CATIE
CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA
Programa de Cultivos Anuales

CROPPING SYSTEM RESEARCH IN SEMI-ARID REGIONS OF CENTRAL AMERICA

A proposal submitted to the International Development

Research Center by CATIE

Turrialba, Costa Rica

1978

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I. BACKGROUND INFORMATION

A. The Institution

CATIE the "Centro Agronómico Tropical de Investigación y Enseñanza" at Turrialba, Costa Rica, was created in 1973 as a non profit autonomous institution under the laws of Costa Rica to carry out and promote research on agriculture, forestry and livestock in response to the needs of tropical America, particularly in the countries of the Central American Isthmus and The Antilles. Its organization, physical plant and professional staff were developed as the Tropical Center for Training and Research of the Inter-American Institute of Agricultural Sciences (IICA) whose headquarters moved from Turrialba to San José, Costa Rica in 1960.

In addition to the basic budgetary support which continues from IICA, CATIE is supported financially by the governments of Costa Rica and Panamá. At present CATIE also receives project and fellowship support from the following sources:

- USAID-ROCAP for research programs in Central America on Small Farmers Cropping Systems and Soil Fertility.
- Canadian International Development Research Center for the Small Farmers Cropping Systems Project and for studies on the use of agricultural by-products as cattle feed.
- The government of The Netherlands for graduate training fellowships, and technical assistance.
- The government of West Germany for the program on plant genetic resources.

- The Overseas Development Ministry of Great Britain for technical assistance in entomology and forestry.
- The Swiss government for technical assistance in forestry.
- The American Cocoa Research Institute for support of the program of cacao genetic improvement.
- The Rockefeller Brothers Fund for support of work on the management and conservation of forest areas.
- Oregon State University for technical assistance on weed control to the Small Farmers Cropping Systems Program.

The basic objective of CATIE is to provide as much knowledge and assistance as it possibly can in order to improve the production level, the net income and the general well-being of the low-income farmers of the Central American Isthmus.

CATIE tries to identify and develop production technologies which will enable the low income farmer of the Central American Isthmus to raise production levels through a rational and efficient use of the resources available to him.

The 1100 ha of land granted to CATIE is located in the lowlands of the Atlantic slope of Costa Rica, with main headquarters in Turrialba where basic facilities have been created for research and training. These include laboratories, classrooms, greenhouses, herbarium, housing facilities for the staff, guests and students, restaurantes, hotel, and experimental farms for crops, cattle and forestry. A data analysis facility and a Library are also located at CATIE.

