "Tuxpeño" intercepted more light (20%) than "Maicito".

Distribution of available light within the maize is closely related to the intensity of growth of the crop. "Maicito", with its short vegetative cycle, produced greatest light interception (63%) 20 days before "Tuxpeño" (73%).

These variations in the amount of intercepted light are especially dependant on leaf area index and leaf structure.

Cowpea (288 and TVU-401) growth patterns were affected by time of sowing; whilst biomass growth in 288 was reduced by sowing time (Fig. 8 and 9), TVU-401 showed a tendency to increased growth (Figs 10 and 11).

On average, biomass production was highet in TVU-401 (45%) than in 288.

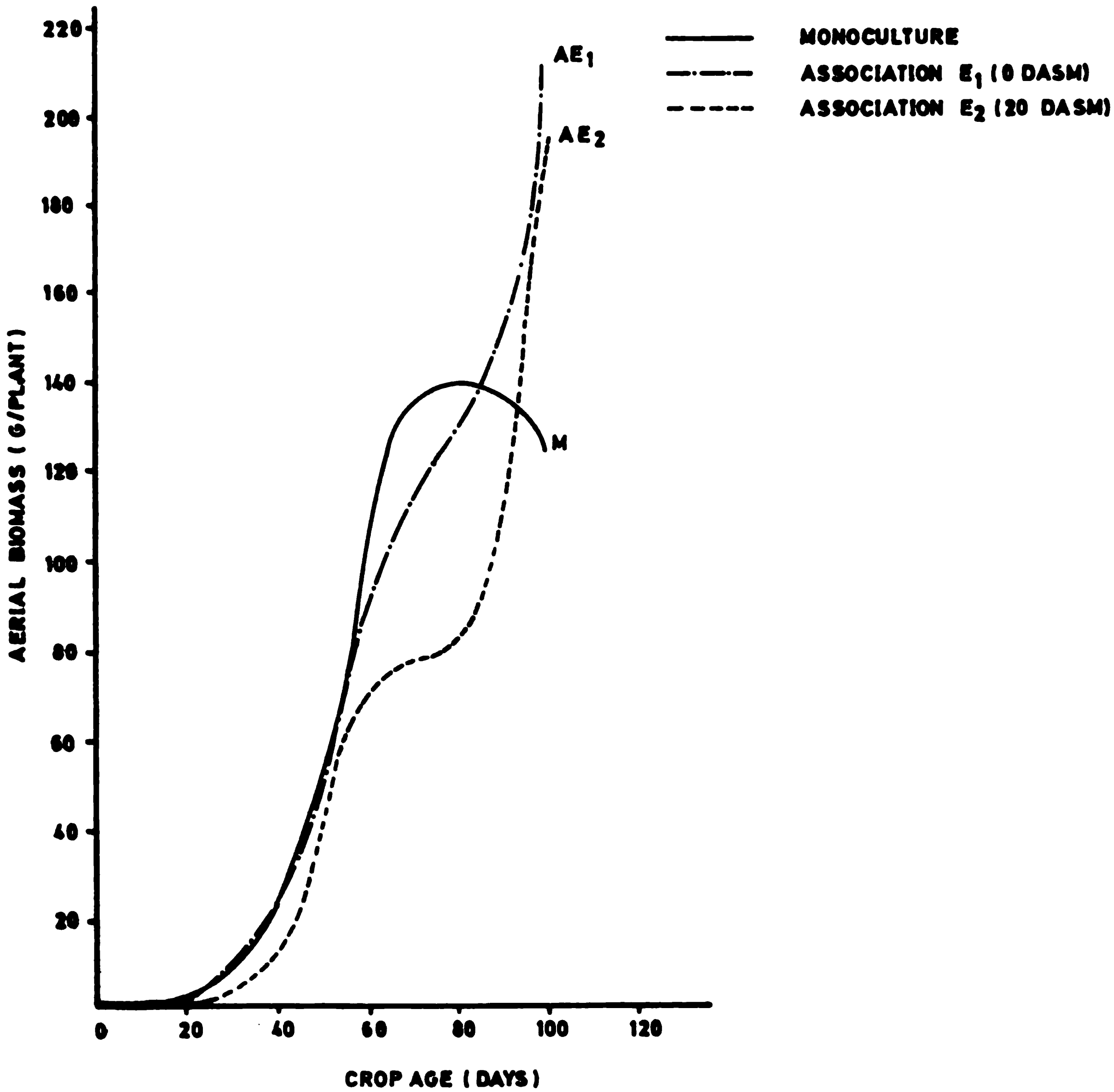


FIG. 6. VARIATIONS OF TOTAL AERIAL BIOMASS PER PLANT FOR MAICITO VARIETY MAIZE IN MONOCULTURE AND ASSOCIATED WITH PK-7394 VARIETY SOYA IN TWO CHRONOLOGICAL ARRANGEMENTS.

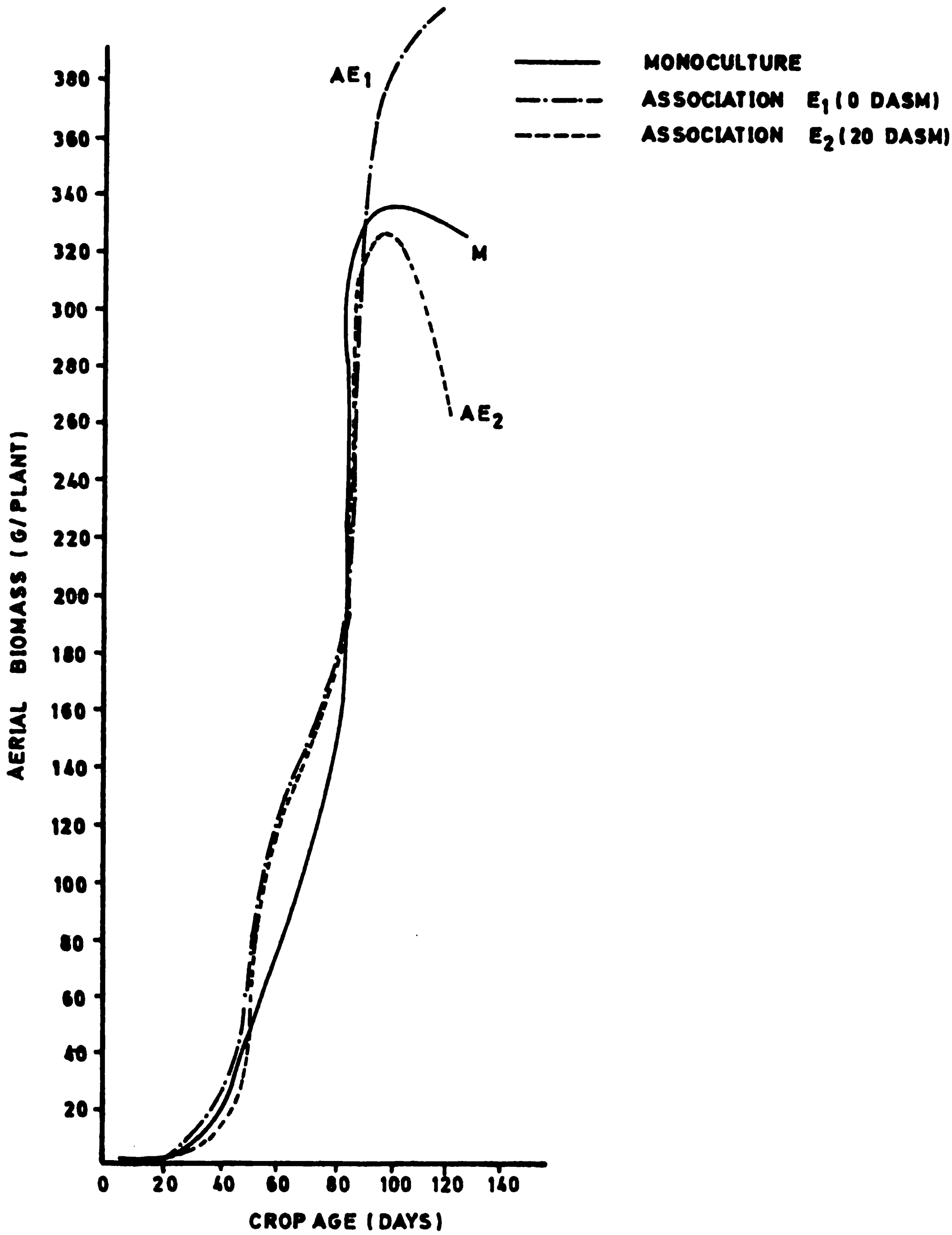


FIG. 7. VARIATIONS IN TOTAL AERIAL BIOMASS PER PLANT IN TUXPEÑO pB-C7 VARIETY MAIZE IN MONOCULTURE AND ASSOCIATED WITH PK-7394 VARIETY SOYA, IN TWO CHRONOLOGICAL ARRANGEMENTS.

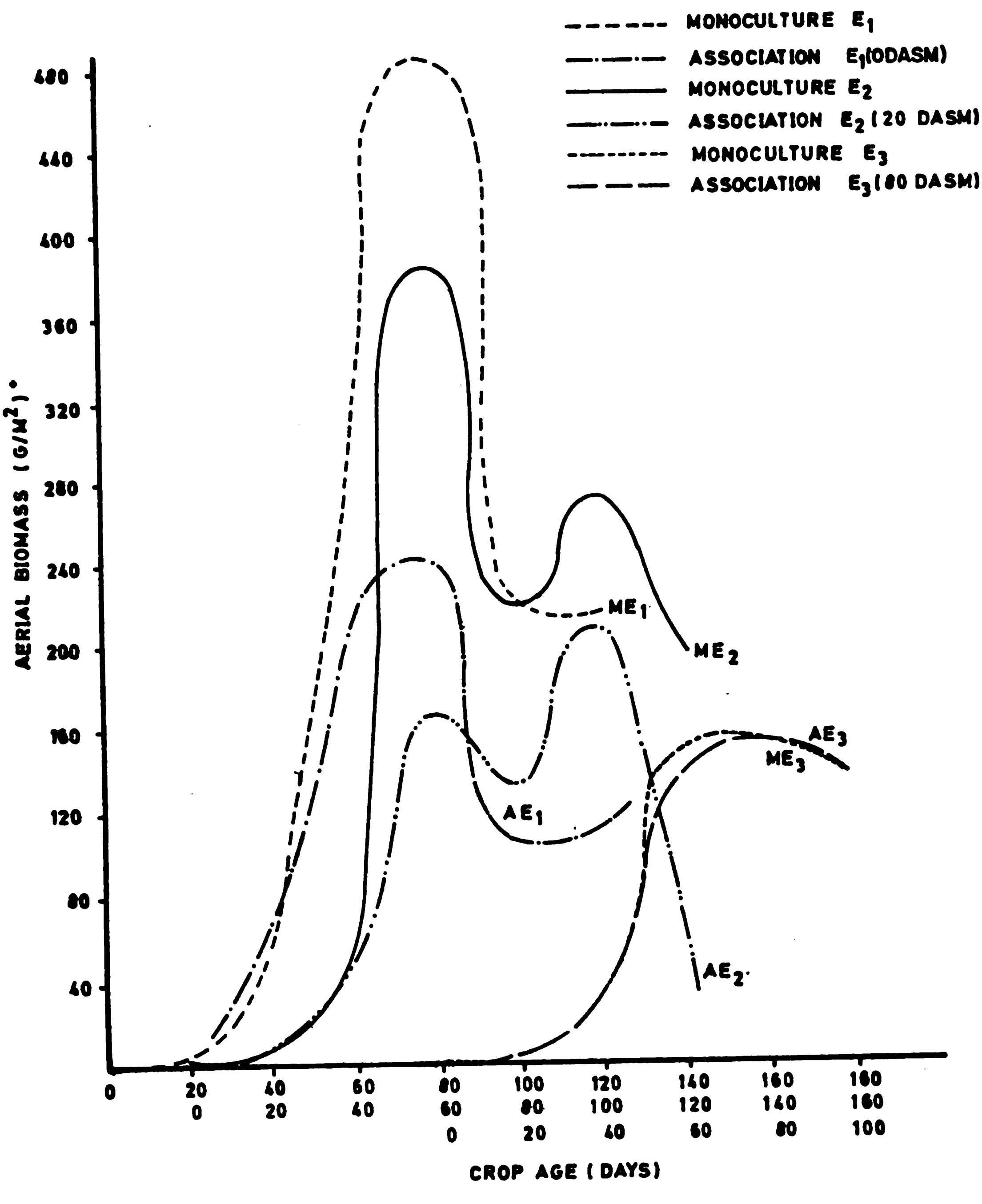


FIG. 6 VARIATIONS IN TOTAL AERIAL BIOMASS IN SELECTION 288 COWPEA, IN MONOCULTURE AND IN ASSOCIATION WITH MAICITO VARIETY MAIZE, IN THREE CHRONOLOGICAL ARRANGEMENTS.

* 8 PLANTS/M^2.

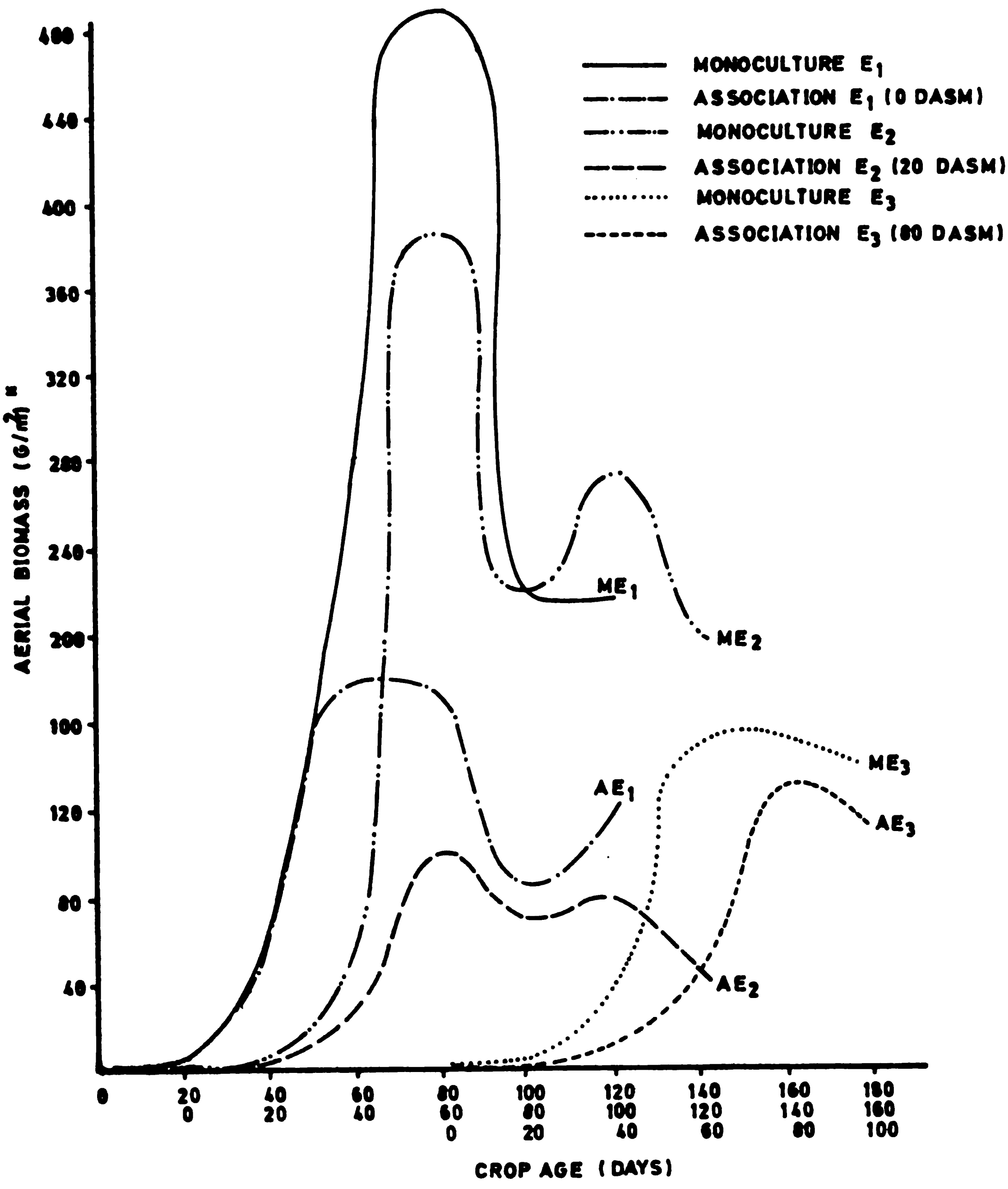


FIG. 0. VARIATIONS IN TOTAL AERIAL BIOMASS IN SELECTION 208 COWPEA IN MONOCULTURE AND IN ASSOCIATION WITH TUXPEÑO pB-C7 VARIETY MAIZE, IN THREE CHRONOLOGICAL ARRANGEMENTS.

* 8 PLANTS/ m²

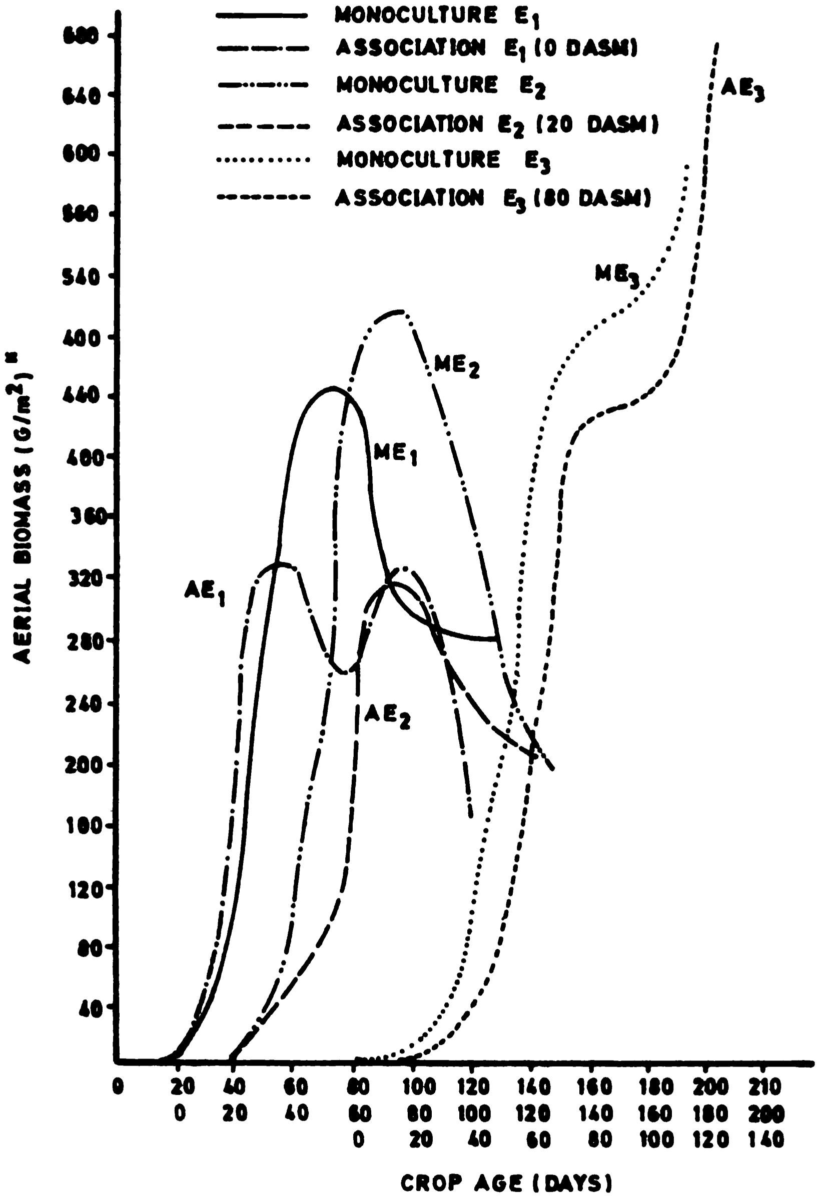


FIG. 10. VARIATIONS IN TOTAL AERIAL BIOMASS IN TVU-401 VARIETY COWPEA IN MONOCULTURE AND IN ASSOCIATION WITH MAICITO VARIETY MAIZE IN THREE CHRONOLOGICAL ARRANGEMENTS.

* 8 PLANTS / m^2

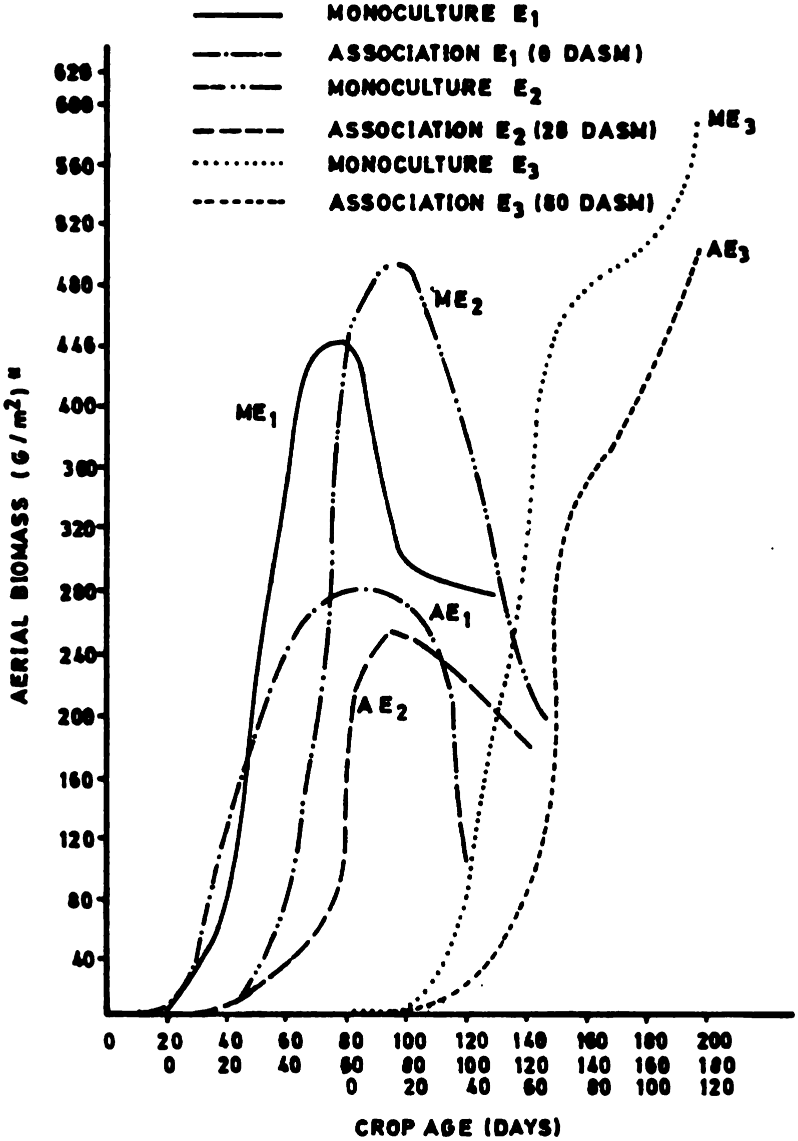


FIG. 11. VARIATIONS IN TOTAL AERIAL BIOMASS IN TVU 401 VARIETY COWPEA IN MONOCULTURE AND IN ASSOCIATION WITH TUXPEÑO pB-C7 VARIETY MAIZE IN THREE CHRONOLOGICAL ARRANGEMENTS.

* 8 PLANTS / m^2

Cowpea 288 maximum biomass production is reduced by 50% compared to monoculture production when in association with "Maicito", at simultaneous sowing and 20 DASM. At these two times growth patterns are similar and approximately parallel (Fig 8). There is a similar tendency for "Tuxpeño" (Fig 9) although reduction of cowpea biomass is more drastic in simultaneous sowing (63%) and at 20 DASM (74%). For both maize varieties at 80 DASM, growth patterns for cowpea 288 are similar.

In simultaneous association with "Maicito", cowpea TVU-401 shows a characteristic growth pattern with a bimodal curve lower (34%) and different in shape from that in monoculture (Fig 10). This growth pattern, and that of "Maicito", reflect mutual competition owing to similar demands for resources during the same period (Figs 2 and 10) When sown simultaneously with "Tuxpeño", this variety also shows marked competition with maize, with substantial reduction of growth pattern without apparent changes in growth (Fig 2 and 11) This reduction is 38% relative to monoculture, with a long period of maximum biomass accumulation, possibly due to its more developed climbing habit than Tuxpeño, which causes marked yield reduction. Growth tendencies for TVU-401 sown 20 DASM are similar with both maize varieties, although there are greater reductions in "Tuxpeño" associations. At 80 DASM the cowpea growth is similar with both maize types. There is a general tendency for greater biomass when in association than in monoculture. These differences are small since they are found at different periods of maturation.

In cowpea, highest yields (1475 kg/ha for 288 and 2093 kg/ha TVU-401) were found for monoculture rather than association with "Maicito" and "Tuxpeño"; the greatest reduction was with "Tuxpeño" (68%). This reduction is expressed as a lower number of pods. Association with "Tuxpeño" shows greatest reduction (50%) compared to "Maicito" at only 21%. Number of grains per pod was also lower (10%) in association and mainly caused by maize shading.

In soybeans, biomass reduction due to maize competition was lower with "Maicito". Greatest variations were caused by sowing time - at 20 DASM there was 50% reduction. At simultaneous sowing, soybean biomass reduction, when associated with "Tuxpeño", was 6% of that when associated with "Maicito". Differences shown in associations with both maize varieties, due to effects of competition of maize on soybean, variety characteristics, and chronological arrangement within the period of competition from maize (Fig 12) showed a 30% reduction of monoculture maximun biomass, which was lower than at 20 DASM (50%).

In most cases, leaf area index for associations was greater than for monoculture.

Greatest bean yield for soybeans was found in monocultures (2061.4 kg/ha) although leaf area index was reduced. Reduction compared to monoculture was less in "Maicito" associations (41%) than in "Tuxpeño" (76%).

Maize in Association: Shading and Available Root Space Interactions.

Using Tuxpeño - C7 maize as the dominant crop and rice, sweet potato, adzuki bean (*Vigna angularis*) cowpea (*Vigna unguicultata*) and soybeans as subsidiary crops, interactions between available root space (by root isolation) and artificial shading were evaluated. Three chronological arrangements were used: simultaneous sowing, 90 DASM and 110 DASM. Control plots (Monoculture) were sown for all crops at each planting date.

The effect of available root space was evaluated by means of root isolation using plastic sheets. Effects of shading were evaluated from the growth of the associated dominated crop under simulated shade and in association.

With all the dominated crops, maize (in monoculture and association) produced the same biomass and grain yields. Root isolation did not affect maize growth compared with non

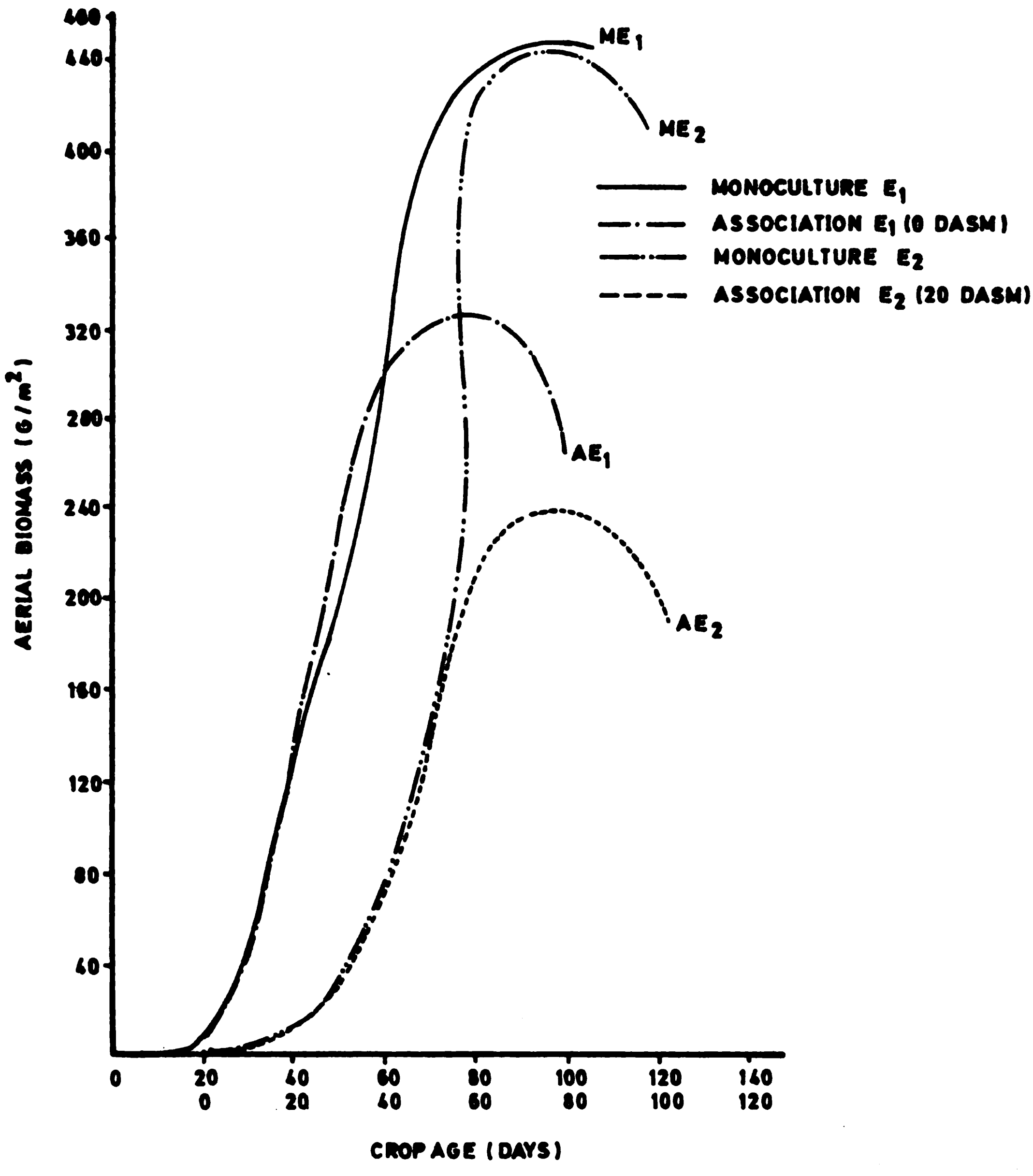


FIG. 12. VARIATIONS IN TOTAL AERIAL BIOMASS IN PK-7394 VARIETY SOYA IN MONOCULTURE AND IN ASSOCIATION WITH MAICITO VARIETY MAIZE IN TWO CHRONOLOGICAL ARRANGEMENTS.

* 24 PLANTS / m^2

insolation. The similar growth shown in monoculture and intercropped maize shows there was no effect of competition for water and nutrients by the dominated crops on root space availability. This may be due to early competition for light and reduced growth.

Crops grown with maize suffered a noticeable reduction in biomass production and yield compared to their monocultures.

Growth reduction in non-fertilized plots was greater in monoculture (TC4) than intercropped maize (Table 1). Competition for light probably limited nutrient absorption in the intercrops.

With the exception of cowpea, the growth of dominated crops in fertilized and non-fertilized plots was comparable, with or without root isolation.

Increased biomass production and yield in cowpea with root isolation compared to non-isolated is probably related to greater nutrient demand coinciding with maximum absorption by maize. Due to the latter's more extensive root system, it absorbs nitrogen more freely from solution in the soil, limiting absorption of the element by the cowpea.

Shading, either by maize (TC1 an TC2) or simulated using screens, affected the dominated crops compared to monoculture.

Under conditions of simulated shade, the dominated crops, with the exception of fertilized rice (Fig 14) showed similar total dry biomass and yield values to intercropped (TC1 and TC2). However it is possible to see slightly different behavioral tendencies in crops grown under simulated shade compared to those intercropped with maize. Leaving aside the first sample, a slight increase in biomass can be seen for screened adzuki bean (Figs 15 and 16) and sweet potato (Figs 19 and 20) and a slight decrease for soybean (Fig 21) whilst cowpea (Figs 17 and 18) on average showed similar behavior whether screened or intercropped.

TABLE 1. Biomass production in crops under competition of fertilization and non-fertilization. Percentages of F2 means in relation to F1 and goodness of fit (chi^2) for levels of fertilized (observed) vs. non-fertilized (expected) for all samples.

Crops	DAS*	F_1	TC_1 $\bar{x}$	F_2	F_1	TC_2 $\bar{x}$	F_2	F_1	TC_3 $\bar{x}$	F_2	F_1	TC_4 $\bar{x}$	F_2	Mean of F_2 in relation F_1	$chi^2=(O-E)^2$ O(5%)
RICE	30	5.23	4.92	4.61	5.76	6,02	6.29	7.22	7.15	7.09	9.52	8,35	7.18		SIGNIFI-CANT
	45	26.94	23.18	19.42	32.52	27.96	23.41	85.62	32.64	29.67	55.08	50.98	46.88		
	75	97.13	76.85	56.58	77.79	72.56	67.34	118.08	92.20	66.33	228.61	167.76	106.91		
	90	101.84	87.97	74.10	93.88	81.06	68.24	126.41	102.33	78.26	187.83	157.79	127.76		
F2/F1X100($\bar{x}$)**			72.81%			85.11%			74.89%			68.82%		$\bar{x}$ %=75.41	
ADZUKI BEAN	25	2.74	2.60	2.47	2.41	2.25	2.10	2.19	1.99	1.79	4.44	3.64	2.84		SIGNIFI-CANT
	40	10.92	8.78	6.65	10.41	8.93	7.73	10.70	10.56	10.42	17.34	13.72	10.10		
	60	33.66	30.16	26.66	30.43	30.30	29.64	35.51	32.91	30.31	52.10	50.48	48.86		
F2/F1x100($\bar{x}$)			76.75			86.92			88.16			72.00		$\bar{x}$ %=80.95	
COWPEA	25	2.46	2.39	2.33	2.92	3.07	3.23	2.64	2.32	2.00	2.86	2.37	1.89		SIGNIFI-CANT
	40	27.09	21.10	15.11	16.47	15.43	14.40	24.76	18,95	13.14	29.17	20.76	12.35		
	60	88.73	76.38	64.04	69.84	68.36	66.88	84.23	71.05	47.87	120.73	109.44	98.15		
	80	148.53	151.34	154.06	107.38	107.87	108.37	138.42	127.08	115.74	297.24	266.61	235.99		
F2/F1x100($\bar{x}$)			81.58			98.68			70.29			67.28		$\bar{x}$ %=79.46	
SWEET POTATO	30	11.69	11.15	10.60	11.87	11.02	10.16	9.37	9.37	9.37	23.10	22.45	21.80		SIGNIFI-CANT
	50	32.86	31.46	30.06	33.08	28.77	24.46	34.82	29.59	24.31	52.47	47.39	42.30		
	70	116.55	121.86	127.17	134.14	124.98	115.82	155.64	139.52	123.40	388.34	346.03	303.70		
	90	155.34	153.67	151.99	169.51	146.57	123.63	165.36	145.41	125.46	443.50	417.54	391.58		
F2/F1x100($\bar{x}$)			97.28			79.70			86.19			85.37		$\bar{x}$ %=87.13	

* Days after sowing

** Means in all samples

TC_1 Assoc. with maize + root isolation

TC_2 Assoc. with maize-root isolation

TC_3 Under screen (simulation)

TC_4 Monoculture

F_1= Fertilized

F_2= Non-fertilized

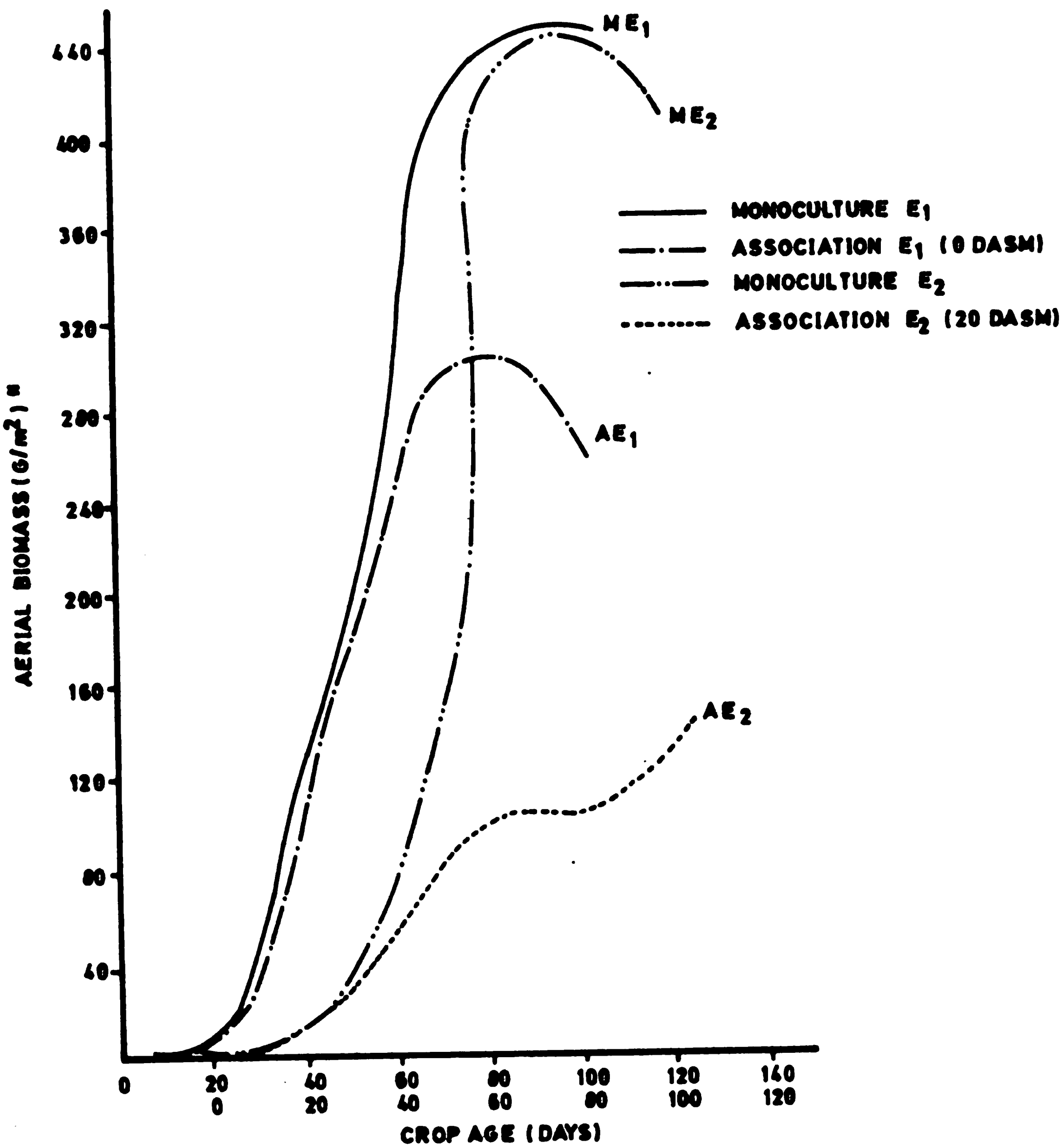


FIG. 12. VARIATIONS IN TOTAL AERIAL BIOMASS IN PK 7394 VARIETY SOYA IN MONOCULTURE AND IN ASSOCIATION WITH TUXPEÑO pB-C7 VARIETY MAIZE IN TWO CHRONOLOGICAL ARRANGEMENTS.

* 24 PLANTS / m^2

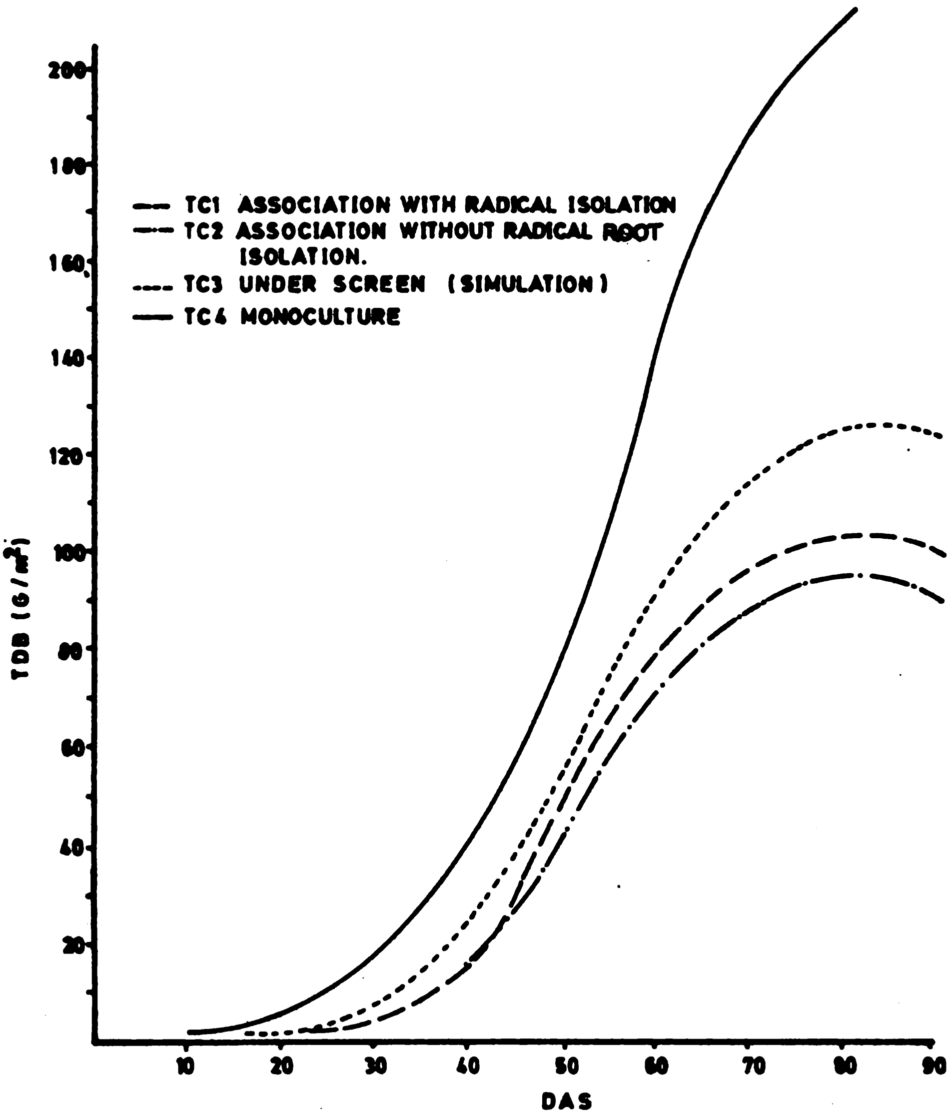


FIG.14. GROWTH CURVES FOR TYPES OF COMPETITION IN FERTILIZED RICE (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m²).