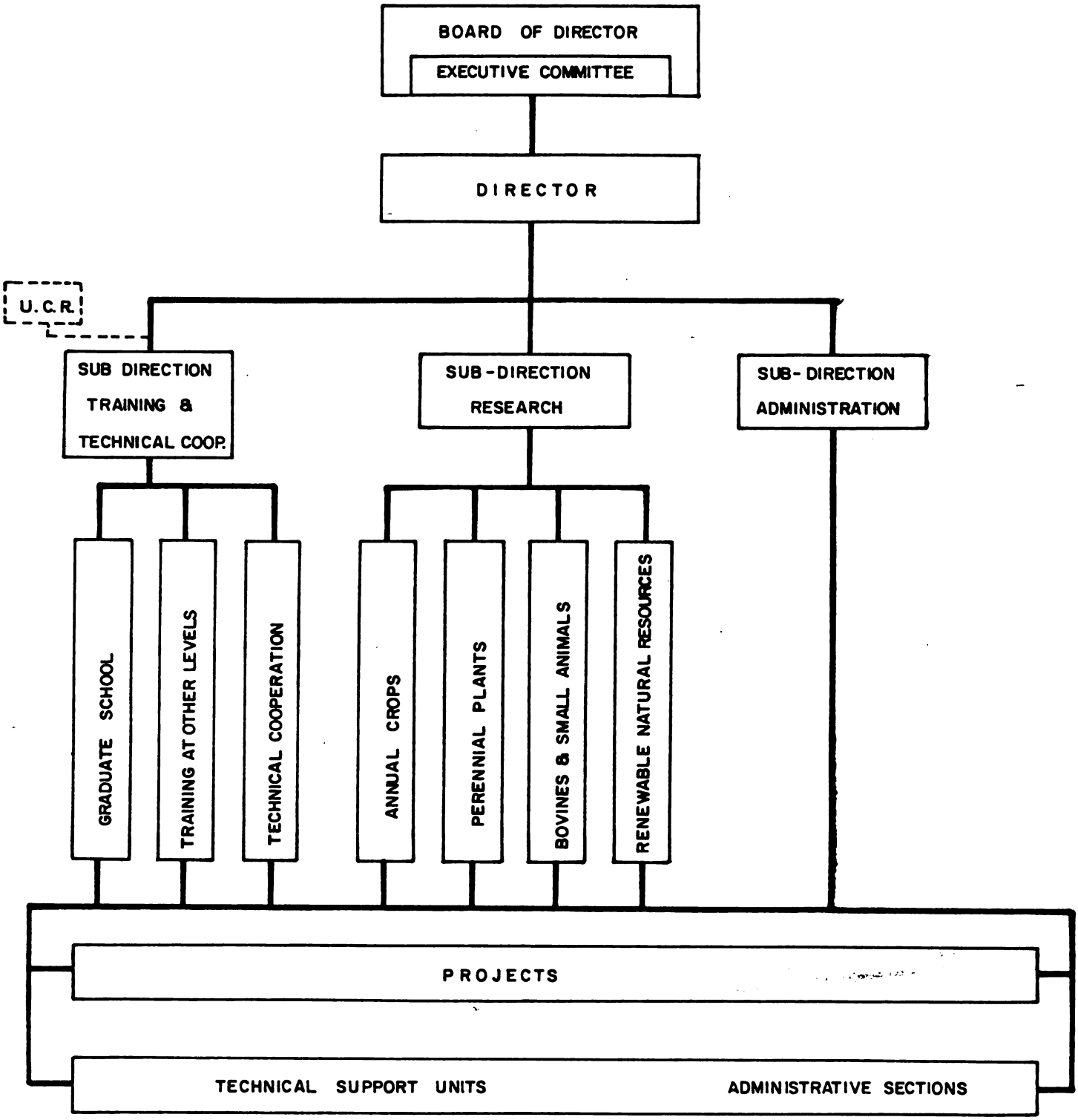

Fig. 1 Funtional structure of CATIE

At present 42 staff members are located at CATIE's headquarters at Turrialba and 10 in different Central American countries. The technical staff have been organized in four Production Programs: Annual Crops, Perennial Plants, Cattle and Small Animals, and Renewable Natural Resources (Figure 1). The Small Farm Cropping System Research Project is one of the most important projects of the Annual Crops Program.

B. The Small Farm Cropping System Research Project (SFCS)

The most important basic food crops producers in Central America are small farmers. Small farmers of this area use production systems which are frequently designated as traditional. These systems have been developed after centuries of interaction of man and his environment under conditions involving high risk and a series of factores which limit production, notably limited availability of land and capital.

Agricultural research in Central America has been traditionally dedicated to a few export crops such as banana, coffee, cacao and sugar cane while most of the available knowledge for improving basic food crop production has been transferred from temperate countries. The temperate and economically developed countries in the years between 1950 and 1970 concentrated their agricultural research into a basic and developmental type of research (development of new varieties, pesticides, fertilizers, etc.). When this research approach was transferred to underdeveloped countries outstanding increases in rice and wheat production were obtained particularly through the process known as the "green revolution".

However about 1970 it became evident that not all farmers were benefiting from the new technology. While national productivity had increased, many farmers, in some countries a majority, had not adopted the new

varieties, chemicals and production methods.

It became evident that knowledge of the process of integration of component technologies into farming systems was lacking, especially for small tropical farms.

Small farmers of Central America work under a very complex ecological and socio-economic environment. Because favorable conditions for growth exist for longer periods, tropical ecosystem can be very complex and farming systems adapted to these conditions are very different from those of the temperate zone. Discipline oriented research is ill-equipped to study the numerous interactions which characterize such complex situations. The process of integrating component technologies into small tropical farming systems needs an holistic approach taking into consideration the wide range of human activities involved in the process of transforming resources into products.

Due to the lack of available technology adapted to the conditions of Central American farmers, the former Tropical Crops and Soils Department of CATIE initiated a research program on cropping systems for small farmers in 1973 at its headquarters in Turrialba. A basic research methodology, through the work of the technical staff and the graduate students, was developed before the outreach phase of the program was initiated. This basic and methodological research on cropping systems still constitutes a nucleus for training students and visiting scientists from Central American countries. The research scope is being increased by including perennial crops and timber trees as components of some of the cropping systems being tested. Nevertheless to realize fully the program's philosophy and include a more realistic socio-economic component in the

research, the work should be done with the farmer on his land.

The Regional Office for Central American Programs (ROCAP) of the Agency for International Development (AID) of the U.S.A. is financing the outreach phase of this program throughout Central America.

In addition to the staff in Costa Rica, the SFCS Project has resident agronomists stationed in Nicaragua, Honduras, El Salvador and Guatemala. Figure 2 represents experimental sites throughout Central America in which field research is taking place.

Resident agronomists in cooperation with personnel from national agricultural institutions of the countries are conducting on-farm studies to ascertain and quantify the interaction between the crops, the environment and the small farmers. The objective is to develop improved cropping practices that will increase production and improve the general well-being of the farmers.

The farmer actively participates in the planning of the experiments conducted on his land and works closely with CATIE and national institution personnel. This relationship should transfer some knowledge from researchers to the farmers and conversely makes it possible for researchers to learn more about the situation confronting the farmer. The basic methodology followed by the SFCS's research team could be summarized as follows:

- Identification of relevant cropping system in a particular area of concentration of small farmers.
- Determination of the objectives of the community and the government.
- Study the performance of the cropping pattern under different environmental variables.
- Determine the degree and form of relationship among these environmental variables.

- Use of the previous information to maintain, arrange or redesign the system so that it operates optimally with respect to its objectives.