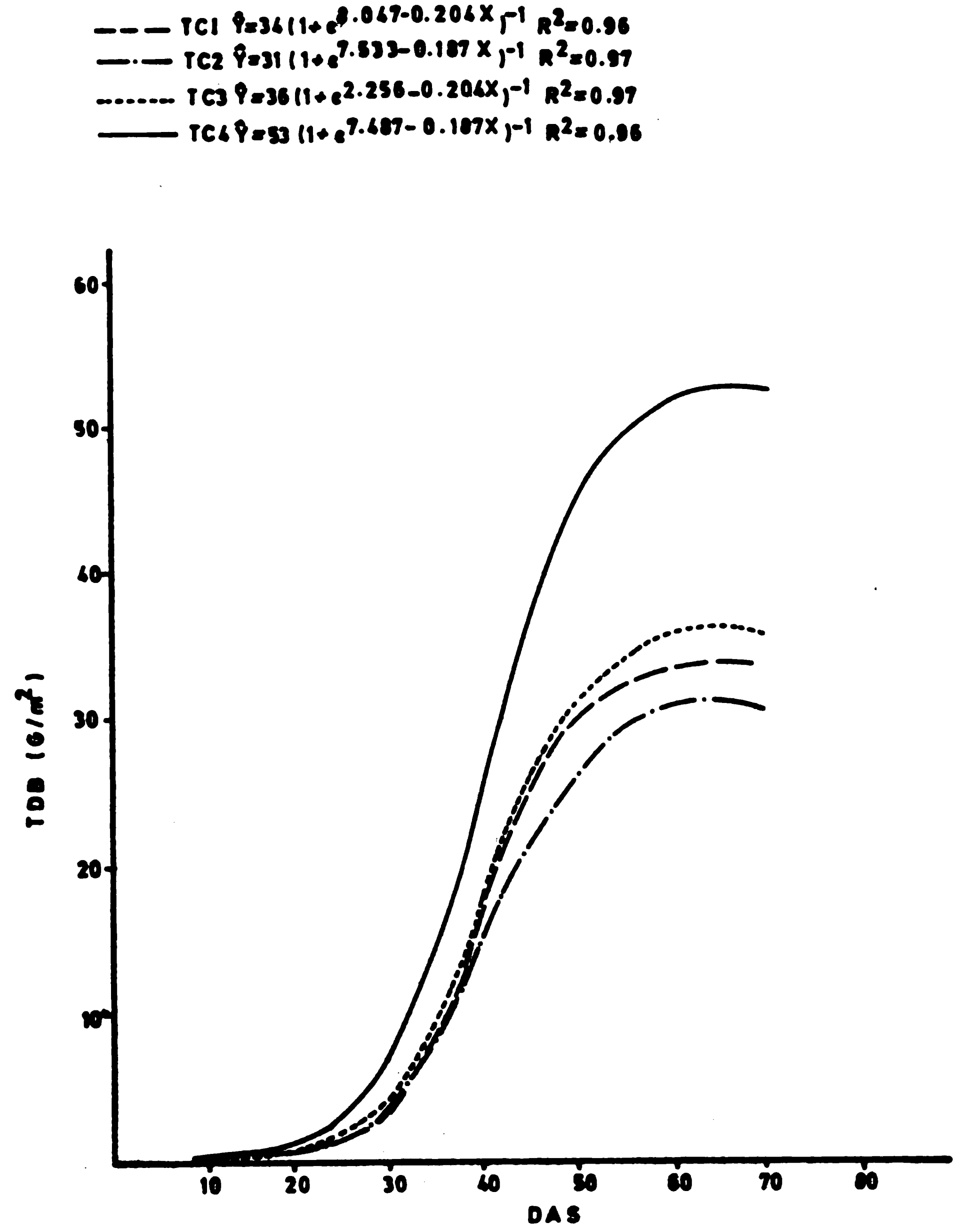


FIG.15. GROWTH CURVES FOR TYPES OF COMPETITION IN FERTILIZED ADZUKI BEANS (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m²).

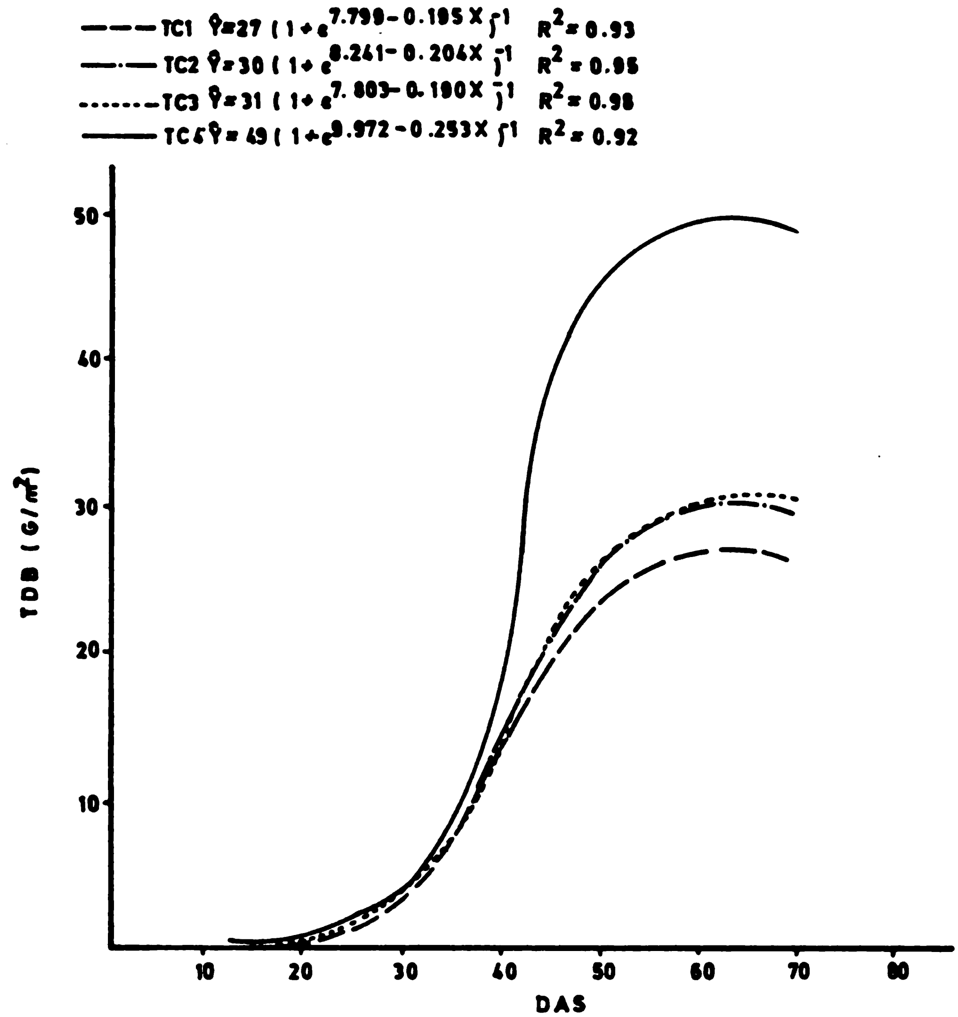


FIG. 16. GROWTH CURVES FOR TYPES OF COMPETITION IN UNFERTILIZED ADZUKI BEANS (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m^2).

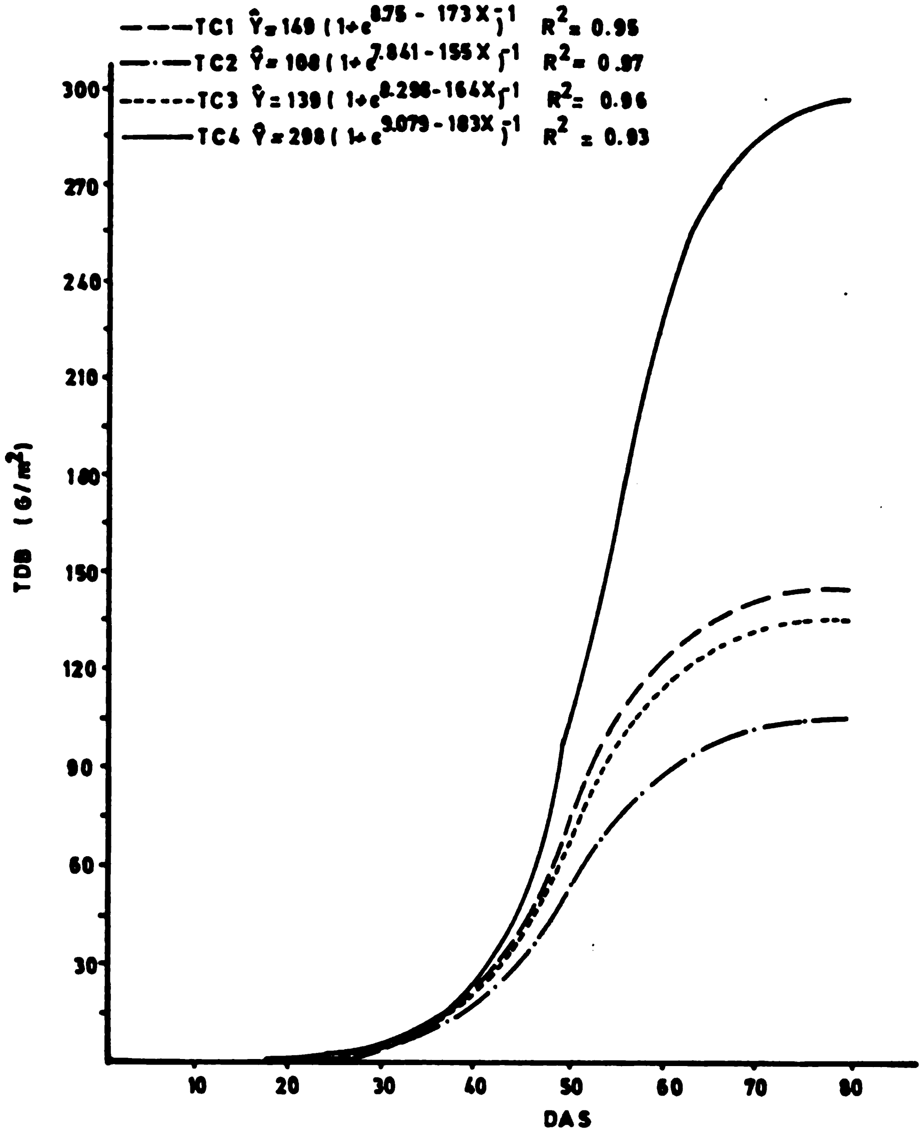


FIG. 17. GROWTH CURVES FOR TYPES OF COMPETITION IN FERTILIZED VIGNA (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m²).

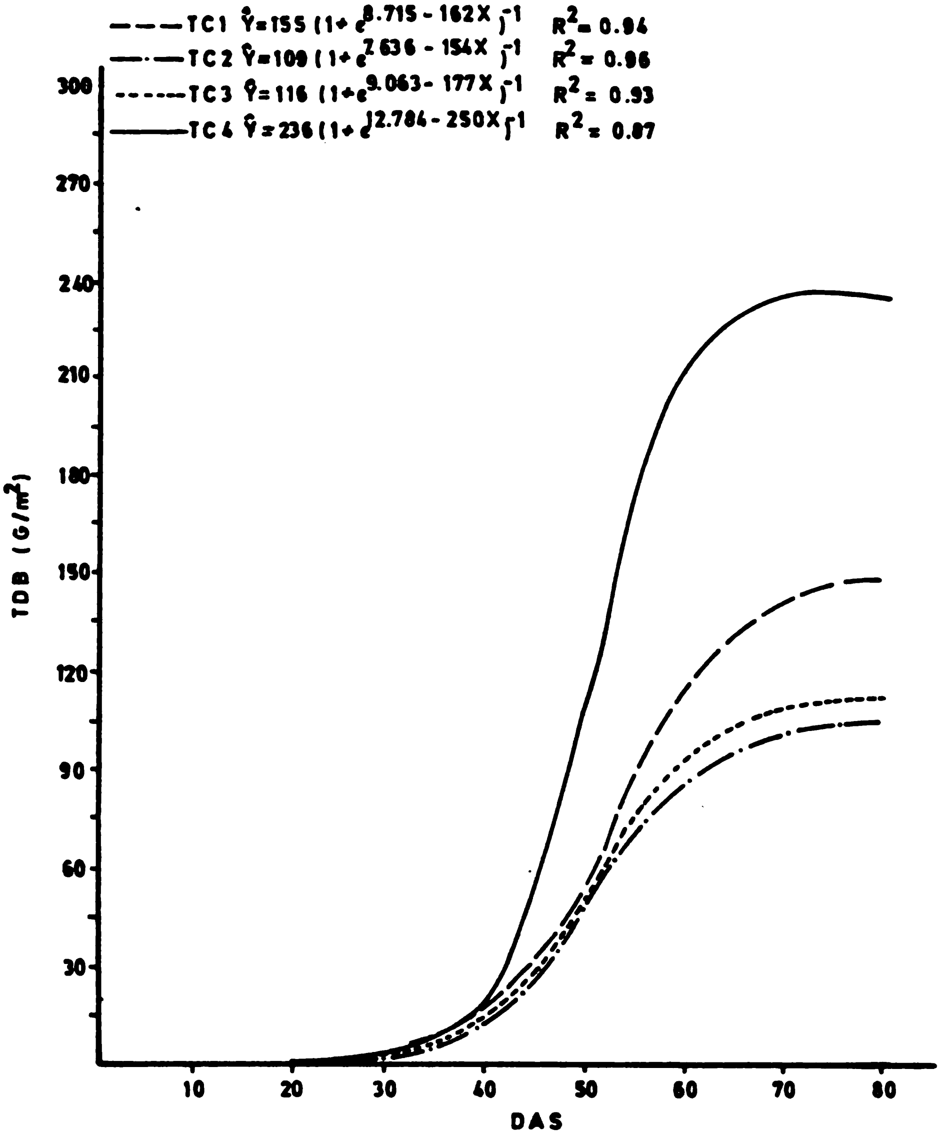


FIG. 18. GROWTH CURVES FOR TYPES OF COMPETITION IN UNFERTILIZED VIGNA (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m²).

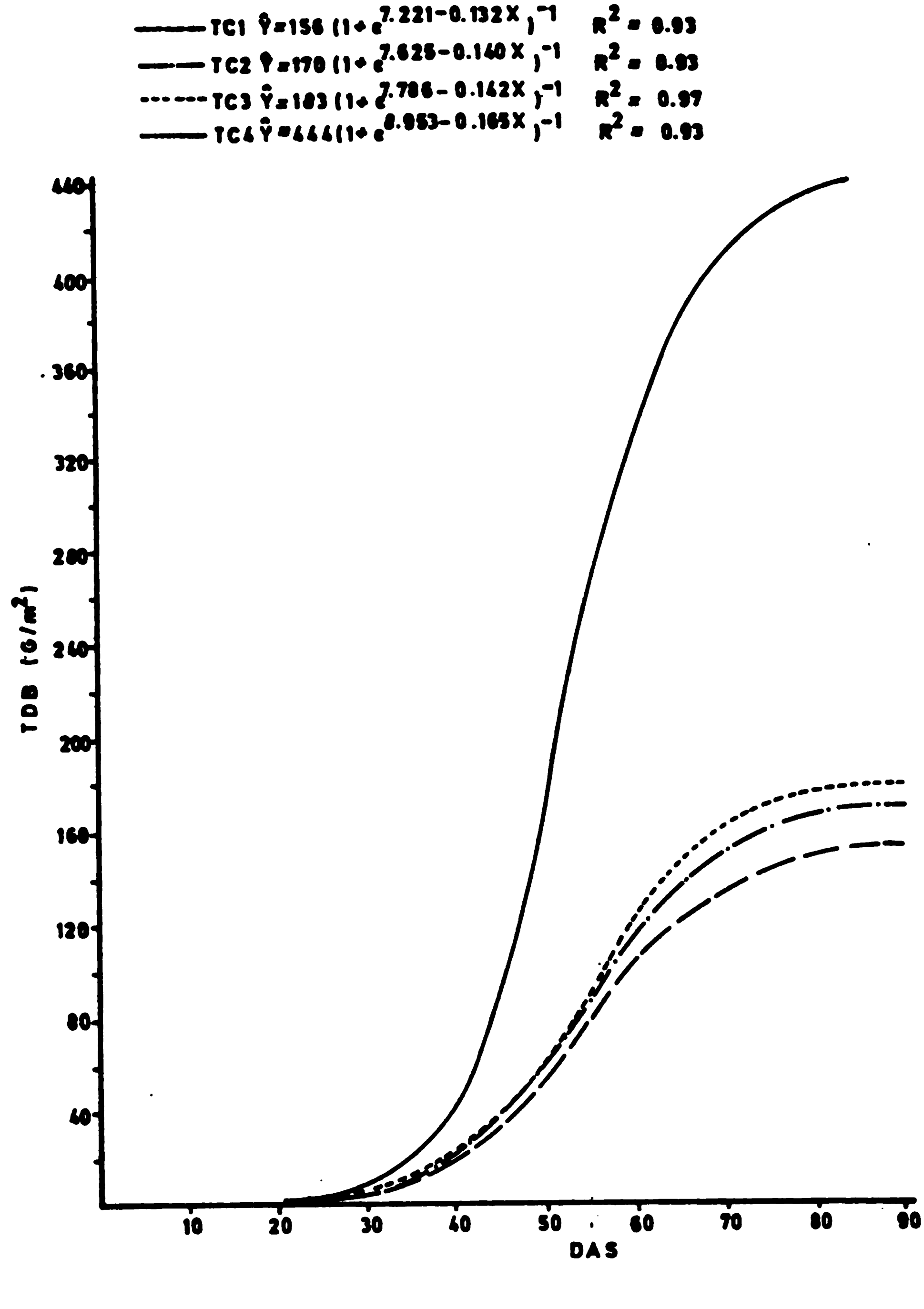


FIG. 19. GROWTH CURVES FOR TYPES OF COMPETITION IN FERTILIZED SWEET POTATO (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m²)

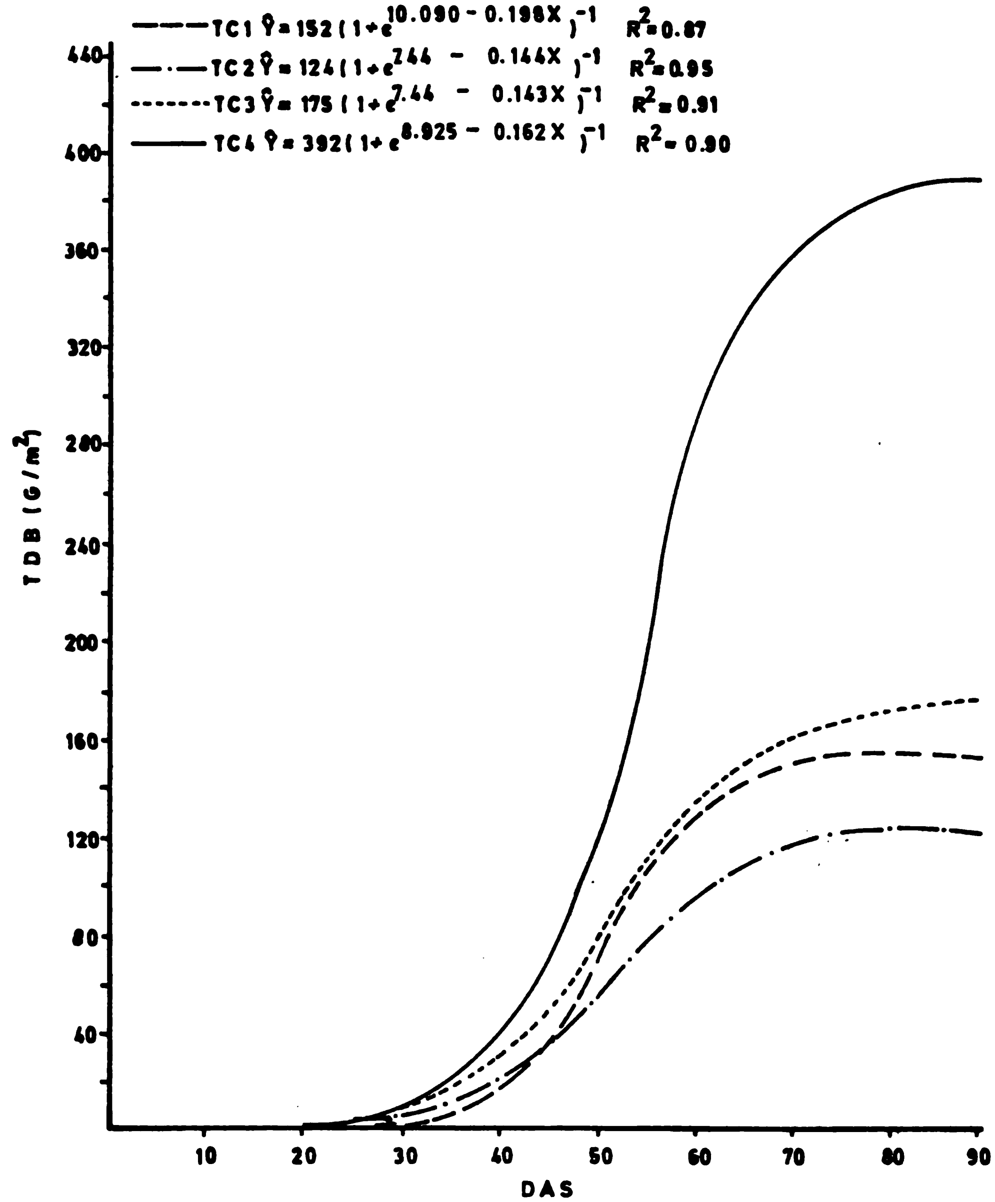


FIG. 20. GROWTH CURVES FOR TYPES OF COMPETITION IN UNFERTILIZED SWEET POTATO (SIMULTANEOUS SOWING) TOTAL DRY BIOMASS (G/m^2).

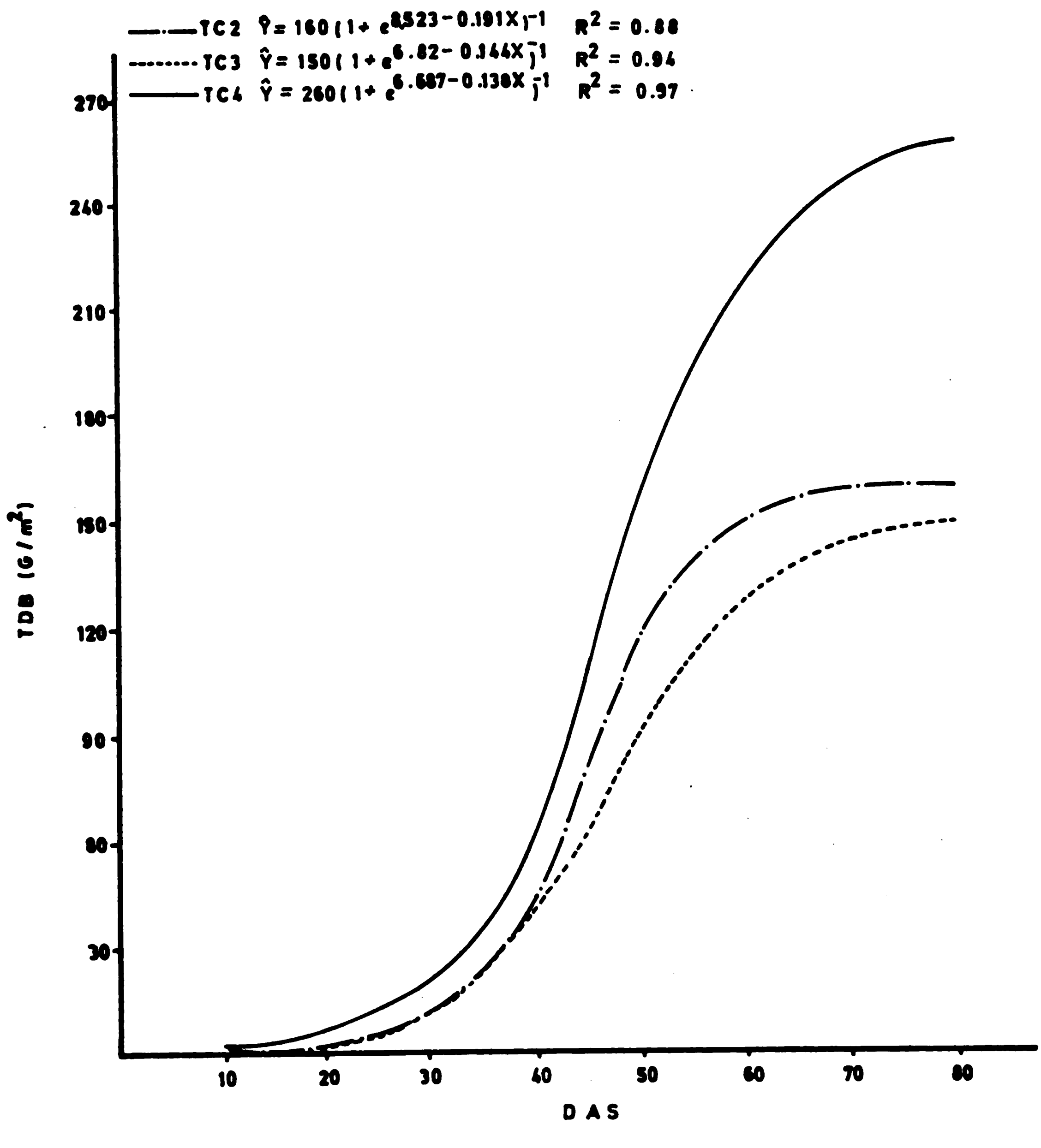


FIG. 21. GROWTH CURVES FOR SOYA BEAN IN EACH COMPETITION TYPE (FERTILIZED- SIMULTANEOUS SOWING).