The process involves several research stages that consider the three mutually dependent research functions of cenceptual model development, information collection and information synthesis.

Some types of project research are:

- The study of crop association and overlapping rotations that intensify land use in time.
- Methods are investigated that will reduce land preparation cost and facilitate soil and water conservation in specific cropping systems.
- Farming systems are studied to determine the interactions between the activities within the farm.
- Research is designed to allow extrapolation of results for use in other zones in Central America that have similar ecological conditions and production determinants.
- Benefit-cost ratio studies on the different crop management and agronomic practices used by farmers will be developed.
- Case studies are conducted with selected farmers to obtain a dynamic perspective of the capital and labor allocation throughout the year.

Some of the results of three years of field experience are summarized in Annex 1.

C. The SFCS in El Salvador

Early in 1977 the Centro Nacional de Tecnología Agropecuaria (CENTA) and CATIE signed an agreement to extend the research in cropping systems for small farmers to El Salvador. The Salvadorean government has given priority in its development programs to the North-East region of El Salvador. Consequently CATIE's resident agronomist has been assigned to this region particularly to the Chalatenango and La Unión counties to develop the research project in conjunction with the CENTA's Multiple Cropping Division research team and the National Extension Service. The villages of "La Trompina Alta" in La Unión and "Las Peñas" in Chalatenango have been selected, in agreement with CENTA as sites to carry out the field work. Figure 3 represents the location of these two villages in El Salvador. In Annex 2 a summary of a study conducted by CATIE and CENTA researchers about general characters of these villages is included.

Due to the distance between the villages, the large number of small farms and lack of enough economical support, field research is actually concentrated mainly in "Las Peñas" and nearby villages. In deep field work at "La Trompina" have been delayed until additional national researchers could be hired.

These two villages of El Salvador together with other experimental areas of the SFCS project elsewhere in Central America corresponds in terms of climatic characters to what is known as semi-arid tropics. In this particular region of Central America during the long dry season, most farm land is unproductive and the scarce rural employment barely provide enough cash for some inputs purchasing to begin the planting process at the onset of the short rainy season. Drought resistant crops and

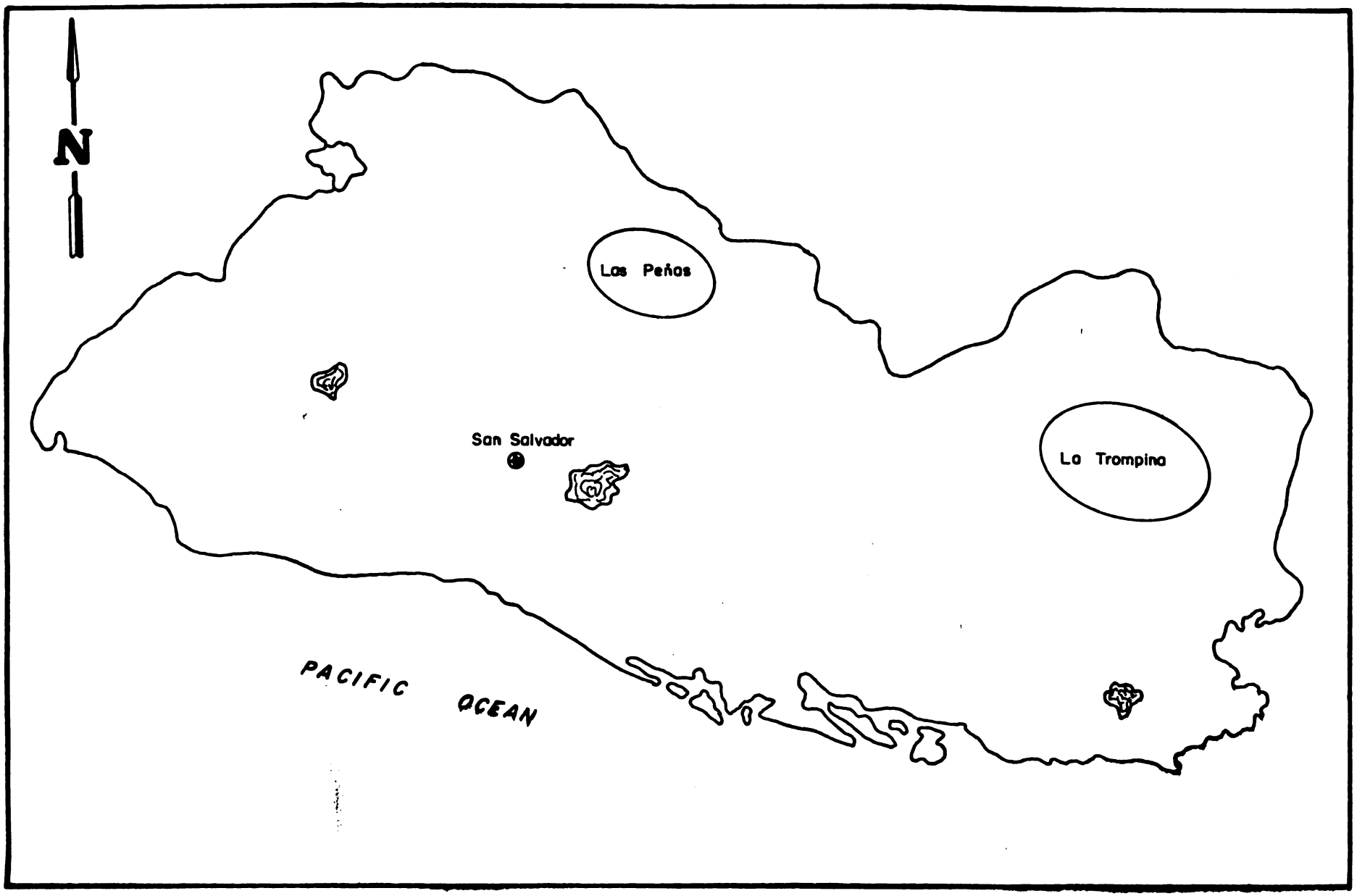

Fig. 3 Location of "Las Peñas" and "La Trompina" villages in El Salvador

better methods of land and water utilization could alleviate this situation by maintaining land in production for more than a single annual harvest.

The SFCS project in El Salvador is testing the response of traditional as well as improved cropping systems to some soil and water conservation practices such as ridges, furrows and mulching.

In order to develop new cropping systems well adapted to the condition of the semi-arid regions of El Salvador, Honduras and Nicaragua a dynamic program on introduction, search, and testing of drought resistant crops is needed. A research plan for this type of action is included in this proposal to IDRC.

Several other experimental sites of the SFCS project throughout Central America are very similar to "La Trompina" but a more detailed description of their climatic characteristics is needed to accurately extrapolate information among sites. At the present time this information is not available. A research approach to complete and update this information is included in this proposal to IDRC.

D. Some Agroclimatic Regions of Central America

The Central American Isthmus extends from East to West with the Caribbean Sea at the North end and the Pacific Ocean at the South. Hot humid lowlands predominate at the coast. The interior is composed of mountains and valleys with a wide range of temperatures.

Precipitation is the most important variable that determines farming systems throughout Central America. Following is a brief description of the precipitation regime.

There is a wide belt of steppe conditions through Guatemala and Honduras into North-Western Nicaragua in which the annual rainfall totals stay below 1,000 mm. Part of the Pacific coast west of the Bay of Fonseca and South-West of the city of Panama are very close to 1,000 mm. In contrast the mountains of Guatemala and the mountains between Costa Rica and Panama together with Belize and part of the Atlantic coast of Panama usually register high rainfall (4,000-6,000 mm).

The reasons for the strong contrast of precipitation totals are only partly understood but it is supposed that the dryness of the interior Central America is due to mountains-valley winds rather than to shielding effect of the mountains. In Central America most of the rain bringing disturbances come from the Caribbean Sea, therefore precipitation at the Atlantic seaboard is much higher than at the Pacific. The dry season (5-6 months) that occurs along most of the Pacific Coast of Central America is mainly due to the northwards displacement of the Humbolt current and the trade wind close to the Isthmus.

At the Pacific coast (El Salvador strongly influenced by this regime) the six driest consecutive months produce 5,5% of the annual rain while on the Atlantic side 29,4% of the total annual precipitation occurs during the driest months.

According to Porting (Geographical Review 55:68-90) the atmospheric conditions of the interior Central America varies from "dry" to "very dry" in November, December, January, February and March.

According to Troll (Seasonal Climates of the Earth...Springer Verlag 1966) there are two climatic regions within the tropics which could be classified as semi-arid:

- wet and dry tropical climates with 4, 5 to 7 months in which precipitation exceeds or equals potential evapotranspiration.
- dry tropical climates with 2 to 4,5 humid months with precipitation exceeding or equaling potential evapotranspiration.

The "La Trompina" and "Las Peñas" villages in El Salvador, together with Ocotepeque in Honduras and Estelí in Nicaragua correspond to what have been described as semi-arid regions. The SFCS Project is conducting cropping system research in the above mentioned locations.

The agroclimatic characters of these regions are similar to other semi-arid regions of the world. They can be summarized as follows:

- The beginning of the rainy season is uncertain
- More than 90% of the annual precipitation occurs during the rainy season which generally last from 4 to 7 months.
- Precipitation during the wet season is often extremely variable not only from year to year but also within one season.
- The mean daily rainfall intensities are 2 to 4 times greater than in many temperate regions, the short duration intensities frequently exceed the intake capacity of the soil.

E. Some characters of the farming systems in the semi-arid regions of Central America

The rain-fed type of agriculture practiced by small farmers in semi-arid regions throughout Central America has failed to provide minimum food requirements for their rapidly increasing populations.

Although the reasons for this are very complex, involving socio-

economic as well as physical-biological reasons, the primary constraint to agricultural development in the seasonally dry tropics is the lack of suitable technology for land and water management and crop production under conditions of comparatively low and erratic rainfall. This situation results not only in low general production level but also causes great instability and uncertainty year after year.