One possible cause for these tendencies may be related to the dominated crops differing reaction to microenvironmental changes ocurring in the maize canopy and affecting growth. These changes may be caused by quality and distribution of light, relative humidity, temperature etc.

At the second sowing (90 DASM) the associated crops are subjected to fierce competition from the 90 day maize, during their first stage of growth. Microenvironmental conditions imposed by the maturing maize create a favorable environment for phytopathic attack in plants already weakened, in some cases by poor growth, compared to simulated shading by screens.

Rice showed a similar tendency when sown simultaneously producing greater biomass under screens compared to the intercrop means.

In the majority of cases, growth and yields for adzuki bean, cowpea and soybean grown under screens, were also higher compared to the means of intercropped plants, althought in many cases the differences were not statistically significant.

All plants grown with maize showed poor growth (etiolation). This was not seen in plants grown under screens due to the more uniform light penetration.

Etiolation led to weakened stems and greater susceptibility to disease and lodging.

Sweet potato showed the same tendencies as the previously mentioned crops, althought not affected by disease or light availability. Greater biomass production under screens compared to intercrops caused higher production of tubers. This may be due to greater soil compaction in the maize plots, caused by human traffic (for weeding etc.) and greater physical interference with the maize plants and their root systems (including maize roots from previous sowings).

Sowing dominated plants at 110 DASM constituted a relay where competition for light was minimal. At this time interval, sowing was carried out with doubled - over maize.

Rice grown under screens produced greater biomass than when grown with maize, althought the differences were not significant. Similar tendencies were shown in adzuki bean and soybean but to a lesser extent than in rice. Biomass and yield were lower for intercropped plants, but not significantly so.

Cowpea behavior, especially grain yield, was affected by a greater incidence of virus in the plots under screens than those intercropped with maize. This may be because the presence of maize stalks reduced the arrival and movement of insect vectors.

Sweet potato showed similar growth whether under screens or intercropped (mean of TC1 and TC2) and was the crop least affected by possible differences in soil fertility and microenvironmental variations under the maize stalks. Owing to its growth and arrangement of adventitious roots in the nodes of its lateral branchings, sweet potato is able to exploit soil well, as long as it is growing under acceptable light conditions.

Maize monoculture

From December 1984 to March 1985, 8 maize cultivars under two management systems have been evaluated in Pital, Alajuela, Province. the systems were:

a) 53.33 pl/ha (0.75 X 0.5 m - 2 plants per hole); seed treatment with captan (80 gm/5a kg); carbofuran at base of hole (8 kg/ha PC at 5%) fertilization (230 kg/ha 12-24-12 at sowing and 100 kg/ha NH_4NO_3 20 DAS); chemical weed control (atrazine 1 kg ai/ha and pendimenthalin 0.67 kg/ha at preemergence) and insect control (*Spodoptera frugiperda*) with foxim 2.5%.

b)Farmer's practice defined by surverying several producers. This practice consisted of 62,500 pl/ha (0.8 x 0.6 m with 3 plants per hole); fertilization only at sowing (66 kg/ha 12

-24-12), manual weed control and no insect or disease control. Land preparation was the same in both cases - 1 ploughing and 2 harrowings. The soil in the study area is clay loam, low in phosplorus (1.2 mg/ml) and very acid (pH 5.1) similar to that predominating in the majority of farmer's fields in the Pital area.

A completely randomized block design was used with a split plot arrangement; varieties in the large plots and management systems in smaller plots. Yields were significantly different between varieties. The recommended system a) was not more economic than the farmers (Table 2).

Variety yields have been discussed in the main body and appear in Table 3.

Maize - Cassava system

In 1985, studies of phenotype interaction on an association system were continued. The effects of cassava genotypes on different growth patterns of one variety of maize and vice versa were considered. These studies allowed the identificación of three genotypes of both maize and cassava for evaluation in monoculture and association during 1985.

Maize genotypes were Tuxpeño PBC-12, (intermediate height, very leafy) Tuxpeño PBC-17, (of intermediate height and leafiness) Tico V-5, (tall, intermediate leafiness) and Valencia , (tall, non leafy). A completely randomized block design was used with three replicates. Cassava was sown at 1.0 x 1.0 m and maize at 1.0 x 0.87 m 20 DASM, between the cassava rows.

Maize data:

Results indicate significant interactions between maize and cassava genotypes with respect to grain yield, LAI and plant height. Mean yield for maize fell by 7.1% in association, however the maize genotypes behaved differently according to the cassava genotypes used. "Tuxpeño PB C-17" was affected most, with yield reductions between 12% and 18% compared to monoculture, followed by "Tico V-5" which

TABLE 2. Means of variables calculated for promising maize cultivars under two management systems in Pital. San Carlos. 1985

Management Level	Height in cm		Lodging		Yield of healthy grain/ha 13% H	Potential Yield kg/ha 13% H	Loss through birds, rot, etc Kg/ha
	Plant	Ear	Stem	Root			
Farmers' management practice	160[b]	80[b]	0.87[a]	3.3[a]	1926[a]	2054[a]	128[a]
Recommended practice	182[a]	95[a]	0.90[a]	2.6[a]	2149[a]	2257[a]	108[a]

TABLE 3. Grain yield at 13% humidity according to management system and estimated loss through rot and bird damage. Pital, 1985.

Cultivar	Yield $\bar{x}$ Kg/ha	Yield Kg/ha 13% H: Following farmers' management	Yield Kg/ha 13% H: Following recommended practice	Estimated loss through birds and rot Kg/ha
Guaymas (1) 8022	2747^{a*}	2530	2963	17
Ferke (1) 8129	2360^{ab}	2279	2240	20
Across 7929	2352^{ab}	2336	2368	18
Salaboni	2308^{ab}	2377	2240	16
Tico V-7	2118^{abc}	2039	2197	16
Across 8043	2050^{bc}	1950	2151	26
Maicena	1318^{c}	993	1644	250
Diamantes	1155^{c}	1005	1305	71

* Means with same letter within column do not differ significantly ($P = 0.05$).

yielded 1.8 to 6.5% less with all the cassava genotypes. In "Tuxpeño PB C-12", cassava genotypes CMC-84 and Valencia caused a 10% reduction in yield, but "Criollo Zamorano" produced yield increases of 14.8% (Table 4, Figs 22 and 23)

Genotypes "Tico V-5" and "Tuxpeño PB C-12" showed increased foliar area when associated, whilst "Tuxpeño PB C-17" showed a significant decrease. Maize plant height also followed this pattern (Table 5).

Cassava data:

Association reduced mean yields of commercial roots by 28% compared to monoculture. Most affected was "Valencia" (37 %) then "CMC-84" (26.7%) and "Criollo zamorano" (22.5%) The three maize genotypes were similar in provoking yield reduction, but "Tuxpeño PB C-12" reduced cassava yields slightly more (Table 4).

Genotype " Criollo zamorano" gave greatest yield of commercial roots, both in monoculture, (36.8 t/ha) and in association, (28.5 t/ha) and least affected maize yields (2.1%) making it the best for these associations and better than the traditional Valencia cultivar (Table 6). The most productive maize variety in association was Tuxpeño PB C-12 although Tuxpeño PB C-17 performed better in monoculture.

This shows the importance of selecting maize genotypes according to the system to be used. In cassava, however, once again no significant differences in phenotype interaction were found, indicating that selection for association may be made in monoculture following conventional methods.

Cassava - bean

Eleven bean cultivars previously selected in monoculture were evaluated in association with "Valencia" cassava. Cassava was sown at 1.25 m between hills, 1.0 m between plants. Beans were sown in double hills between the lines of cassava with 45 cm between each hill and 40 cm from the cassava, 35 cm between holes and 2 plants per hole giving a bean population of 91400 pl/ha.

TABLE 4. Percentage reduction in maize and cassava yield according to associated genotypes

GENOTYPES	% reduction in maize yield				% reduction in cassava yield			
MAIZE / CASSAVA	CMC-84	Criollo Zamorano	Valencia	$\bar{X}$	CMC-84	Criollo Zamorano	Valencia	$\bar{X}$
Tuxpeño PB C-17	12.2	14.6	18.1	15.0	23.0	22.8	38.5	28.1
Tuxpeño PB C-12	10.1	14.8	10.7	2.1	31.7	27.7	32.3	30.6
Tico V-5	1.8	6.5	4.3	4.2	22.4	17.1	40.4	26.6
MEANS	8.1	2.1	11.0	25.7	25.7	22.5	37.1	

TABLE 5. Maize leaf area (cm^2/plant) according to cassava genotypes associated

GENOTYPE	Maize leaf Area cm^2/ Plant		
MAIZE \ CASSAVA	CMC-84	Criollo Zamorano	Valencia
Tuxpeño C-17	7457	7328	7243
Tuxpeño C-12	10170	11189	10207
Tico V-5	9095	8504	8504

TABLE 6. Mean yields form maize and cassava in monoculture and association

CROP	MONOCULTURE	ASSOCIATION	% REDUCTION
MAIZE	3.09	2.86	7
Tuxpeño PB.C-17	3.36	2.85	15
Tuxpeño PB C-12	3.28	3.21	2
Tico V-5	2.64	2.53	4
CASSAVA	34.37	24.71	28
CMC-84	34.40	25.57	25
Criollo Zamorano	36.80	28.50	22
Valencia	31.90	20.07	37

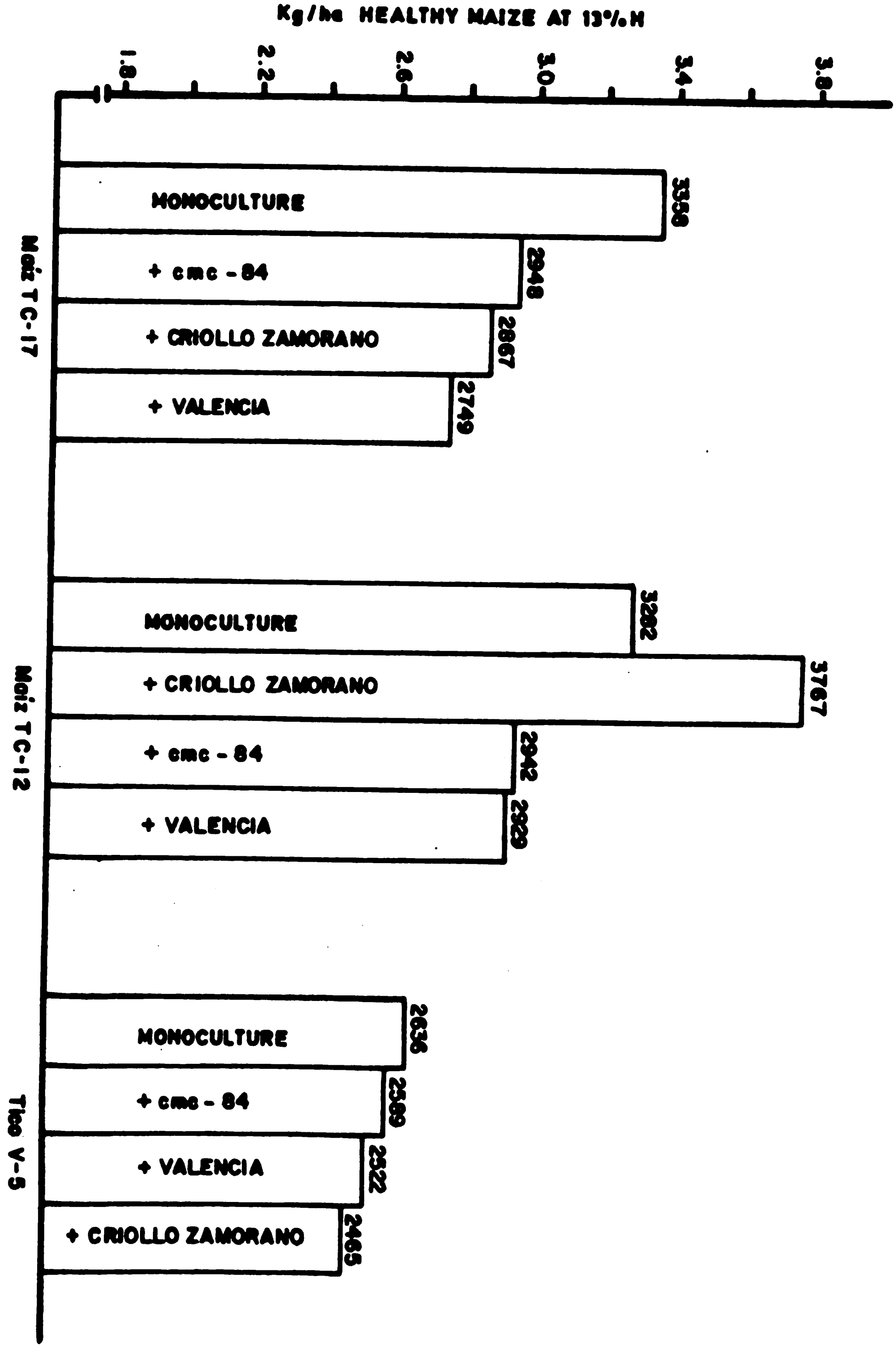


FIG 22. EFFECTS OF MAIZE AND CASSAVA PHENOTYPE ASSOCIATIONS ON MAIZE YIELD (Kg/ha)

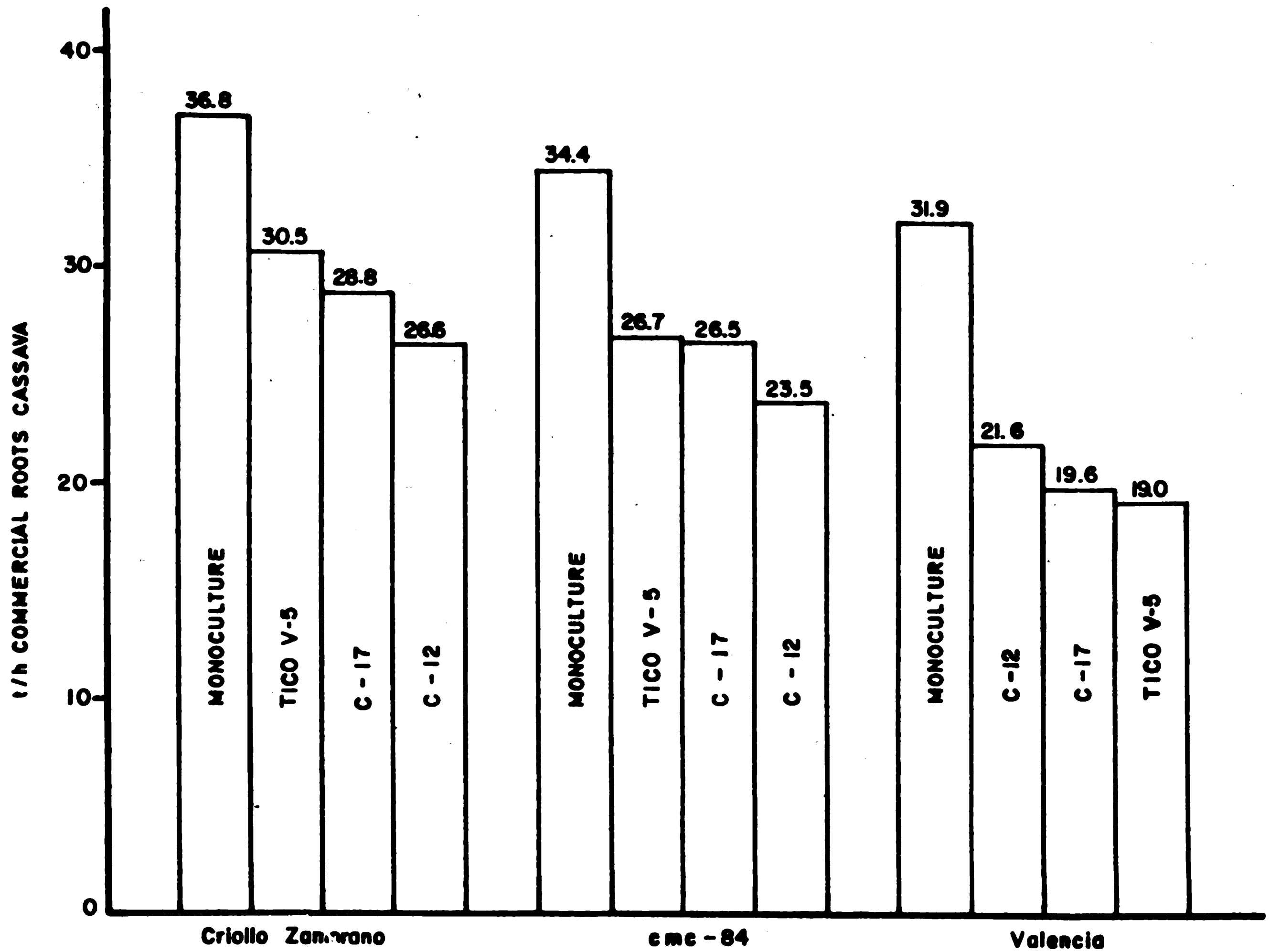


FIG. 23. EFFECT OF ASSOCIATION OF DIFFERENT MAIZE PHENOTYPES ON YIELDS OF COMMERCIAL CASSAVA ROOTS.

Beans were sown during the first week of January 1985 and harvested in the last week of March. They showed good development and very low incidence of diseases or pests. The experiment was carried out in La Fortuna, San Carlos, Costa Rica.

Variables measured were plant height, number of plants harvested, yield and number of pods per plant.

Statistical analysis indicated significant differences between cultivars for the first three variables. Bean yield (15% RH) varied from 633 kg/ha (cv. A-227) to 979 kg/ha (cv. R-675). These relatively low yields are mainly due to low bean population in the system (aproximately 25% of the monoculture). However, individually, the bean plants were more efficient in association with cassava, since with a population 25% that of the monoculture, yields of 47% of those in monoculture were obtained.

The local cultivar "Chimbolillo" did not show good perfomance in association mainly because of a population reduction (33% less than R-675, the best performer).

As has been noted in the main body, the best cultivars in association with cassava were R- 675 (979 kg/ha), ICTA TAMAZULAPA (943 kg/ha) and ICTA 8164 (895 kg/ha). They also had good yield in monoculture. Compuesto 1 came second in yield in monoculture and fifth in association, making it another adequate alternative (Table 7).

Cultivar Negro Huasteco yielded highest in monoculture but was relatively poor in association. This shows that cultivars that perform well in monoculture are not always the best in association.

Bean Monoculture

In experiments previously carried out in San Carlos, eleven bean genotypes with potential for this zone were identified.

These were evaluated again in January 1985 at 3 sites in order to select the best genotypes to offer to national programs.

TABLE 7. Plant height (cm), plants harvested per experimental unit and yield for 11 bean cultivars in association with Valencia cassava

Cultivar	Plant height	Plants harvested/12.5 m^2	Grain yield kg/ha at 15. H	
			Association	Monoculture
R-675	53 a	71 a	979 a	1724 b
ICTA TAMAZULAPA	50 ac	65 ab	943 ab	1843 ab
ICTA 8164	52 ab	59 ad	895 ac	1839 ab
ICA Pijao	55 a	61 ac	831 ad	1311 d
Compuesto-1	50ac	59 ad	824 ad	1909 ab
Porrillo Sintético	48 ac	58 ad	811 ad	1682 b
Brunca	40 d	61 ac	811 ad	1716 b
Talamanca	53 a	59 ad	801 ad	1721 b
ICTA 8126	45 cd	58 ad	758 bd	1647 b
Negro huasteco	48 cd	51 cd	724 dc	2084 a
Chimbolillo	45 cd	47 d	663 d	1419 cd
A-227	43 cd	55 cd	633 d	-

* Means with same letter within same column do not differ significantly ($p = 0.05$)

Selected sites were Zona Fluca and La Bruja (volcanic origin soils, high fertility, good drainage, loam or clay loam texture) and Pital (clay, leached, low fertility and more acid).

A complete randomized block design with 4 replicates and experimental unit size 10 m^2 was used. Sowing density was 250 thousand pl/ha (50 x 8 cm).

The genotypes behaved normally. Results for each site (Table 8) show better yield, as expected, at La Bruja and Zona Fluca. At Pital, prevailing conditions reduced the size and number of plants and affected the number of pods per plant. However, even at these sites yields were relatively high, easily outyielding the national mean of 0.5 t/ha.

Table 8 Yield and other Bean Characteristics with Locality San Carlos, 1985.

	kg/ha 15% H	No plants harvested	Beans/ pod	Pods/ plant	Plant height
La Bruja	1708	210	5.8	13.4	52
Zona Fluca	1676	200	5.2	13.1	58
Pital	1070	160	5.6	10.2	39

The best genotypes were ICTA 8164, Negro Huesteco, and Compuesto 1. However, under the conditions at Pital, there were no significant differences between genotypes, although ICTA 8164 also occupied first place with 1.3 t/ha beans. On average, these 3 genotypes outyielded the recommended improved variety (Talamanca) by 13% and the local variety used by farmers (Chimbolillo) by 29%.