The extended dry season during which no crops can be grown, except on residual soil moisture or under irrigation, represents the main factor for instability and makes farming in the dry tropics risky. During this dry season there are no jobs on the farm. Most people and available animal power is not utilized appreciably. Migration towards areas with plantation type of agriculture in search for temporal jobs is the main feature of labor distribution during the year. Few animals and well adapted, but low yielding, local varieties of corn and sorghum are prevalent in these areas. The few existing animals are used mainly as an emergency cash source rather than a source of protein for the family. Off the farm jobs provide barely enough cash for some input purchasing to be used at the beginning of the rainy season.

Both "La Trompina Alta" and "Las Peñas" sites appear to offer excellent conditions for possible improvements of traditional agriculture in the semi-arid zone of Central America. Despite the common insufficient rainfall, the two areas offer considerable differences in soils and socio-economic structure. Trompina Alta is made of small subsistence farmers, barely scratching an existence from a very thin layer of highly eroded soils. Partly because of the land tenure system, capital inputs are minimal and production is low. Due to lack of other opportunities in the area, the community depends only on the products of these minifundia.

Any improvement in the area must depend on improving soil and water conservation and management. Nothing else can be done without completely changing the nature of the community.

"Las Peñas" has a much higher level of technology and is integrated into the cash economy. Most farmers seek some employment off the farm during the dry season, providing some capital for a more intensive agriculture on their own lands. Double and mixed cropping of corn and beans, sorghum and cucurbits is a common practice. Fertilizer use is common and small silos are used for storing grain. Many farmers own land and the farm size is larger than in "La Trompina Alta". The limiting factor in "Las Peñas", as in "La Trompina Alta" is soil moisture. Farmers from both areas are aware of the importance of soil conservation practices such as the use of mulch, ridges and the incorporation of organic matter into the soil. They are ready for a more intensive program of soil and water conservation.

II. OBJECTIVES

A. General

- To increase agricultural production and productivity and thereby the general well being of small farmers living in semi-arid regions of Central America.

B. Specific

- To compare the efficiency of the traditional cropping systems practiced in semi-arid conditions of Central America and to develop improved cultural practices to enhance this efficiency.
- To identify and test species and varieties of crops that could be used to enlarge the crop components of the traditional cropping systems of the semi-arid regions.
- To identify, introduce and test species and varieties of plants to feed animals and/or improve the environment in which traditional cropping systems are practiced.
- To better ascertain the extend and relative importance of the semi-arid regions of Central America.
- To further identify and describe the main features of the farming systems practiced by small farmers in semi-arid regions of Central America.
- To promote a more intensive collaboration between researchers of Central America with researchers working in more advanced semi-arid research centers in the World.

III. METHODOLOGY

On farm field research on cropping systems and testing of new species of crops will be conducted mainly in the semi-arid regions of El Salvador namely "La Trompina". Validation of the most promising species and varieties of crops will be conducted at Las Peñas (El Salvador), Ocotepeque and Comayagua (Honduras) and Estelí (Nicaragua).

Field research on diagnosis and characterization of Central America semi-arid zones and its farming systems will be conducted in Nicaragua, Honduras and El Salvador.

A. Testing of new species and varieties adapted to the semi-arid regions of Central America.

Species to be tested will be procured from several institutions around the world: The International Crops Research Institute for the semi-arid Tropics (ICRISAT) for sorghum and pearl millet. The International Center for Tropical Agriculture (CIAT) will provide early maturing common bean varieties. The International Center for Wheat and Corn Improvement (CIMMYT) will provide early maturing corn varieties. The Puerto Rican AID's sponsored program on legumes research, ICRISAT and IITA Programs on tropical legumes will be also approached for pigeon peas, cowpeas and other legumes.

The existing collection of germplasm of national institutions of Central America will be more throughly evaluated.

The CATIE's SFCS Project has established working relations with CIAT and CIMMYT.

The agreement between IICA-CATIE and CENTA will provide the mechanism

for the introduction of new species and varieties of plants in El Salvador.

The new CENTA greenhouse facilities located at San Andrés will be used in the increase of plant material to ensure an adequate amount for testing purposes. A close collaboration between the government of Germany's sponsored program on genetic resources located at CATIE's headquarters and the proposed project is expected.

The most important species to be tested at "La Trompina" are:

Tepari beans	(*Phaseolus acutifolius*)
	(*Phaseolus aureus*)
	(*Phaseolus calcaratus*)
Pigeon peas	(*Cajanus cajan*) as crop and forage
Cowpea	(*Vigna unguiculata*)
Groundnuts	(*Arachis hypogea*)
Common beans	(*Phaseolus vulgaris*) early maturing var.
Saquil	(*Cucurbita niveta*)
Sorghum	(*Sorghum vulgaris*)
Pearl millet	(*Pannisetum typhoides*)
Castor	(*Ricinus comunis*)
Calabash	(*Crescentia data*)
Leucaena	(*Leucaena leucorephae*) arbored type
Cashew	(*Anacardium occidentalis*)
Prickly pear	(*Opuntia*) as forage

The most promising species and varieties from tests in "La Trompina" and nearby villages will be further evaluated in "Las Peñas" in El Salvador.

CATIE's resident agronomists in Nicaragua and Honduras working with national scientists will be also testing this promising material in Comayagua and Ocotepeque (Honduras) and Estelí (Nicaragua). Figure 4 represents steps in the process of testing new plant material in "La Trompina" and subsequent transfer of information to Honduras and Nicaragua.

The exploratory tests will be conducted with 2-3 of the farmers but the evaluation field tests will be conducted in collaboration with a minimum of 6-7 farmers representing the different topographic situation in the area. Topography seems to be one of the most important variables determining the cropping pattern and the management in "La Trompina" and nearby villages. According to CATIE methodology different farmers constitute repetitions.

Home Economics researchers working in the area are already collaborating with CATIE's resident agronomist in El Salvador and they will be in charge of evaluating the acceptability of the new species and/or varieties of crops.

International travels, programming meetings, workshops and interchange of field results are the mechanisms of communication and transfer of information among researchers working associated with the SFCS research project.

B. Field research on cropping systems.

Several field experiments will be conducted at farmer's fields in order to:

- Determine total yield, and yields per unit of time, per unit of available water, and per hour of labor of the traditional cropping system (corn and sorghum) with 4 representative farmers.

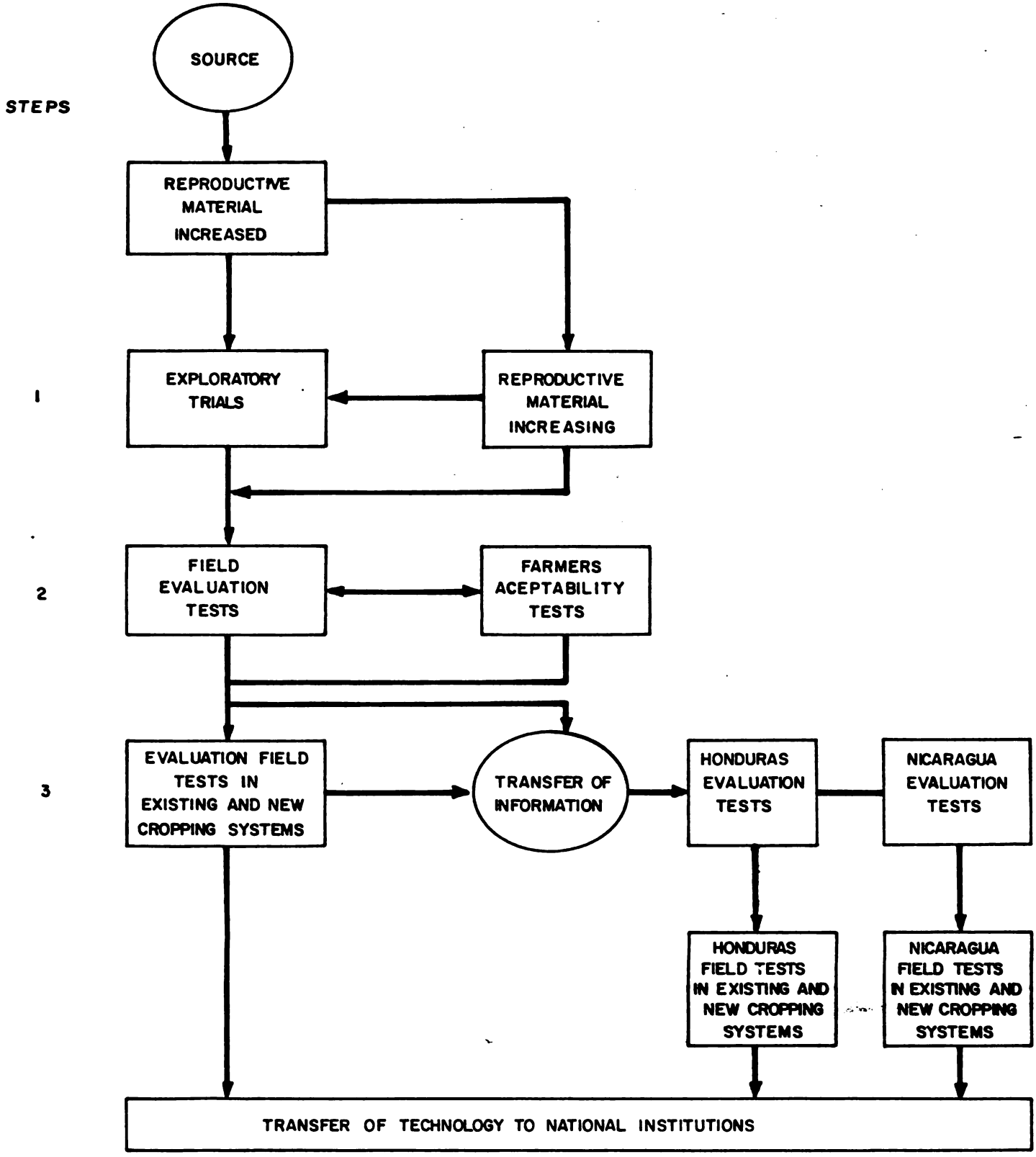

Fig. 4 Steps in the development of a research effort into diversification of the plant components of traditional cropping systems through introduction and testing of new plant material