The best genotypes were delivered to the MAG bean program at San Carlos and to many farmers who had cooperated.

Table 9 Mean Yields for Bean genotypes by Location, San Carlos, 1985.

c.v	kg/ha 15% RH	c.v.	kg/ha 15% RH
ICTA 8164	1692	Porrillo sintético	1478
Negro Huesteco	1630	Talamanca	1457
Compuesto 1	1622	ICTA 8126	1448
ICTA TAMAZULAPA	1574	A - 227	1286
Brunca	1564	Chimbolillo (local)	1278
R - 675	1480	BAT 1556	1198

<u>Rice Monoculture</u>

Six herbicides at various concentrations, by themselves or in combinations, applied pre and postemergence, were evaluated at Rio Frio, Costa Rica. 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. Treatments are shown in Table 10.

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

The predominant weeds at the experimental site were <u>Eleusine indica</u>, <u>Digitaria sanguinalis</u>, <u>Panicum maximun</u>, <u>Paspalum paniculatum</u>, <u>Cyperus ferax</u>, <u>Killinga pumila</u> and <u>Pilea hyalina</u>.

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

Treatments showing the smallest percentage of ground cover at the three evaluations were oxyfluorfen 0.29 and 0.34 and oxadiazon).88, 1.0 and 1.13 kg ai/ha (Table 11).

TABLE 10. Counts of grasses, sedges and total weeds at 20, 40 and 60 days after planting in a herbicide evaluation experiment in minimum tillage rice. Rio Frio, 1984-85.

TREATMENT (kg a.i/ha)		Number of weeds/m²								
		Grasses d.a.a 1/			Sedges d.a.a.			Total d.a.a.		
		20	40	60	20	40	60	20	40	60
PREEMERGENCE HERBICIDES										
Oxyfluorfen 3/	0.24	115bc 2/	219cd	215cd	4 b	22 cd	0 ab	119cd	241cd	215cde
Oxyfluorfen 3/	0.29	159bc	330bcd	270cd	0 b	7 d	0 ab	159cd	337bcd	270bcde
Oxyfluorfen 3/	0.34	74 c	137cd	148cd	0 b	0 d	0 ab	74 d	137 cd	149 de
Oxadiazon	0.88	4 c	85 d	167cd	0 b	0 d	0 b	4 d	85 d	167 de
Oxadiazon	1.00	0 c	52 d	222cd	0 b	0 d	0 b	0 d	62 d	222cde
Oxadiazon	1.13	0 c	22 d	70 d	0 b	0 d	0 b	0 d	22 d	70c
EARLY POSTEMERGENCE HERBICIDE 4/										
Pendimethalin 3/	0.92	530bc	285bcd	419c	156ab	104bcd	115ab	685b	329bcd	530b
Pendimethalin 3/	1.16	626b	333bcd	322cd		274abc	207a	741b	607bcd	530b
Pendimethalin	1.19	293bc	281bcd	244cd	174ab	33cd	59ab	467bcd	315bcd	304bcde
Propanil	3.0	241bc	733bc	352c	185ab	274abc	189ab	426bcd	1007b	541b
Propanil	3.5	281bc	644bcd	181cd	315a	337ab	219a	596bc	981b	400bcd
Propanil	4.0	141bc	593bcd	256cd	270a	233bcd	244a	411bcd	826bc	500bc
Propanil + Pendimethalin	3.0 1.6	444bc	178cd	156cd	293a	493a	200ab	737b	670bcd	356bcde
Propanil + Pendimethalin	3.5 1.6	167bc	341bcd	193cd	222a	178bcd	189bcd	189bcd	519bcd	318bcd
Propanil + 2.4-D	3.0 1.44	219bc	867b	667b	141ab	115bcd	117ab	159bcd	991b	804c
Grower's check (hand weeded at 20,40 and 60 dap)		107bc	107cd	137cd	19b	20cd	115 ab	126cd	178cd	252bcde
Non weeded check		1281a	1600a	90	122ab	44cd	63ab	1404a	1644a	907a

1/ Days after application.

2/ Means with a letter in common within a column are not significantly different according to Duncan's Multiple Range Test (0.05)

3/ Propanil was applied at 3.5 a.i/ha at 60 days after planting

4/ Herbicides applied at 8 d.a.p

TABLE 11. Percent of ground covered by weeds in a herbicide evaluation experiment under minimum tillage rice. Rio Frio, 1984 - 1985.

TREATMENT kg a.i./ha		% OF GROUND COVERED BY WEEDS d.a.p.1/ 20	40	60
PREEMERGENCE HERBICIDE				
Oxyfluorfen2/	0.24	8.0	20.9	40
Oxyfluorfen2/	0.29	5.3	10.0	18.3
Oxyfluorfen2/	0.34	5.0	11.0	18.3
Oxadiazon	0.88	6.7	11.0	21.7
Oxadiazon	1.00	6.0	10.7	20.0
Oxadiazon	1.13	5.0	9.0	16.7
EARLY POSTEMERGENCE HERBICIDE3/				
Pendimethalin2/	0.92	79.7	35.0	56.7
Pendimethalin2/	1.16	84.7	38.3	66.7
Pendimethalin2/	1.49	54.3	18.3	55.0
Propanil	3.00	37.3	57.3	76.7
Propanil	3.50	30.0	70.7	81.7
Propanil	4.00	27.3	50.0	80.0
Propanil + Pendimethalin	3.00+ 1.60	21.7	54.0	65.0
Propanil + Pendimethalin	3.50+ 1.60	18.0	30.0	68.3
Propanil + 2.4-D	3.00+ 1.44	35.3	74.7	98.3
Grower's check (hand weeding at 20, 40 and 60 d.a.p.)				
Non weeded check		95.3	100	100

1/ Days after planting.

2/ Propanil was applied at 3.5 kg ai/ha at 60 d.a.p.

3/ Herbicides applied at 8 d.a.p.

The same treatment showed the smallest dry weight of weeds at 18 weeks after planting (immediately after harvest), (Table 2).

The highest yields of unhulled rice (14% moisture) were found in the oxadiazon and oxyfluorfen treatments (Table 12) No significant differences were detected between these two preemergence herbicides, but they were far better than the majority of the early postemergence ones (Table 12).

The oxadiazon 1.13 kg ai/ha treatment had the least ground cover by weeds, the smallest weed dry weight and the highest rice yield of all the treatments studied.

TROPICAL ROOTS, CORMS AND TUBERS

Ginger production systems

Cassava + ginger:

Nine herbicides at various concentrations by themselves or as mixtures were evaluated. They included ametryn, diuron, linuron, oxyfluorfen, alachlor, atrazine, Pendimethalin metolachlor and T.C.A., as well as a hand weeded and a non weeded treatment. Treatments are shown in Table 13.

At eleven weeks after treatment application, plots having the smallest dry weight of weeds were under the diuron 2.8 or 3.9, ametryn 4.5 and the mixtures of ametryn 3.4 + alachlor 1.0, and diuron 2.8 + alachlor 1.0 kg ai/ha treatments (Table 13).

The most important weeds at the experimental site were *Ipomoea* sp., *Paspalum conjugatum*, *Cyperus* sp., *Borreria laevis*, *Ludwigia decurrens*, *Lantana camara*, *Drymaria cordata*, *Digitaria sanguinalis*, *Melapodium divaricatum*, *Panicum trichoides*, and *Mimosa pudica*. The predominant weed was *Ipomoea* sp.

None of the treatments caused visual symptoms of phytotoxicity to either crop.

The highest yields of ginger (grade A) were found in the metolachlor 3.6, diuron 1.7, oxyfluorfen 1.0, ametryn 2.3 + alachlor 1.0, metolachlor 1.8, linuron 3.4, ametryn

TABLE 12. Dry weight of weeds and yield of hulled rice (14% humidity) in a herbicide evaluation experiment in minimum tillage rice. Rio Frio, 1984-1985

TREATMENT	kg a.i/ha	DRY WEIGHT OF WEEDS AT HARVEST kg /ha	YIELD kg/ha
PREEMERGENCE HERBICIDES			
Oxyfluorfen[1/]	0.24	400 e[3/]	2652 ab
Oxyfluorfen[1/]	0.29	398 e	2539 abc
Oxyfluorfen[1/]	0.34	304 e	2638 ab
Oxadiazon	0.88	315 e	2436 abc
Oxadiazon	1.00	330 e	2413 abc
Oxadiazon	1.13	278 e	3036 a
EARLY POSTEMERGENCE[2/]			
Pendimethalin[1/]	0.92	1082 abc	1355 de
Pendimethalin[1/]	1.16	923 bcd	1855 bcde
Pendimethalin[1/]	1.49	540 de	2062 bcd
Propanil	3.00	1223 ab	1681 cde
Propanil	3.50	745 cde	2062 bcd
Propanil	4.00	751 cde	2214 abcd
Propanil + Pendimethalin	3.0 + 1.6	585 de	1751 cde
Propanil + Pendimethalin	3.5 + 1.6	551 de	2130 bcd
Propanil 2.4-D	3.0 + 1.44	667 cde	1900 bcde
Grower's check (hand weeding at 20, 40 and 60 d.a.p[4/])		363 e	2267 abc
Non weeded check		1498 a	1100 e

1/ Propanil was applied at 3.5 kg ai/ha at 60 days after planting

2/ Herbicides applied at 8 days after planting

3/ Means within a column with a letter in common are not significantly different according to Duncan's Multiple Range Test (=0.05).

4/ Days after planting

TABLE 13. Phytotoxicity, ground coverage and dry weight of weeds and yield of ginger (*Zingiber officinalis*) in a preemergence herbicide evaluation experiment in the cassava + ginger system. San Carlos, 1984 - 1985.

TREATMENT kg ai/ha		PHYTOTOXICITY[1/] w.a.p[2/] 7	% WEED COVER w.a.p 6	% WEED COVER w.a.p 10	DRY WEIGHT OF WEEDS 11 w.a.p kg/ha	GINGER YIELD 1st Grade kg/ha	GINGER YIELD 2nd Grade kg/ha	GINGER YIELD Total kg/ha
Ametryn	2.3	1.0	55	92	1690 a[3/]	2773 cd	2126 cdef	4899 edf
Ametryn	3.4	1.0	34	70	947 abcde	5685 bcd	3321 abcdef	9005 cdef
Ametryn	4.5	1.3	28	77	595 cde	5817 bcd	4092 abcd	9909 bcde
Diuron	1.7	1.0	33	88	1105 abcde	9236 ab	3705 abcde	12941 ab
Diuron	2.8	1.0	26	62	632 cde	6651 bcd	2982 abcdef	9633 bcde
Diuron	3.9	1.0	19	47	527 de	5793 bcd	3426 abcdef	9219 bcde
Linuron	3.4	1.0	35	82	1255 abcde	8073 abc	2490 bcdef	10562 bcde
Linuron	4.5	1.0	35	85	1037 abcde	7376 abcd	2746 bcdef	10122 bcde
Oxyfluorfen	0.5	1.0	30	72	1139 abcde	7444 abcd	4707 ab	12150 abc
Oxyfluorfen	0.7	1.0	36	92	1210 abcde	5228 bcd	2097 cdef	7324 bcde
Oxyfluorfen	1.0	1.2	30	68	804 bcde	8946 abc	2764 bcdef	11710 abc
Alachlor	1.0	1.2	42	88	1038 abcde	5357 bcd	2323 cdef	7680 cde
Alachlor	1.4	1.0	40	85	1172 abcde	7465 abcd	3263 abcdef	10728 bcd
Alachlor	2.9	1.2	50	92	1518 ab	1356 d	1925 def	3280 f
Atrazine	3.4	1.0	33	88	881 abcde	6005 bcd	3240 abcdef	9245 bcde
Pendimethalin	0.7	1.0	37	87	1123 abcde	3836 bcd	5063 a	8899 bcde
Pendimethalin	1.0	1.0	33	75	929 abcde	3527 bcd	2397 cdef	5924 cdef
Pendimethalin	1.3	1.0	40	78	957 abcde	7006 bcd	2986 abcdef	9992 bcde
Metolachlor	1.8	1.0	42	92	1321 abcd	8185 abc	1788 ef	9973 bcde
Metolachlor	3.6	1.0	36	75	904 abcde	13051 a	4036 abcde	17087 a
T.C.A	5.6	1.0	34	80	1171 abcde	7197 abcd	3766 abcde	10963 bcde
Ametryn + Alachlor	2.3 1.0	1.0	27	70	825 bcde	8634 abc	2236 cdef	10870 bcd
Ametryn + Alachlor	3.4 1.0	1.0	26	73	590 cde	6203 abc	2401 cdef	8605 bcd
Ametryn + T.C.A	3.4 5.6	1.0	40	87	984 abcde	6522 bcd	2335 cdef	8857 bcd
Ametryn + Pendimethalin	2.3 0.7	1.2	37	85	1214 abcde	6920 bcd	2178 cdef	9098 bcd
Ametryn + Pendimethalin	3.4 0.7	1.0	34	72	990 abcde	7860 abc	2698 bcdef	10558 bcd
Ametryn + Metolachlor	2.3 1.8	1.0	43	85	895 abcde	6615 bcd	1894 def	8510 bcd
Ametryn + Metolachlor	3.4 3.6	1.0	32	68	873 abcde	6347 bcd	3011 abcdef	9358 bcdef
Linuron + Alachlor	3.4 1.0	1.0	29	80	1045 abcde	6321 bcd	2751 bcdef	9072 bcdef
Linuron + T.C.A	3.4 5.6	1.0	30	75	923 abcde	6224 bcd	2843 bcdef	9067 bcdef
Linuron + Metolachlor	3.4 1.8	1.0	38	82	1371 abcd	3408 bcd	1399 f	4806 ef
Linuron + Pendimethalin	3.4 0.7	1.0	41	90	739 bcde	5534 bcd	2835 bcdef	8369 bcde
Diuron + Alachlor	2.8 1.0	1.0	24	58	665 cde	3801 bcd	2850 bcdef	6651 bcde
Hand weeded check		1.0	17	47	458 cde	7803 abc	3613 abcdef	11416 abcd
Non weeded check		1.0	47	94	1405 abc	4596 bcd	4202 abc	8798 cdef

1/ Visual phytotoxicity scale: 1.- completely heathly crop plant, no symptons. 2.- more than half of the plant per experimental unit show yellowing, wrinkling or other disorder but not more than one leaf per plant showed necrosis. 3.- more than half of the plants with at least one necrotic leaf. 4.- more thanhalf of the crop plants with severe necrosis or dead. 5.- all crop plants dead.

2/ Weeks after planting

3/ Means within a column with a letter in common are not significantly different according to Duncan's Multiple Range Test ($\alpha = 0.05$)

3.4 + pendimethalin 0.7 kg ai/ha and in the hand weeded 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 treatment, and the 22 other treatments (Table 13).

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

Yam (Dioscorea) monoculture:

In 1985 three control studies in yam were conducted. In one experiment of season-long weed control, herbicide combination with or without hand weeding operations were studied. The initial herbicide treatments were applied in combinations with paraquat 0.26 kg ai/ha at three weeks after planting, when less than 10% of the yams had sprouted. The highest yield of yam (22 t/ha) in the experiment was obtained where diuron 2.5 + paraquat 0.26 kg ai/ha were applied at 3 and 9 weeks after planting (w.a.p.), and paraquat by itself at 0.4 kg ai/ha at 14 w.a.p. This was not different from the less costly treatment where diuron 2.5 + paraquat 0.26 kg ai/ha was applied at 3 w.a.p. The treatment hand weeded at 7, 12, 16 and 24 w.a.p. gave the third highest yield (20.8 t/ha).

Even though no significant statistical differences were detected in this study, results suggest that the optimum weed management practice for yam is application of the diuron- paraquat combination at 3 w.a.p., followed by a light hand weeding operation at 9 w.a.p.

The second and the third experiment on yam were conducted to evaluate herbicides applied preemergence to the yam and postemergence to the weeds. Seven herbicides applied by themselves or in combination at various rates were applied at 3 w.a.p. in the second and at 4 w.a.p. in the third.

In the second experiment, the highest yields were obtained in the (1) linuron 3.5 + pendimethalin 1.0 (34.9 t/ha), 2 oxadiazon 0,6 (34.0 t/ha) and (3) oxifluorfen 0.3

kg ai/ha (32.4 t/ha). All of them were superior (0.05 probability level) to the non weeded check (22.0 t/ha) but not different from the hand weeded check at 4, 8, 12 and 15 w.a.p. which produced 33.8 t/ha of total tubers. When the treatments were applied prior to crop emergence, no visual phytotoxicity symptoms developed.

In the third experiment, that will be harvested in August 1986, the following preliminary results are available: the smallest percentage of the ground was covered by weeds in the ametryn 4.0 + metolachlor 2.9, oxyfluorfen 0.6, diuron 3.0 and ametryn 4.0 kg ai/ha treatments at 11 weeks after herbicide application (waa). The smallest dry weight of weeds at 13 waa were in the ametryn 4.0 + metolachlor 2.9, diuron 3.0 ametryn 4.0, oxyfluorfen o.6 and oxadiazon 0.9 kg ai/ha treatments. None of the treatments caused phytotoxicity to the yam. Overall results indicate so far that the best alternatives for chemical weed control in yam could be found in the diuron 2.5 + paraquat 0.26 kg ai/ha combination and the linuron (3.5) or ametryn (4.5) combination with pendimentalin (1.0) kg ai/ha.

Aroids

White cocoyam (*Xanthosoma sp*) monoculture

Two exploratory trials were established in 1985; one at Zona Fluca San Carlos, and the second one at Turrialba. The cultivar known as "blanco" was used.

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

The fresh and dry weight of weeds at 12 weeks after treatment application, the percent ground cover at 8 and 11 weeks after application, and the phytotoxic effects of the herbicide were recorded at San Carlos. Treatments with the smallest dry weight of weeds at three months after planting were oxifluorfen 0.5, ametryn 3.4 + metolachlor 3.6, ametryn 3.4 + T.C.A. 5.6, diuron 2.8, linuron 3.4 or 4.5 ametryn 3.4 + pendimethalin 0.6, and linuron 2.3 + alachlor 1.0 kg ai/ha. With the exception fo oxyfluorfen 0.5 kg ai/ha, these treatments had less than 21% of the plot surface covered by weeds at 8 weeks after treatment application.

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

Six weeks after treatment application, no visual phytotoxicity symptoms in cocoyam were found in any of the treatments at San Carlos. Phytotoxicity at Turrialba could not be evaluated 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.

OTHER PROMISING CROPS FOR THE LOWLAND HUMID TROPICS

Soybean

Storage:

In June 1985 the study on the behavior of 25 soybean genotypes under four types of storage was concluded.

This study was initiated in October 1984 hoping to identify lines whose seed could be stored for longer periods of time, as well as to evaluate their agronomic characteristics under field conditions.

The experimental design used was a factorial 25 x 4 with 2 replicates. Treatments consisted of seed from 25 soybean genotypes and 4 types of storage.

The storage 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^{o}C and 60% R.H. Relative humidity in Turrialba, the study site, averages 85% in dry months and 88 % in wet months. Tests for germination, vigor and other characteristics were made every two months. The period of storage was 8 months.

Most of the genotypes evaluated came from IITA (Nigeria). They were harvested and processed by hand and dried in sheds using the heat of the sun. For each type of storage, 1 kg of seed for each genotype was used, pretreated with malathion 4% PM and captan (3 g/kg seed).

Variables evaluated were:

1. Percentage of plants germinated and with rapid, uniform growth at 10 days (normal or vigorous plants)
2. Percentage of plants with slow growth, including abnormal or non-vigorous plants not reaching normal development in the field.
3. Percentage of viable seed, including the sum of 1 and 2
4. Percentage of plants lost (including non germinating and hard seeds).

Highly significant differences were detected between types of storage for all the evaluated variables except for percentage of abnormal plants at 4 months. Fig 24 summarizes the means for genotypes evaluated fo the variables with tne four types of storage.

Mean values for viability and vigor in the 25 genotypes of treatment 1 rapidly decreased to zero after 8 months of storage. In treatment two, seeds remained good until the fourth month (89% viability and 75% vigor) and in treatment three until the sixth month (83% viability 70% vigor). After 8 months of storage under treatment 4, seeds were still viable and vigorous (95% and 85% respectively).