- Compare during at least 2 cropping season the relative advantages of the corn + sorghum[1/] versus the corn/sorghum cropping patterns, plus sorghum/sorghum rotation cropping pattern.
- Substitute varieties of the crops used in the farmer systems with improved seeds (H_5 maize and S_1 or S_2 sorghum) in both cropping pattern corn + sorghum and corn/sorghum. These comparisons will be made at different levels of technology considering the farmers inputs, intermediate level of technology and a relatively high level of technology.
- Test some new species in the farmer cropping systems such as: local maize + pearl millet[1/]; local maize/pearl millet; improved maize + pearl millet; improved maize/pearl millet; local maize + cowpeas; local maize/cowpeas; local maize + cowpea/pearl millet; improved maize + cowpea/pearl millet; local maize/pearl millet + cowpeas; and several other cropping patterns.
- Determine the performance of the traditional corn + sorghum cropping system, 4 representative fields will be selected and periodic evaluation of agronomic parameters will be conducted. Some of these parameters are: number of plants per unit of area, biomass production per unit of time and mm. of water, leaf area index, nutritive value for both human and animal consumption and others. Samples will be taken at random in the farmer field and evaluate in the laboratory if needed.

1/ + = association of crops
/ = rotations of crops

- The corn + sorghum cropping system is widely used by farmers not only at "La Trompina" and "Las Peñas" villages but also in several locations throughout Central America. However there are still some farmers practising cropping systems consisting of corn in rotation with sorghum and sorghum in rotation with sorghum. A better understanding of the ecological and socio-economical variables determining this particular choice of cropping system is needed in order to be able to design new alternatives of cropping systems for farmers cultivating these two plant species. Surveys on farming systems and cropping system will provide information about the determinant variables conditioning this choice of system but experimental work at farmers field comparing the corn + sorghum, corn/sorghum and sorghum/sorghum cropping systems will complement the information. The above mentioned agronomic parameters will be used for comparative studies and representatives random samples in 4 farmers fields will be used.
- Some of the improved varieties produced by CENTA and several other Central American research agencies often demand a higher level of inputs compared with local varieties in order to perform as expected. Field trials in which this improved material is tested in the farmer cropping system under different levels of technology will provide information about the minimum level of management necessary to obtain a reasonable economic return using improved seed in the farmer cropping system. Four farmers already using improved varieties will be needed for

this type of research. Seed treatments, soil insecticides, fertilizers and storage insecticides will be the main inputs to be tested. Field experiments in which the farmer level of management constitute the check treatment and additional amounts or combinations of inputs are randomly distributed in different areas of this field provide the best information for this type of research since every aspect of management besides levels of inputs is left to the farmer.

- Since corn and sorghum constitute the two basic ingredients of the diet in this region of El Salvador, additional crops to be included in new cropping systems will have to be tested in either rotation of association with these two traditional crops. Field experiments in which corn and/or sorghum intercropped with cowpea, pigeon peas, tepari beans and others will be conducted with 2-3 farmers at the first trials but 6-7 farmers representing the different topographic conditions of the area once, more information about the best combination of crops is available.

C. Diagnosis and characterization of some semi-arid zones of Central America.

To ascertain the extent of the semi-arid regions of Central America, available data on ecology and climatology will be analized by consultants in both fields. Existing maps on soils analogs for Nicaragua, Honduras and El Salvador will be extensively used. These maps were prepared by CATIE's Soil Fertility Program in collaboration with the soils research divisions of the Ministries of Agriculture in the three countries. Some

of the maps must be further analized and some extended to include new areas of the semi-arid regions.

Consultants in ecology from the "Tropical Science Center" in San José, Costa Rica will provide their services for this study. Dr. Leslie R. Holdridge, Joseph Tosi Jr. and associates are being in close contact with CATIE's scientists for several years. Meteorological information and data interpretation from the semi-arid regions of El Salvador, Honduras and Nicaragua will be made by Dr. G. Pérez from the "Servicio Meteorológico" of the Ministry of Agriculture of El Salvador.

After the semi-arid agroclimatic regions of the three countries have been delimited, two additional target locations (one in Honduras and one in Nicaragua) will be selected to determine their farming systems in general and their cropping systems in particular. Social scientists from the University of Costa Rica and several students of agriculture and social sciences will conduct this survey during the dry season. Information will be processed in CATIE's computer facilities and results will be published and distributed to national institutions of Central American countries.

Figure 5 is a summary of the relationship among the three main activities included in this proposal: 1) introduction, search and testing of new species and varieties of plants; 2) cropping system research and 3) bioclimatic characterization of some semi-arid regions of Central America.