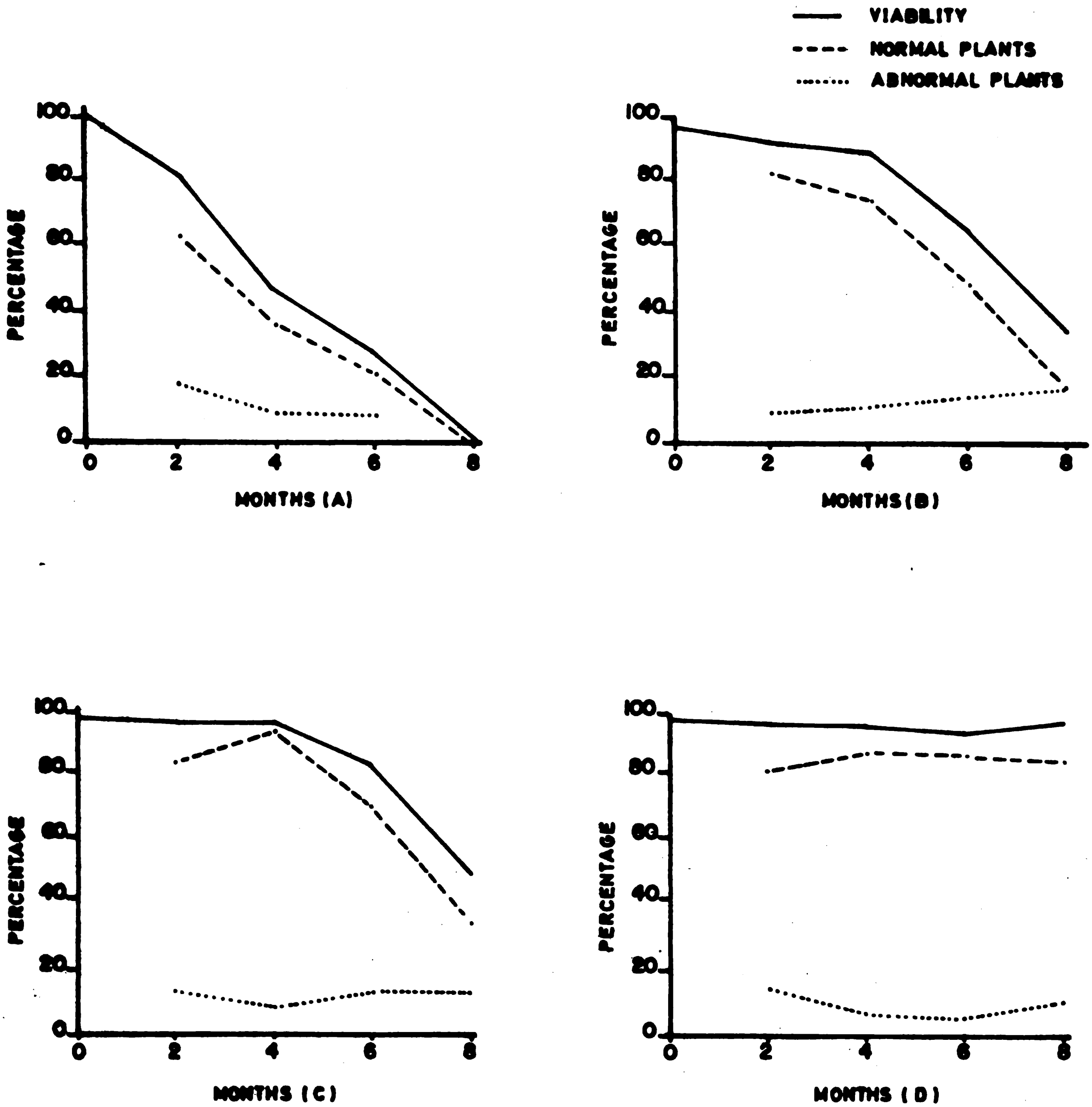


FIG. 26. AVERAGE PERCENTAGES FOR VIABILITY, NORMAL (VIGOROUS) AND ABNORMAL PLANTS OF 25 SOYA BEAN GENOTYPES IN FOUR TYPES OF STORAGE:

A) AS PLANTS
B) IN BAGS AT AMBIENT. TEMP
C) IN HERMETICALLY SEALED BAGS
D) KEPT IN DARK AT 15° C Y 60 % RH.

Viability and vigor differences between genotypes were highly significant and except for treatment 4, their behavior was variable over time with storage.

Considering treatments 1, 2 and 3, genotypes M-79, TGX 342 456 and TGX 307 047d were most stable over time and storage method, maintaining a mean viability of 82% and 73% vigor after 6 months storage. In general, TGX 742 02D had greatest storage capacity (Table 14)

Storage in hermetically sealed containers, even after 8 months, was as efficient as cold room storage at 15^{o}C and 60% RH, for genotypes such as TGX 742 02D, TGX 307 047, and TGX 342 356C. Commercial varieties SIATSA 194 A. Jupiter and the check Bossier showed poor storage capacity (Fig 25).

Reduction of gaseous exchange and oxygen concentration in the sealed containers minimizes respiration and so slows deterioration. It also prevents the entrance of insects, fungi and rodents and allows good drying and chemical treatment of the seed, favoring its conservation. One negative factor which may affect deterioration is the relatively high temperature (22^{o}C)

The sharp drop in viability and vigor seen in the eighth month may have been caused by natural deterioration over time and that the seeds used came from sealed containers opened momentarily at the sixth month to remove seeds. This may have caused an increase in humidity and oxygen in the containers favoring respiration and deterioration, since grain humidity rose to 13.2% at the eighth month.

The study identified genotypes with superior storage capacity and seed production (all with means over 2.9 t/ha). It validated storage in sealed containers as a viable alternative for farmers with limited resources allowing them to store seed between harvest and the next sowing.

Groundnut

TABLE 14. Means of percentage seed germination for samples of 25 soya bean genotypes under 4 storage methods. Turrialba, Costa Rica 1985.

GENOTYPES	PERCENTAGE GERMINATION				
	Initial	2 months	4 months	6 months	8 months
TGX742 02 D	100^{a}	90.5^{ad}	92.0^{ad}	78.3^{ad}	70.0^{a}
TGX342 356C	96.1^{eh}	99.7^{a}	96.0^{a}	88.1^{ab}	62.5^{ab}
TGX307 047 D	98.7^{be}	96.4^{ac}	94.6^{ac}	88.2^{ac}	58.0^{ac}
TGX306 036 C	99.0^{ad}	89.6^{ad}	86.7^{af}	71.0^{ac}	56.5^{ac}
TGX604 027 C	93.1^{hi}	90.5^{ad}	86.6^{af}	70.0^{ac}	54.4^{ac}
TGX724 01D	99.7^{ab}	95.0^{ac}	93.7^{ad}	64.0^{ac}	53.5^{ac}
TGX604 01 D	99.4^{ac}	95.2^{ac}	86.5^{af}	69.7^{ac}	52.0^{ac}
M-90	96.7^{dg}	95.4^{ac}	88.3^{ac}	85^{ad}	50.7^{ac}
TGX307 048 D	99.4^{ac}	86.8^{bc}	86.3^{af}	64.5^{ae}	49.2^{ad}
TGX330 03 E	97.2^{ef}	90.5^{ad}	$69,8^{ef}$	52^{de}	46.0^{ad}
TGX711 01 D	95.4^{fi}	93.3^{ad}	91.6^{ac}	78.4^{ad}	44.5^{ad}
M-79	98.3^{bf}	99.7^{a}	95.1^{ab}	92.0^{a}	39.6^{ad}
TGX342 375 D	99.2^{ad}	96.8^{ac}	81.2^{af}	74.5^{ac}	38.3^{ad}
TGX709 06 D	91.6^{i}	92.1^{ad}	87.7^{af}	71.0^{ac}	37.6^{ad}
TGX573 104 C	99.7^{ab}	95.3^{ac}	89.1^{ac}	81.1^{ad}	37.2^{ad}
TGX713 06 D	99.4^{ac}	97.5^{ac}	84.4^{af}	76^{ad}	35.7^{ad}
TGX330 054 D	99.4^{ac}	98.5^{ab}	75.0^{bf}	62.1^{bc}	35.2^{ad}
TGX356 055 D	95.4^{fi}	86.8^{bc}	70.4^{ef}	57.3^{bc}	26.7^{ad}
Papillon	99.2^{ad}	96.7^{ac}	83.8^{af}	68.0^{ac}	25.6^{bd}
TGX336 100 C	98.1^{bf}	83.9^{cd}	74.1^{cf}	57.2^{bc}	24.3^{bd}
TGX367	96.5^{dg}	90.8^{ad}	80.6^{af}	58.5^{bc}	24.1^{bd}
Jupiter	93.1^{hi}	95.4^{ac}	82.0^{af}	55.6^{ce}	23.4^{bd}
Bossier	94.3^{gi}	81.9^{cd}	74.1^{df}	57.2^{bc}	17.0^{cd}
TGX297 192 C	100^{a}	89.6^{ad}	83.1^{af}	61.4^{bc}	16.0^{cd}
SIATSA 194-A	93.9^{gi}	75.0^{d}	63.1^{f}	39.5^{e}	10.3^{d}

Values with same letter within the same column do not differ statistically according to Duncan's Multiple Range Test at 5%.

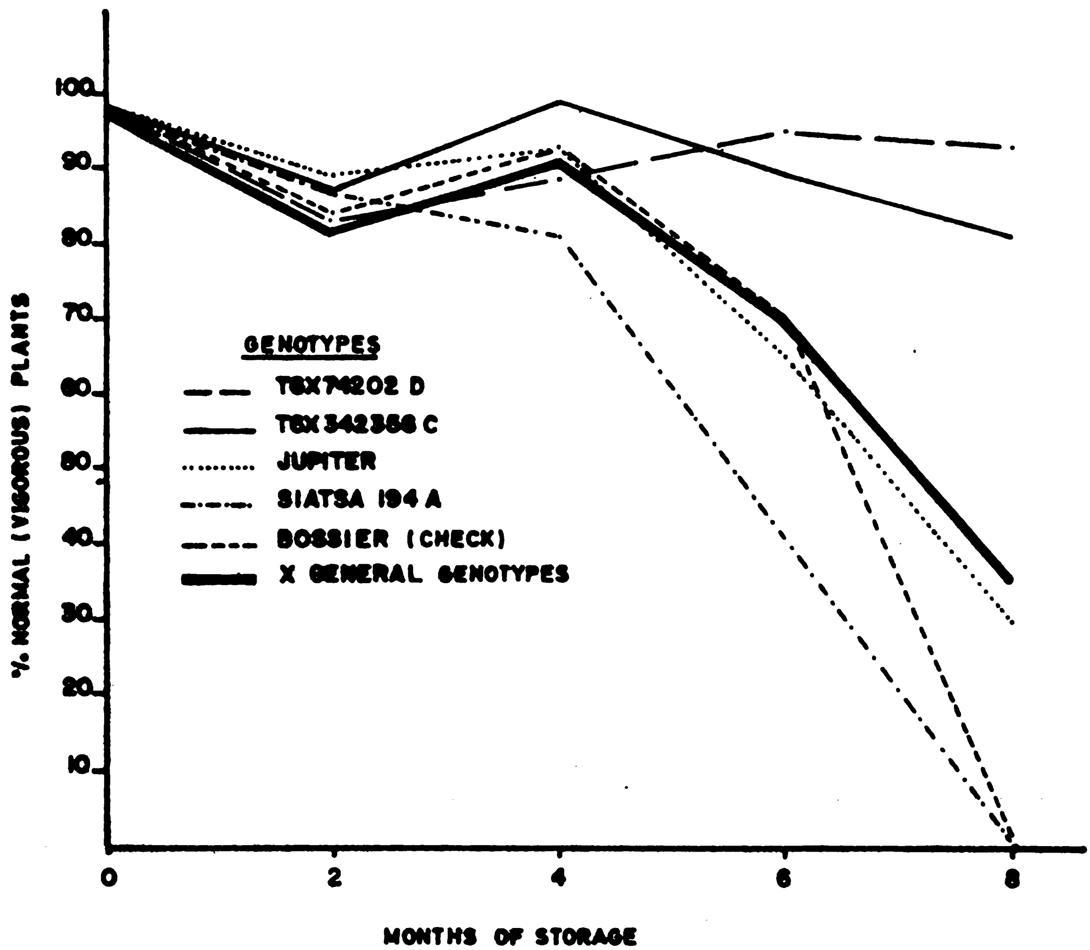


FIG. 25. PERCENTAGE OF NORMAL PLANTS FOR FIVE SOYA BEAN GENOTYPES STORED IN GLASS-JARS WITH HERMETIC SEALS (C)

Preliminary studies in the Pital area of San Carlos, as well as results from other experiments in other countries, suggest groundnuts as an alternative crop for small farmers in the Pital project area. 32 genotypes from ICRISAT with potential for humid zones were introduced for evaluation and selection of the best.

An experiment carried out in Turrialba from November 1984 to March 1985 used a completely randomized block design with 4 replicates on clay soil with medium fertility and pH 5.6.

Variables evaluated were: days to flowering, plants harvested, whole healthy shells per plant (10 plants sampled), yield for shells and healthy nuts, percentage nuts (1 kilo samples) and susceptibility to *Cercospora* sp.

Statistical analysis showed significant differences between genotypes for harvested plants, healthy shells and percentage nuts. Differences in nut yields were not significant, though varying between 2944 and 4292 kg/ha.

The experimental mean for nut production was 3523 kg/ha and all genotypes except one exceeded 3 t/ha.

Shells per plant varied between 33 and 50 but most genotypes had between 40 and 45 per plant.

Percentage healthy nuts varied between 70 and 78% with only small differences between genotypes.

Flowering started 25 days after sowing but maturation did not occur until between 130 and 140 DAS, possibly due to lower temperatures during this period (20-21^{o}C).

All genotypes were affected by *Cercospora* sp. but with differences (Table 15)

Genotypes selected for increased yield, resistance to *Cercospora* sp. and good nuts were ICGS (E)-2, Robust 33-1, ICGS (E)-8, ICGS (E)-15 and ICGS (E)-5 all yielding over 4 t/nuts/ha.

Nutrient cycling

During 1985, the soil management specialist concentrated most of his activities in the area of nutrient

TABLE 15. Mean values for various [illegible]

GENOTYPE	Clean nut yield kg/ha 14% H	Healthy stems per plant	Clean nut % of total weight nut + shell	Nº plants harvested	Nut size	Nut Color	Susceptibility to *Cercospora* sp[3/]
IGGS (E)-2	4292	47^{ab}	77^{a}	82^{a}	L	P	1
" -22	4222	44^{ab}	73^{ab}	76^{ac}	M	P	3
Robust 33-1	4129	41^{ab}	72^{ab}	70^{ad}	L	P	0
IGGS (E)-8	4125	43^{ab}	77^{a}	75^{ac}	M	P	1
" -15	4111	47^{ab}	76^{ab}	66^{ad}	L	P	1
" -5	3986	40^{ab}	72^{ab}	77^{ac}	L	P	2
" -16	3892	40^{ab}	75^{ab}	73^{ac}	S	P	1
" -3	3885	38^{ab}	74^{ab}	57^{dc}	L	P	3
" -18	3767	33^{b}	78^{a}	71^{ac}	M	P	3
" -26	3736	43^{ab}	73^{ab}	68^{ad}	M	P	2
" -28	3705	47^{ab}	74^{ab}	66^{ad}	S	P	1
" -21	3663	42^{ab}	74^{ab}	65^{ad}	M	P	3
" -20	3622	50^{a}	77^{a}	68^{ad}	M	P	2
" -12	3576	48^{ab}	75^{ab}	66^{ad}	S	P	1
JL24	3566	37^{ab}	76^{ab}	66^{ad}	L	P	2
IGGS (E) 24	3535	42^{ab}	73^{ab}	68^{ad}	M	W	2
IGGS-30	3521	44^{ab}	72^{ab}	73^{ac}	L	R	1
IGGS (E)-6	5304	40^{ab}	75^{ab}	60^{ad}	M	P	2
" -13	3500	44^{ab}	73^{ab}	58^{dc}	L	P	2
" -7	3403	38^{ab}	75^{ab}	81^{ab}	M	P	3
" -17	3399	40^{ab}	75^{ab}	73^{ac}	L	P	3
" -23	3340	45^{ab}	76^{ab}	66^{ad}	M	P	3
" -14	3330	43^{ab}	73^{ab}	75^{ac}	M	P	2
" -11	3321	42^{ab}	73^{ab}	69^{ad}	M	P	2
" -1	3316	49^{ab}	72^{ab}	57^{cd}	L	P	2
" -9	3306	41	76^{ab}	63^{ad}	L	P	3
IGGS (E)-4	3271	45^{ab}	73^{ab}	70^{ad}	M	R	3
" -10	3233	40^{ab}	75^{ab}	67^{ad}	M	P	2
" -19	3216	43^{ab}	74^{ab}	65^{ad}	L	DR	2
" -27	3170	50^{a}	72^{ab}	59^{bd}	M	P	2
" -25	2944	43^{ab}	72^{ab}	63^{ad}	M	P	3

1/ Nut size: L= Large M= Medium S= Small

2/ Nut color: R= Red DR= Dark red P= Pink W= White

3/ Susceptibility to *Cercospora* sp: O= Resistant 1= Moderately resistant 2= Susceptible 3= Very susceptible

* Means with same letter within same column do not differ significantly (p=0.05)

cycling since this involved long-term experiments which had been set up in previous years, and maintaining them was considered to be of higher priority than new experiments, especially as funding restrictions limited many activities.

Considerable progress was made in this area. Not only was the third cropping cycle completed in the experiment in Turrialba, but soils data for the three years of the experiment were analyzed and several interesting trends noted. An experiment on a farmers fields in San Carlos Costa Rica, set up in late 1984, produced two crop harvests in 1985. An M.S. thesis, completed in early 1986, produced considerable information on the content of elements other than nitrogen in the leguminous mulches and addressed itself to problems of establishment of leguminous trees.

Yield data for the third and fourth years of the Turrialba experiment are summarized in Tables 16, 17, 18. After the completion of the third cropping cycle, several changes were made in the experiment. Due to the poor perfomance of cassava in the third year of the experiment, this crop was eliminated from the study. The _Gliricidia_ alley crop treatment was expanded to include two different alley widths. The _Vigna_ intercrop treatment was changed to a _Gliricidia_ - mulch treatment as the _Vigna_ intercrop had never produced yields or other effects significantly different from the control in the first three years of the experiment.

From Table 16, it can be seen that maize yields showed benefits from the applications of _Erythrina_ prunings whether as a mulch or in alley cropping systems. Although there was a response to mineral nitrogen in the control plots, no effect of nitrogen was observed when _Erythrina_ prunings were applied, indicating that the prunings adequately supplied the N requirements of the crop. Also, yields of maize with Erythrina prunings and withought mineral nitrogen were significantly higher than for maize receiving mineral N but no _Erythrina_ prunings. No benefit to maize yields was

TABLE 16. Third year of crop yields in the alley cropping experiment, Turrialba, Costa Rica.

TREATMENT	Mineral N	Maize 15% moisture kg/ha	Beans 15% moisture kg/ha	Cassava Fresh weight Commercial roots kg/ha
CONTROL	0	1252	482	3430
	+	1712	660	5514
ERYTHRINA MULCH	0	2674	1040	3851
	+	2510	1201	4635
MANURE	0	2081	667	5998
	+	2203	1087	5955
GMELINA MULCH	0	2033	707	5619
	+	2090	1154	5619
VIGNA	0	1204	459	5934
	+	2135	595	5008
ERYTHRINA ALLEY CROP	0	2482	881	3156
	+	2369	1061	2667
GLIRICIDIA ALLEY CROP	0	1220	1004	1073
	+	1166	1172	652
DAIRY MANURE WITHOUT PK	0	2341	492	5344
ERYTHRINA MULCH WITHOUT PK	0	2301	888	4692
L sd p= 0.05		898	245	2951

TABLE 17. Change in total cassava biomass and stems/plant over three years of experiment.

Cassava	Biomass	kg/ha	STEMS PER PLANT	
1 year	2 year	3 year	1 year	3 year
12655	11698	9206	4.33	2.23
16022	12818	11636	5.67	2.10
13158	13718	10267	4.66	1.89
14749	15789	13394	3.00	1.97
15145	14429	9541	4.33	2.31
19008	14942	13044	4.66	2.30
12227	14517	13329	4.00	2.22
10590	14603	12871	5.66	2.19
12825	13124	9688	5.00	2.02
15663	15900	11279	6.00	2.19
15590	8424	7208	4.33	1.73
17736	10038	6395	3.66	1.66
18546	8195	4208	4.66	1.83
15640	7127	4131	5.33	1.97

TABLE 18. Yields in the fourth year of alley cropping experiment

		MAIZE 15% moisture	BEANS 14% moisture
CONTROL	0	2126	1141
	+	2425	1396
ERYTHRINA MULCH	0	2903	1688
	+	3158	1755
MANURE	0	3013	1683
	+	2899	1987
GMELINA MULCH	0	3246	1807
	+	2496	1932
GLIRICIDIA MULCH	0	2751	1489
	+	2783	1678
ERYTHRINA ALLEY CROP	0	2192	1446
	+	2106	1550
GLIRICIDIA ALLEY CROP	0	1757	1296
	+	1431	1387
DAIRY MANURE WITHOUT PK	0	2747	1752
ERYTHRINA MULCH WITHOUT PK	0	2901	1784
LSD. different N treatment in different main plots		734	280

observed when maize was alley cropped with *Gliricidia sepium* however. There was a greater response to mineral N with beans but this was only significant when manure or *Gmelina* mulch were used as amendments. As these materials are low in N content (See Table 19), they would be expected to induce an increase in the N requirement of the crop. All the high nitrogen-containing amendments (*Erythrina* mulch, *Erythrina* alley crop, *Gliricidia* alley crop, and *Erythrina* alley crop without mineral N) produced significant increases in the yields of beans over the control. Increases in yields, although non-significant, were about the same as for the control when mineral N was applied. These materials would therefore not appear to completely satisfy the N requirement of beans; and the benefit observed from their application may not be due entirely to the nitrogen they supply.

Cassava yields showed a marked decline in the third year of the experiment. As in the second year, yields of commercial roots increased somewhat over the control when dairy manure or *Gmelina* mulch were used as amendments but these increases were not significant. Cassava perfomed poorly in alley cropping systems; especially with *Gliricidia sepium*, as can be seen in Table 17. However, biomass production in the non-alley cropped plots did not decline as much as commercial root production over the three years of the experiment. It would seem, therefore, that a deterioration in soil physical condition, preventing root bulking, is primarily responsible for the decline in cassava yields.

During 1985, soils data from the first three years of the experiment was subjected to statistical analysis. Soil samples had been taken from the 0-20 and 20-40 cm depths in all plots every six months from Nov, 1982 to May, 1985. Changes in levels of extractable potassium and exchangeable calcium and magnesium are shown in Table 20. Changes in organic carbon, exchangeable aluminium (titrable acidity)

TABLE 19. Mean nutrient content of additions. (Means of 12 determinations).

	DM	N	P	K	Ca	Mg
		kg per 6 months				
Dairy manure*	5370	77.3	13.4	69.8	49.9	26.3
Gmelina mulch*	5746	94.2	12.6	72.9	81.0	27.6
Erythrina mulch*	4636	114.5	11.6	72.3	38.5	23.7
Gliricidia mulch*	5224	195.4	11.5	91.4	61.1	20.9
Erythrina alley Crop**	4509	129.1	9.3	71.7	19.0	15.0
Gliricidia alley Crop**	3946	108.6	7.7	65.8	51.7	18.5

* 20 t/ha fresh weight applied

** Pruned biomass

TABLE 20. Levels of nutrients in soil, 6 and 36 months after initial application of amendments, Typic Humitropept, fine, halloysitic, isohyperthermic, Turrialba, Costa Rica

Depth (cm) / Months after initial application / Treatment	Mineral N	Extractable K 0–20 6	Extractable K 0–20 36	Extractable K 20–40 18	Extractable K 20–40 36	Exchangeable Ca 0–20 6	Exchangeable Ca 0–20 36	Exchangeable Mg 0–20 6	Exchangeable Mg 0–20 36
		cmol (p^+) L^{-1}							
Control	0	0.49	0.52	0.36	0.46	5.46	4.72	1.10	0.76
	+	0.48	0.50	0.37	0.49	5.46	4.78	1.10	0.72
Erythrina Mulch	0	0.52	0.82	0.53	0.81	5.80	5.13	1.30	0.87
	+	0.51	0.74	0.41	0.67	6.23	5.01	1.06	0.83
Dairy Manure	0	1.01	0.61	0.32	0.57	4.26	4.41	0.86	0.76
	+	0.75	0.60	0.26	0.53	4.10	3.63	0.83	0.67
Gmelina Mulch	0	0.40	0.61	0.34	0.52	4.63	4.05	0.96	0.64
	+	0.43	0.58	0.30	0.56	4.13	3.66	1.00	0.60
Vigna Intercrop	0	0.40	0.48	0.32	0.47	4.90	4.53	0.97	0.69
	+	0.45	0.58	0.32	0.47	5.16	4.66	0.97	0.64
Erythrina alley crop	0	0.46	0.71	0.38	0.67	6.40	4.91	1.16	0.74
	+	0.45	0.61	0.33	0.55	6.43	5.00	1.13	0.68
Gliricidia alley crop	0	0.49	0.68	0.39	0.67	6.46	5.23	1.20	0.78
	+	0.46	0.58	0.32	0.56	6.30	4.78	1.16	0.74
l.s.d. p 0.05 (different subplots in different mainplots)		0.68	0.20	0.15	0.20	2.15	1.62	0.33	0.23
Extra plots: Erythrina mulch without N, P, K		0.60	0.81	0.51	0.77	6.03	5.34	1.37	1.01
Dairy manure without N, P, K		0.44	0.76	0.43	0.75	5.56	5.72	1.27	0.98

TABLE 21. Levels of Organic carbon, total nitrogen, exchangeable Aluminum, and olsen-extractable Manganese 6 and 36 months after initial application on a Typic Humitropept, fine, halloysitic, isohyperthermic, Turrialba, Costa Rica. All results are from the 0-20 cm depth

Months after initial Aplication Treatment	Mineral N	Organic Carbon 6	36	Total Nitrogen 6	36	Exchangeable Al 6	36	Extractable Mn 6	36
		---mg/g---		---mg/g---		Cmol (p+) L^{-1}		---ppm---	
Control	0	35.2	32.5	2.9	3.3	0.70	0.83	10.8	8.3
		35.6	34.1	2.8	3.4	0.67	0.87	11.7	10.6
Erythrina Mulch	0	35.1	33.3	2.9	3.3	0.40	0.53	9.5	6.7
	+	33.3	32.8	2.8	3.4	0.43	0.60	10.9	8.0
Dairy Manure	0	34.4	33.8	2.9	3.5	1.07	1.03	12.0	9.7
	+	34.5	34.2	2.9	3.5	1.00	1.32	12.0	11.0
Gmelina Mulch	0	33.7	31.9	2.9	3.2	0.73	0.93	11.5	8.0
	+	32.0	31.9	2.7	3.4	0.77	1.15	11.3	9.0
Vigna Intercrop	0	36.0	34.3	2.8	3.5	0.63	0.83	11.0	7.7
	+	35.1	33.7	2.9	3.4	0.67	0.85	10.5	9.0
Erythrina alley crop	0	33.8	33.4	3.1	3.4	0.67	0.78	11.0	8.0
	+	35.4	34.5	2.9	3.5	0.57	0.75	10.7	8.7
Cliricidia alley crop	0	35.0	32.7	2.9	3.3	0.47	0.60	10.9	7.7
	+	35.0	31.9	2.9	3.2	0.47	0.90	9.6	9.3
l.s.d. p=0.05 different subplots in different main plots		2.3	2.1	0.4	0.3	0.47	0.64	2.9	2,3
Extra plots Erythrina mulch without N, P, K		33.3	33.9	2.8	3.3	0.40	0.42	9.9	9.7
Dairy manure without N, P, K		32.9	33.7	2.9	3.5	0.53	0.40	9.8	8.3

and olsen extracted manganese are shown in Table 21. It should be noted that over the three years of the experiment, all plots except the extra plots received a total of 216 kg/ha of K as KCL and 20 kg/ha of $MgSO_4$ $7H_2O$. The amounts of nutrients contained in the mulches can be calculated by multiplying the values in Table 19 by six in the case of _Erythrina_ mulch and dairy manure, and by four in the case of the _Gmelina_ mulch and the alley cropping treatments, which were only begun in the second year of the experiment.

From table 20, it can be seen that soil potassium levels only declined in the case of the dairy manure amendment while plots receiving _Erythrina_ mulch had significantly higher levels of extractable K at the end of three years than the control plots. All plots except that receiving dairy manure without mineral N showed losses of exhangeable Ca. There were no significant differences among plots with respect to calcium levels at the end of three years. Magnesium levels declined in all plots over the experiment.

Organic carbon levels decreased in all plots over the course of the experiment, while total nitrogen levels increased slightly. At the end of three years, there were no significant differences in these parameters with respect to treatments. Exchangeable aluminum levels increased over time in all plots except those receiving manure without P and K fertilization. However, all plots which received mineral N had significantly higher levels of exchangeable aluminum at the end of the three years than the plots receiving no mineral nitrogen. Lowest levels of exchangeable aluminum were found in the plots which received no mineral fertilizer over the three years. Similar results were found for Olsen-extractable manganese but the plots receiving _Erythrina_ mulch without mineral N had significantly lower levels of this element than the control plots receiving mineral N. It would seem that some of the undesirable effects of applying mineral nitrogen to these soils could be avoided by using leguminous trees as a nitrogen source.

Changes in olsen extractable potassium at the 0-20 and 20-40 cm depths and in Olsen-extractable Mn at the 0-20 cm depth for selected treatments are shown in Figures 26, 27, and 28, respectively. The gradual increase in manganese in the control plus mineral nitrogen treatment can be clearly seen in Figure 27. For the 0-20 cm depth, extractable K increases rapidly in the Erythrina mulch treatment but begins to decline after 30 months. Increases with alley cropping or manure appear later. The control treatment shows a slight increase, then a decrease, but after the eighteenth month always has significantly less K than the Erythrina mulch treatments, with or without additional mineral phosphorous and potassium (Figure 26). Differences could also be detected at the 20-40 cm depth (Figure 28), despite a seasonal fluctuation in K levels. The control has significantly less extractable K than the Erythrina mulch treatment at both 30 and 36 months after initial application of mulches.

Crop recovery of potassium in the third cropping cycle indicates the same differences as the soils data (Table 22). For maize, the Erythrina mulch treatment contained significantly more potassium than the control. Without additional mineral P and K, the levels are even higher. For beans, the alley cropping treatments also contained significantly more potassium than the control. In cassava, none of these differences were significant. Summing these values, the crop biomass is found to contain 78 kg/ha more potassium than the control when a mulch of Erythrina is applied. When alley cropped with E. poeppigiana, the crop biomass contained 64 kg/ha more K than the control, more than any other amendment in the absence of N fertilization. It can be concluded that Erythrina can be an important

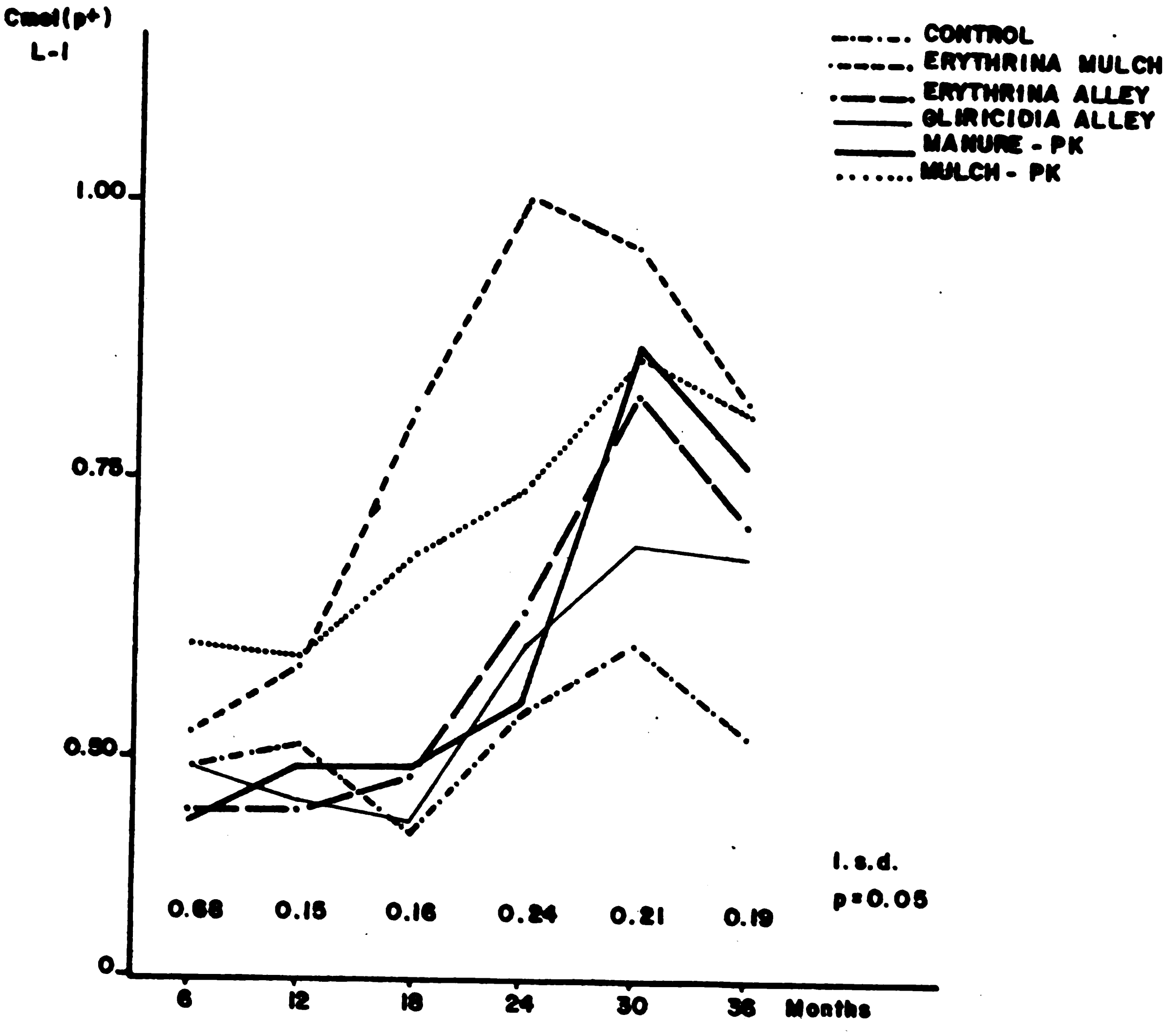


FIG. 26. EXTRACTABLE K

0-20 cm

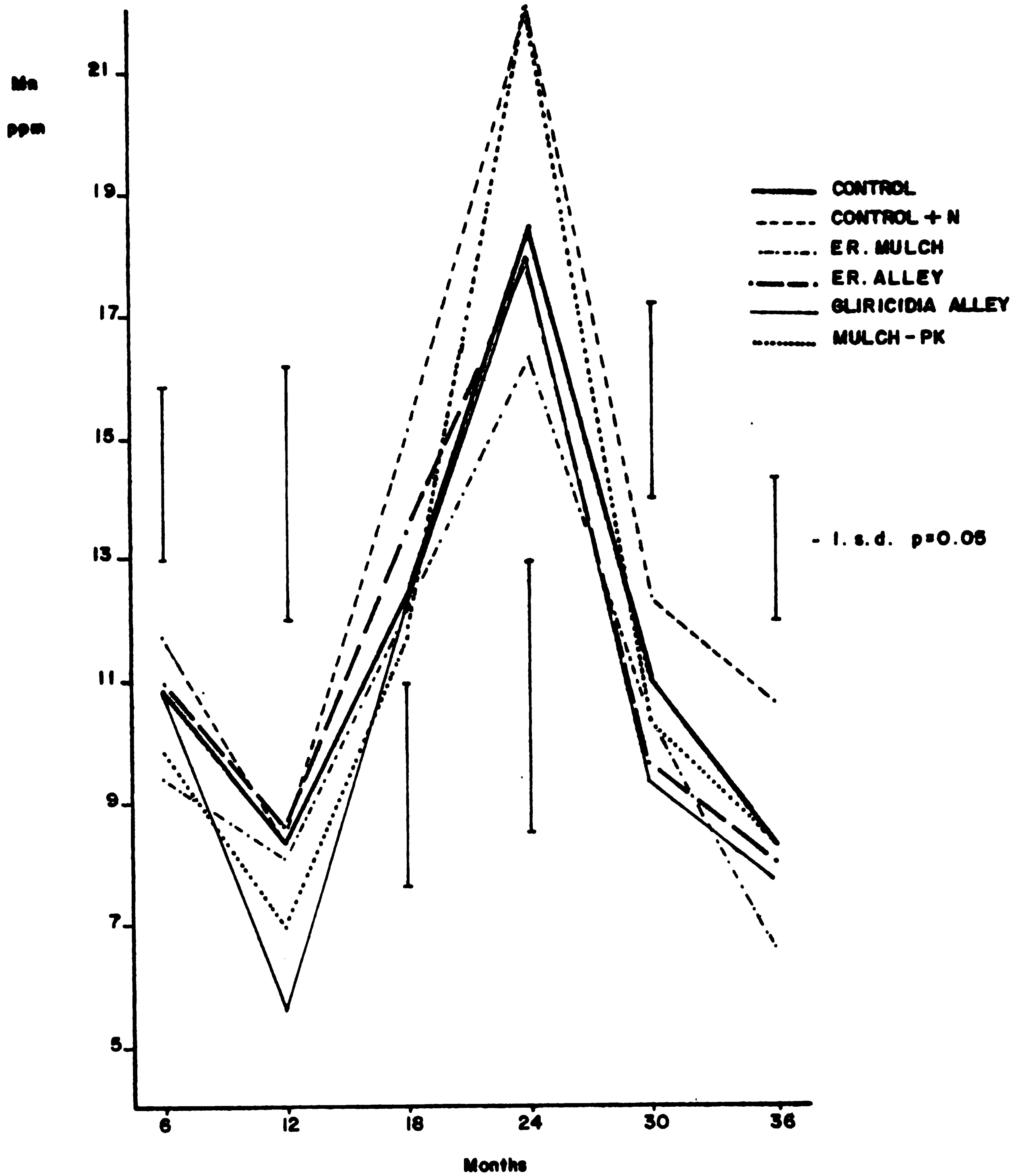


FIG. 27. OLSEN EXTRACTABLE Mn ppm 0 - 20 cm

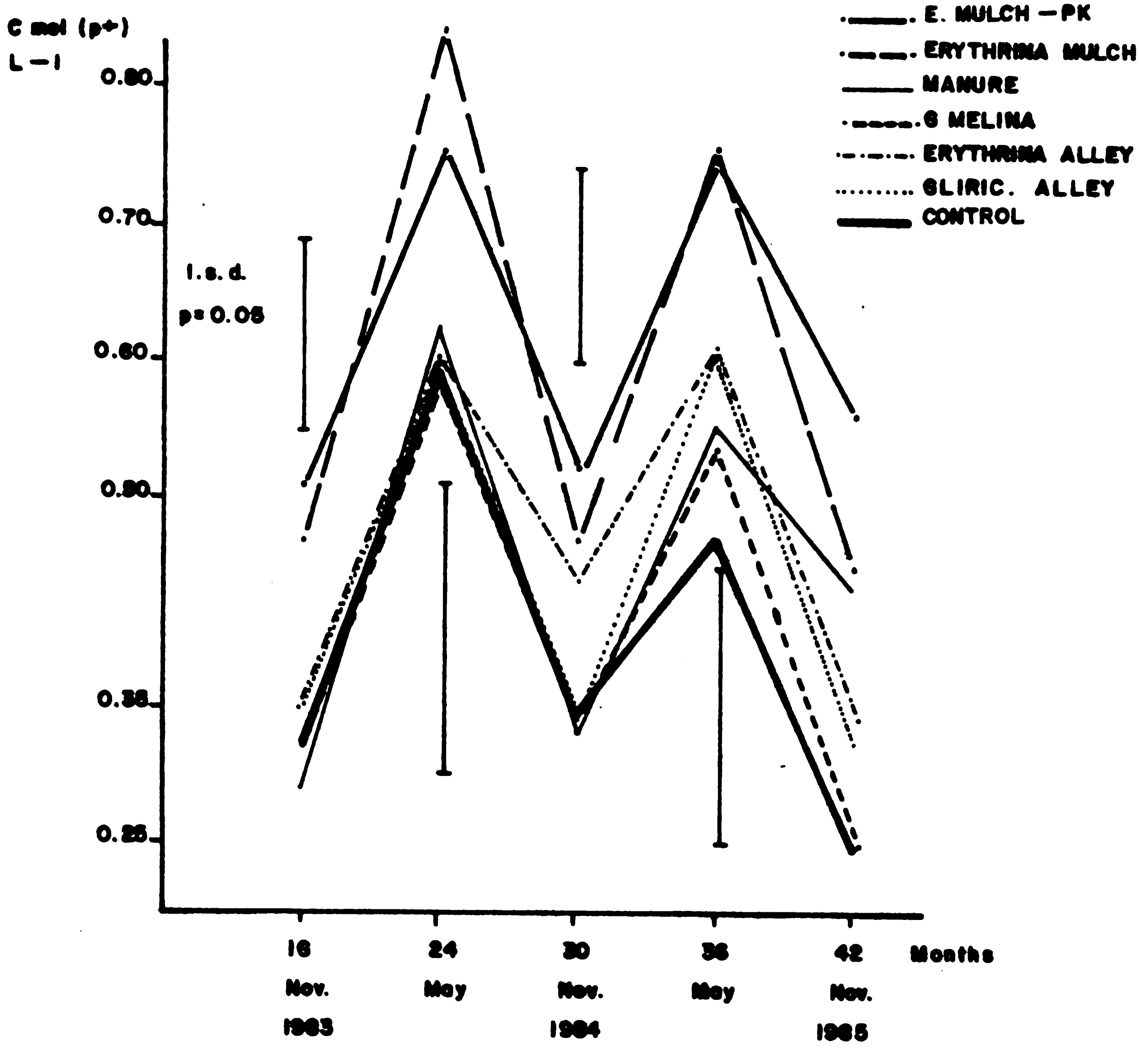


FIG. 28. EXTRACTABLE (OLSEN) K 20 40 cm

TABLE 22. K content of crop biomass in third cropping cycle, kg/ha

		Maize	Beans	Cassava	Total
Control w/out	N	33.11	11.2	81.86	126.17
	+	44.90	15.4	109.27	169.57
Erythrina	-	69.09	37.30	99.25	205.64
Mulch	+	91.56	44.05	107.80	234.41
Dairy	-	50.81	21.98	83.58	156.37
Manure	+	68.38	30.36	107.81	23.55
Gmelina	-	43.28	25.00	110.32	178.60
Mulch	+	54.00	33.27	113.36	200.53
Vigna	-	38.33	12.65	85.80	136.78
Intercrop	+	45.78	20.15	95.13	161.06
Erythrina	-	55.43	35.45	99.33	109.21
Alley Crop	+	79.79	50.45	64.90	195.14
Gliricidia	-	55.64	42.47	45.67	143.75
Alley Crop		58.32	53.14	41.04	152.47
Manure	-PK	55.63	19.30		
Mulch	-PK	75.13	26.88		
Lsd p = 0.05		22.87	15.70	45.53	

source of potassium to crops since more than half of the potassium contained in the mulch was recovered in the crops.

Crop yields in the fourth year of the experiment, are shown in Table 18. While there is still a significant

benefit from mineral nitrogen fertilization in the case of beans when dairy manure was used as an amendment, there was a significant benefit from alley cropping only with Erythrina and beans. It is also interesting to note that the plots which received only Erythrina mulch without mineral N, P or K over the four years are yielding more maize and beans at the end of four years than the plots which received mineral N, P, and K yearly. In the case of beans, this difference is statistically significant.

It would seem that despite the high organic matter levels of these soils, organic nutrient sources will, in the long run, be of greater benefit to crop yields. Mineral fertilization, besides being unfavorable in terms of requiring imported materials, results in lower yields in the long run.

Part of the unfavorable effect of alley cropping on maize yields may be due to disease rather than shading effects on photosynthesis. This is shown in Table 23 where different yield components are compared as one moves further from the row of Gliricidia trees. Decreases in yields close to the tree rows are more associated with increases in number of diseased ears than with decreases in biomass production. It is perharps due to this effect on ear rots that alley cropping appears to be more beneficial in the case of beans than of maize.

SEMIARID TROPICS

The prototype team in Nicaragua finished work in December 1984 and it was decided that research activities under the Research Support Unit should also be wound up (in 1985). By this time the majority of the original goals proposed for the principal crops and agricultural production systems of the SAT had been achieved.

TABLE 23. Effect of Distance of maize rows from <u>Gliricidia</u> rows on certain Yield components of maize alley cropping experiment

TREATMENTS	Yield of undamaged grain kg /ha	Percent diseased ears kg/ha	Plants without ears	Plants with two ears/ha	Dry matter production kg/ha
Middle maize row (3m from Gliricidia row)	2711 a	15.7 b	2759 ab	552 b	7139 a
Maize row, 2m to north of Gliricidia row	2048 a	27.9 ab	552 b	3863 ab	8156 a
Maize row, 2m south of Gliciridia row	2283 ab	30.3 ab	4967 a	2208 ab	7513 a
Maize row, 1m north of Gliricidia row	1912 bc	30.3 ab	2759 ab	3311 ab	6434 a
Maize row, 1m south of Gliricidia row	1824 bc	38.6 ab	2208 ab	2208 ab	6582 a
Maize in 3m Gliricidia rows	1594 c	45.9 a	3255 ab	1010 ab	6590 a

Values followed by same letter do not differ significantly by Duncan's Multiple Range Test at $p = 0.05$.

CATIE/IFAD Project activities during 1985 were directed by a Production Systems specialist stationed in Nicaragua. Collaboration basically consisted of support in planning, design, preparing guidelines for validation, training and field supervision studies in MIDINRA's Region 1 (Estelí).

In planning, Project personnel participated in 9 meetings (Table 24) with Region 1 and central DGA scientists. In research, the majority of MIDINRA's testing and technology validation trials were a continuation of the work carried out by the CATIE Project from 1982-1984. With collaboration from CATIE, 61 testing and validation plots of maize, beans, sorghum and maize + photoperiod sensitive sorghum were established by MIDINRA in 5 sites during 1985. (Table 25 and 26).

Once the research plan of action (testing and validation) had been determined, Project personnel participed in the preparation of four pre projects:

a) Optimum population density for four maize genotypes in different ecological areas of region 1.

b) Optimum population density for three sorghum genotypes in dry zones of region 1.

c) Maize variety adaptability and yield

d) Bean variety adaptability and yield

Also, as part of the research support, the following instructions were prepared for field personnel:

A) Validation of alternative technology for white endosperm sorghum production.

B) Validation of alternative technology for common bean production.

C) Directions for sowing maize validation plots.

D) Establishment of technology validation areas for maize associated with millon (PSS)

Field supervision was given to trials established for two agricultural cycles in Esteli, Pueblo Nuevo, Somoto and San Juan de Limay. Support was given in mobilization of Agricultural and Agrarian Reform personnel for establishing

TABLE 24. Coordination, assistance and advice given to MIDINRA region I, in basic grains research and validation. 1985.

ACTIVITIES	OBJECTIVES	DATE	PARTICIPANTS
Workplan for Assistance Program directed at basic grains.	Integration of Technical Committee and formulation of Operational plan	March 12, 1985	Eight scientists from MIDINRA Region 1 and central level 2 CATIE scientists
Presentation of 84/85 cycle results and colaboration proposal for 85/86 cycle	Presentation of preliminary proposal for CATIE/MIDINRA collaboration in 85/86	February 12-13 1985	Fifteen MIDINRA scientists from the Agriculture and Agrarian Reform administrations 2 CATIE scientists
Presentation of CATIE/MIDINRA Collaboration plan	Concrete definition of experiments and validation to be carried out	March 12, 1985	Ten scientists from Agrarian reform and Region 1 Agriculture Administrations. 2 CATIE scientists
Coordiantion of activities with the central level Agriculture Administration	Define coordination between region 1 and central level in relation to the research subprogram	March 22, 1985	Five scientists from the maize, bean and sorghum programs. 1CATIE scientist
Setting priorities for research and validation activities	Alignment of proposed plan with available research resources	April 10, 1985	Director of Agriculture and scientists in charge of Region 1 Experimental centers. 1 CATIE scientist
Analysis of methodology and technological validation proposed for the central level	Proposition of methodological and conceptual changes in accordance with resources and characteristics of the region	April 19, 1985	Director of Technical Assistance Agrarian Reform Region 1. 2 scientists from Agriculture Administration . 1 CATIE scientist.
Exhibition of concepts and outreach in the Assistance Program for basic grains	Definition of tasks and objectives for the Basic Grains National Program	April 25, 1985	Director, Basic Grains National Program. 2 scientists from Agriculture Region 1. 1 CATIE scientist
Discussion of concepts and methodology in basic grain validation	Definition of modifications to the validation methodology proposed for the central level	April 29, 1985	3 scientists from the general administrationof agriculture and Agrarian Reform. 6 MIDINRA Region 1 scientist. 1 CATIE scientist
Elaboration of proposal for research plots and validation in basic grains	Definition or necessary inputs (seed, fertilizer, pesticides) and equipment	May 8, 1985	Four scientists from the administration of Agriculture and Agrarian Reform. Region. 1 CATIE scientist

TABLE 25. Research and Technology Validation Plots for Basic Grains during early 1985. Region 1

Activities	Location	producer or Cooperative	Sowing Date	Observations
Optimal population density for four genetic materials of maize in different ecologies of region 1 . Regional trial of promising maize varieties	Japala	Campo Experimental	13/6/85	Casa Blanca and Estelí trials lost through drought in Estelí, low population due to drought and low germination
	Pueblo Nuevo			
	- Casa Blanca	Diaz y Sotelo	6/6/85	
	- Jamailí	Francisco Chavarría	5/6/85	
	Estelí	Centro Experimental	7/6/85	
Regional trial of promising maize varieties	Japala	Campo Experimental	6/6/85	Casa Blanca trial lost through drought. Japala trial sown later to be in wet period
	Pueblo nuevo			
	- Casa Blanca	Diaz y Sotelo	13/6/85	
	Estelí			
	- El Portillo	Ulises Rodriguez	5/6/85	
Optimal population density for three genetic materials of sorghum in the dry zone of region 1	Estelí E.A.G	....	3/6/85	Trials in Estelí and San Juan de Limay are in excellent conditions Some germination failure in Uniles
	Somoto: Uniles	....	5/6/85	
	San Juan de Limay	Campo Experimental	12/6/85	
	- Las Lajas	....	12/6/85	
Regional trial of promising bean varieties	Pueblo Nuevo:			In general the trials are in a satisfactory state. IAG de Estelí trial suffered light attack of web blight and the Guapinol trial moderate attack of slugs
	- Los Galpules	Efrain Martinez	17/5/85	
	- Guapinol	Alfredo Morales	15/6/85	
	Estelí E.A.G	....	3/6/85	
	- Sabana larga	Aurora Chavarría	10/6/85	
	Somoto Uniles			
Alternative technology validation for dry land maize production	Japala:			Casa Blanca trial lost through drought. Jamailí trial resown June 20th since drought affected germination. Valle Colon trial lost through lack of labor for weeding. It was not possible to obtain any information from Jicaro or Quilalí
	- El Carbón	....	13/6/95	
	- Intelí	....	13/6/85	
	- Tanquil	....	18/6/85	
	- Sta. Barbara	....	15/6/85	
	Pueblo Nuevo:			
	- Casa Blanca	Diaz Sotelo	7/6/85	
	- Jamailí	Francisco Chavarría	4/6/85	
	Estelí			
	- El Portillo	Ulises Rodriguez	5/6/85	
	Valle Colon	Cruz Pineda	7/6/85	
	Jícaro		11-13/6/85	
	Quilalí			
Alternative technology validation for the traditional system of maize production in association with photoperiod sensitive sorghum	San Juan de Limay			Two plots in San Pedro and Lajas lost through drought, in Estelí, one plot established instead of the few planned due to delay in site selection by Agrarian Reform Scientists
	- Campo Experimental	....	10/6/85	
	- San Pedro	....	11/6/85	
	- La Gracia	....	11/6/85	
	- Las Lajas	....	13/6/85	
	Estelí:			
	- Las Cámaras	....	18/6/85	

TABLE 26. Research and Technology Validation Plots for Basic Grains during late 1985. Region 1.

ACTIVITIES	LOCATION	PRODUCER OR COOPERATIVE	SOWING DATE	OBSERVATIONS
Regional Trial for promising bean varieties	Jalapa:	....	4/10/85	Weeding delayed at Uniles and Motolin due to lack of labor. 2 replicates at Moropoto lost through flooding
	Pueblo Nuevo			
	- Motolin	Juan P. Umanzor	26/9/85	
	- Los Calpules	1º de mayo	27/9/85	
	Somoto			
	- Uniles	Faustino Jiménez	25/9/85	
	- Moropoto	....	17/9/85	
	Esteli	Esc. Agricultura	17/9/85	
NPK fertilization in bean	Pueblo Nuevo:			Delayed sowing in El Rodeo limited normal crop development. Two replicates at El Horno were harvested by the farmer
	- El Horno	Efrain Acevedo	20/9/85	
	- Motolin	Juan P. Umanzor	25/9/85	
	- Casa Blanca	Manuel D. Sotelo	7/9/85	
	Somoto			
	- El Rodeo	....	7/10/85	
Optimum population density for 3 genetic materials of Sorghum in the dry zone of Region 1	Somoto:			A delayed start of the rains was reflected in poor crop development however, they will probably all complete their cycle
	- Las Cruces	....	27/9/85	
	- El Portal	....	18/9/85	
	- La Esperanza	....	27/9/85	
	Pueblo Nuevo			
	- Motolin	Juan P. Umanzor	26/9/85	
	San Juan de Limay	Centro Experimental	20/9/85	
NPK fertilization in sorghum	Pueblo Nuevo:			Good growth and differences between treatment has been observed. Severe *Spodoptera* attack at Las Lajas
	- Casa Blanca	Manuel D. Sotelo	7/9/85	
	San Juan de Limay			
	- Centro Experimental	....	9/9/85	
	- Las Lajas	....	10/9/85	
	Somoto:			
	- La Esperanza	....	18/9/85	
Alternative technology validation for white endosperm sorghum production	Pueblo Nuevo			Very good growth observed at Casa Blanca and El Socorro. The Plot at San Nicolás was very small and not thinned
	- El Socorro	....	6/9/85	
	- Casa Blanca	Manuel D. Sotelo	11/9/85	
	Esteli:			
	- San Nicolas	....	12/9/85	
	Somoto:			
	- Uniles	....	13/9/85	
	- Las Culebras	....	17/9/85	
	San Juan de Limay			
	- Los Portillos	Humberto Cordónes	17/9/85	
Alternative technology validation for common bean production	Jalapa	....	1/10/85	Generally satisfactory growth and development in plot, with the exception of damage at La Ceiba due to excess rain. Los Conales plot lost due to lack of weeding
	Pueblo Nuevo:			
	- Motolin	Juan P. Umanzor	26/9/85	
	- Casa Blanca	Manuel D. Sotelo	16/9/85	
	Somoto:			
	- Los Canales	....	18/9/85	
	- La Esperanza	....	16/9/85	
	Esteli:			
	- Sabana Largo	Aurora Chavarria	17/9/85	
	- La Ceiba	Juan D. Velásquez	16/9/85	

and supervising on-farm trials, and some of the inputs for testing and validation trials were contributed by the Project.

4 field days (3 on sorghum, one on beans) were held and the "First National Plantain Production Course" was given. This last was at the request of MIDINRA's Agricultural Training Directorate (Dirección de capacitación Agropecuaria).

Results from the work carried out by MIDINRA in 1985 were reduced due to the serious effects of drought on establishment and development of the different experimental plots. This was very dramatic in the early season where, of 15 testing plots established, only 8 managed to complete the cropping cycle successfully. In the validation plots, drought damage was most severe, especially on maize; only 6 out of 14 plots were harvested.

The climatic conditions were more favorable in the later season allowing satisfactory data collection for 75% of the experiments.

WET DRY TROPICS

Research work in the WDT was the responsability of the Prototype team in Los Santos, Panamá. The team started work in 1983 and was the last to finish, carrying on until December 1985. In its final year it functioned for most of the time with only two of its three members. They conducted 22 trials (Table 27) comprising studies started in December 1984 up to harvest in the middle of 1985. The prototype team concentrated its efforts in demonstration trials testing the latest results of the five most important production systems in the region. The principal achievements follow by system.

Rice Vegetable System

A preemergence and early post-emergence herbicide evaluation experiment in rice was established at IDIAP's experimental farm in Los Santos, Panamá. The objective was to control *Rottboelia exaltata* and *Cyperus rotundus*, the two

TABLE 27. Summary of on-farm experiment at Los Santos, Panamá, 1985

Name of experiment	DATE Start	End	No of Sites	Location
Study of the effect of residual fertilizer from tomato crop on fresh maize production	April 85 June 85	June 85 August 85	4	Llano abajo Sabana grande Los Angeles
Demonstration plot for alternative techonology (fertilizer level) on industrial tomato	October 84 November 84	January 85 April 85	2	Nestlé Guararé
Study of fertilizer level on tomato	December 84	Feb-Mar 85	4	Sabana grande (3) Llano abajo
Trial of the behavior of native rice cultivars in unfavorable dry land	July 84	December 84	1	La cruce
Demonstration trial for feasibility of supplementary watering on rice	July 84	December 84	2	Sabana grande
Demonstration trial of nitrogen fertilization on rice in unfavorable dry land	July 84	December 84	4	Guararé arriba La Espigadilla Llano abajo
Fertilization study on onions in a rice-onion system	January 85	April 85	1	Sabana grande
Herbicide trial on dry season onion	November 84	April 85	1	Sabana grande
Herbicide evaluation in wet season onion	May 85	July 85	1	La Espigodilla
Wet season Onion cultivar evaluation	May 84	Feb 85	2	Sabana grande

most important weeds in the Region. Pendimethalin was used as a preemergent treatment, while oxadiazon, bentazon (Basagram 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 soil. Rainfall was very irregular during the first few weeks after planting. 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.

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, Panamá. 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 28. 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, Melapodium divaricatum, Priva lappulacea, Rottboelia exaltata, Cynodon dactylon, Spilanthes americana, Lantana camara, Cenchrus brownii, Ipomoea sp., Sida rhombifolia, Cassia tora, Euphorbia Hypercifolia, Cassia occidentalis and Calotropium mucunoides. The two

TABLE 28. Early postransplanting herbicides evaluated in a sweet pepper (*Capsicum annuum*) experiment. Los Santos, Panamá, 1984

HERBICIDE	CONCENTRATION kg ai/ha	YIELD kg/ha
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		4202
Non Weeded Check		769

predominant species were _Digitaria sanguinalis_ and _Echinocloa colonum_.

Oxifluorfen and the combination linuron + alachlor or linuron + pendimethalin caused severe phytotoxicity to sweet pepper (Table 28).

The best sweet pepper productions and the least dry weight of weeds were obtained with the use of chloramben 3.5 + devrinol 5 kg/ha or with devrinol by itself at 8 kg/ha when the predominating weeds were grasses (_Digitaria sanguinalis_ and _Echinocloa colonum_).

The sweet pepper yields were so low in this experiment that no herbicide recomendation can be formulated yet.

Tomato - Fallow - Rice

Five herbicides at various application rates, applied either at postransplanting by themselves or in combination, were evaluated in tomato at a grower's field in La Jagua, Sabana Grande, Panamá. The herbicides included ,metribuzin, chloramben, alachlor, prometyn and fluazifop butil.

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

The predominant species were _Amaranthus spinosus_, _Eleusine indica_, _Digitaria sanguinalis_, _Momordica charantia_, _Rottboelia exaltata_, _Achyrantes indica_, _Malachra alceifolia_, _Priva lappulacea_, _Melapodium divaricatum_, _Lantana camara_, _Echinocloa colonum_, _Cyperus_ sp., _Brachiaria rigurosa_ and _Leptocloa_ sp.

Prometryn at all the 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.

Of the treatments which did not cause phytotoxicity to tomato, the plots receiving metribuzin 1.2 or alachlor 1.0

kg ai/ha produced the least dry weight of weeds. Those treated with cloramben 3.5 or metribuzin 0.4 kg had the next lowest weed dry weight. Treatments receiving prometryn and 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 evaluation due to poor growth of the tomato plants.

Yams

Support was given in the selection of treatments and in all the evaluations in a preemergence herbicide experiment carried out by IDIAP in non staked *Dioscorea alata* yams in Ocú, Panamá. The objective of the trial was to control *Rottboelia exaltata* and *Cyperus* spp., the two most important weeds in the region. Treatments included linuron 3 and, pendimethalin 0.7, 1.0 and 1.7, ametryn 3 and 4, oxadiazon 0.8 and 1.3, and combinations of ametyn or linuron 3.0 + pendimethalin 1.0, linuron 3.0 + alachlor 1.4 and diuron 1.0 + alachlor 1.4 kg ai/ha. A grower's treatment (1.6 kg ai/ha of ametryn) as well as a hand weeded control were also included.

At five weeks after planting the linuron 3 or 4, linuron 3 + pendimethalin 1, ocadiazon 0.8 or 1.3 and linuron 3 + alachlor 1.4 kg ai/ha treatments had less than 10% of their plot surface covered by weeds (Table 29). At seven weeks after planting, only the treatments with linuron 3 or 4 kg ai/ha had less than 25% of their surface covered with weeds. At this date, the pendimenthalin treatments had from 35 to 45% of the plot 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.

At ten weeks after treatment application, the growth of *Rottboelia exaltata* was so agressive, 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 deiversity in sprouting time of the seeds, an adquate weed management requires: a) proper soil preparation methods, b) use of inexpensive contact hebicides when the weeds are small, and c) use of residual herbicides.

TABLE 29. Visual evaluation of the percent ground cover by weeds in a preemergence herbicide experiment on yam (*Dioscorea alata*). Ocú, Panamá, 1984.

HERBICIDE	CONCENTRATION kg ai/ha	% GROUND COVER BY WEEDS w.a.p[1/]	
		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

1/ Weeks after planting

TRAINING

IFAD support to the training activities of the plant Production Department was started in 1982 and ended in 1985. Along with other Project activities, training was cut drastically in 1985 although a few lines of work were continued from previous years:

1. Support for graduate training and short courses
2. Production of audiovisuals
3. Production of documents
4. Documentation and information

The main achievementes and activities for 1985 follow:

Support for postgraduate training and short courses.

The 1985-1987 "Guide for Students" (PPD No 8588) was produced to guide new students and familiarize them with the PPD

With the support of the training coordinator and IFAD Project personnel, the number of courses planned and given by the PPD for the first five trimesters of the 1985-1987 class reached 93% of that planned.

Advisory committees. Each student assigned to the PPD had and advisory committee made up of four members of CATIE Professional Staff. Participation of IFAD Project personnel can be seen in the following.

Class	No. Students	IFAD personnel Committee members
1983-1985	17	83%
1984-1986	11	82%
1985-1987	18	28%

The percentage of CATIE/IFAD specialists on theses committees fell in 1985 due to the reorganization and reorientation of the project. The percentage of students in the PPD receiving IFAD grants fell from 14.3% in the two previous classes to zero in 1985. Since training support by IFAD started in 1982, 33 MS theses have been presented in the Graduate School, 25% of which were financed by the project.

Non-formal training events took the form of short courses with a maximum duration of 3 months. Short courses offered in 1985 were:

- "III Crop Production Systems Course" August 12-Oct 31 CATIE, Costa Rica, 21 international personnel received training.
- "Farm level research with special reference to bean variety evaluation". Oct 28 - Nov 9, CATIE and San Isidro del General, Costa Rica, 18 professionals received training.
- "In service training" Ing. Ma. Docarmo Ramos Fasiaben (Brazil) Nov 1-7 (Costa Rica).
- "Analysis of soils and plant tissue". Nov 4-30 (CATIE, Costa Rica) developed with PPD coordination 7 International professionals received training.
- "Analysis of experimental information" Nov 11 - 15 San José, Costa Rica. 20 national professionals received training.
- "Design of Technology options for the Guaymí DRI" Nov. 11-22 (Santiago de Veraguas, Panamá).
- "Research and Development of Technology for Crop Systems" MAG/BID. Nov 25 - Dec 6 (Ciudad Quesada, Costa Rica). 23 national professionals received training.

In addition, two field days were held, one on plantain + maize production and the other on plantain and aroids; 89 farmers and professionals participated. A course on plantain production was held in Nicaragua with 31 national professionals attending.

During the development of the third course on Crop Production Systems, three volumes covering methodological concepts of technology research and development were prepared.

Production of Audiovisuals

This line of work was started by the PPD in 1983 and was greatly supported and strengthened by the IFAD Project. It covers the production and aquisition of audiovisuals means of teaching to form a library oriented to agricultural subjects of interest to nationals of the member countries of CATIE.

The Unit offers many services such as supplying and developing films, making transparencies (277 in 1985) for use in seminars and short courses and production of audiovisuals in general. In 1985, a video "Casio Fx-702p operation" was produced, with all photographs, text and sound and music made by Project personnel using material from the IFAD project.

As already mentioned in the main body, two technical guides were also produced and 80 audiovisuals adquired.

Document Production

This includes preparation, edition and publication of documents produced by the personnel of the CATIE/IFAD Project, as a means of disseminating the results and achievements obtained. It has also been of great assistance to the PPD in producing guidelines.

In 1985 16 technical documents were published with a total of 1558 pages and 151 illustrations.

Documentation and Information

This was one of the Project's most dynamic activities, as much in the production of work reports as in formal documents. Since 1984 more than 140 documents have been published plus 28 in 1985.

The Documentation Unit reports for this year, the distribution of 6008 documents in 499 shipments to over 10 countries (Table 30).

Table 30 Documents distributed by the PPD during the months January to December, 1985.

Country	No. Shipments	No. Documents sent
Costa Rica	264	2243
El Salvador	11	247
Guatemala	20	234
Honduras	23	454
Nicaragua	18	237
Panamá	18	266
Dominican Rep.	8	270
Other countries	137	2057
TOTAL	499	6008

OUTREACH

Technical cooperation

Technical cooperation by the CATIE/IFAD Project has been based almost totally on advisory visits to National Programs for Research and Technology Transfer, as well as professional support for the prototypes and their areas of influence. In 1985 these activities were reduced to a minimum in view of the foreseen cuts and since 1985 was the final year of the Project.

The position of Coordinator of External Cooperation, created to direct the activities of this important component, was ended in December 1984. Direct support, which had previously been available on request for CATIE's member countries, was almost completely cut so as to solely deal with activities linked to tne "new project", or support for winding up the prototypes. Thus, in Costa Rica and Panamá, work concentrated on assisting analysis, interpretation and documentation of the results obtained by the prototype and training courses for the PIPA Project (C.R.) and the Guaymí Project (Panamá). In the latter's case, three advisers were sent to assist research and socioeconomic diagnosis in tne Guaymi Indian District.

Three visits were made in 1985 to the PRODESBA Project in Honduras (Financed by IFAD). Similary, the Dominican Republic was visited to assess the present state and future activities of IFAD Projects I, II, III and IV.

Collaboration with Nicaragua basically consisted of support for planning, design, preparing guidelines, training and field supervision in MIDINRA's Region 1 (Estelí). MIDINRA's activities in 1985 were mainly concerned with testing and validating results obtained up to 1984 by the CATIE/IFAD Project.

Between January 21 and February 8, 1985, the CATIE/IFAD Project team undertook a consultation mission regarding policy and development strategies with the agriculture and forestry sector authorities of all countries in the Central American Isthmus. The object of this mission was to seek and collect information regarding policies, plans, programs and agricultural or integrated rural development projects, emphasizing their connexion with the areas of research, training and technical cooperation.

The immediate result of this was a formal CATIE publication which greatly helped in the preparation of the two proposals sent by the PPD to IFAD, Rome, in September 1985 and February 1986. It was also used as a basis for discussing and composing the "10 Year Plan" prepared by the CATIE directorate as a framework and guide to intended support for agriculture and forestry development in the member countries.

ANNEX 2

LITERATURE PRODUCED BY TECHNICAL
PERSONNEL, CATIE/IFAD PROJECT,
1980-1985,

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA

Plant Production Department

1986

TO AID UNDERSTANDING, LITERATURE HAS BEEN DIVIDED AND NUMBERED ACCORDING TO PROJECT COMPONENT AS FOLLOWS:

000 - Coordination and operational support

100 - Support research (Soils management, Physiological weed management, crop systems)

200 - Genotype Management

300 - Socioeconomics

400 - Outreach

500 - Prototype teams

600 - Training

000 - COORDINATION AND OPERATIONAL SUPPORT

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