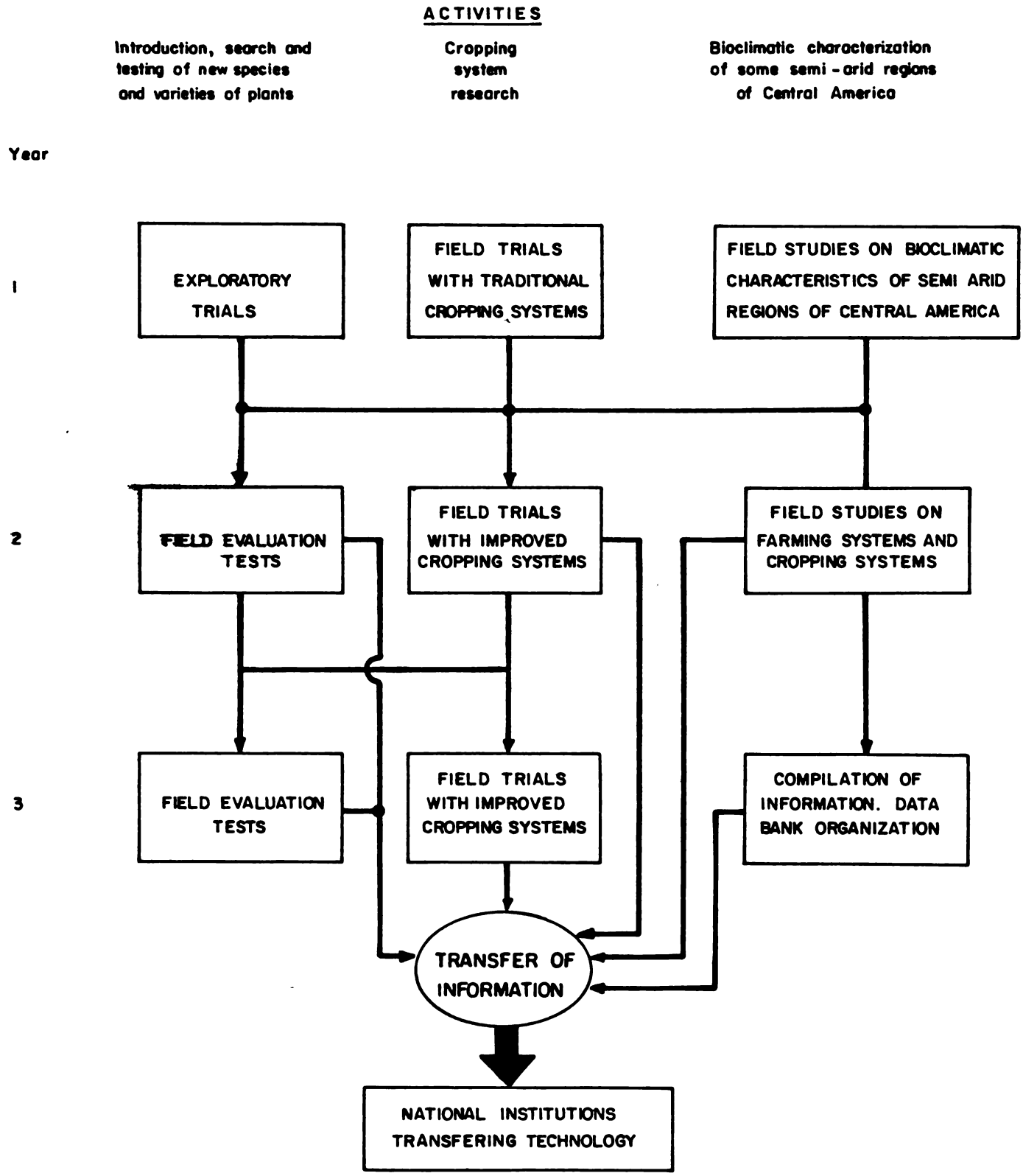

Fig. 5 Activities and relation among activities proposed in this research project

IV. BUDGET

A. Professional personnel

An agronomist is needed to conduct the field research in "La Trompina" El Salvador and nearby villages. Basically his duties were summarized in the Methodology of this Proposal, but data gathering about socio-economical characters of the small farmers in the area will also be his responsibility. A salvadorean professional with a strong background on soil management and general agronomy is preferred.

B. Sub-Professional Personnel

A field assistant for the agronomist is requested to assist in most of the field duties and data gathering. CATIE's previous experience indicated that the efficiency of the professional staff members is significantly increased when this type of sub-professional personnel assistance is provided.

Secretarial services equivalent to one third time for the first year and half time for the successive years are needed.

Field laborers will be hired on a temporary basis to carry out routine field work (planting, harvesting, weeding, etc.) and some soil management practices (ridges, furrows, water containers, etc.).

C. Operational Costs

To conduct the field work, several inputs such as fertilizers, seeds, pesticides, small field equipment are needed as well as office supplies and greenhouse equipment.

D. Travel and Per diem

The agronomist in charge of the project will travel to CATIE's headquarters for training and conferences twice a year. He will visit also some semi-arid regions of Central America to study their cropping systems.

CATIE's staff members (3) will travel to the areas under study to conduct farm surveys on farming systems and cropping system.

E. Vehicles

One four wheel-drive vehicle is requested. It will be allocated in El Salvador to be used by the resident agronomist.

F. Training

Two students from El Salvador are expected to conduct their B.S. research thesis at "La Trompina". Several students from the University of Costa Rica will collaborate in the surveys throughout Central America.

G. Publications and Workshops

Funds would be needed for the publication of brochures and pamphlets describing the objectives and significance of the Project. Two workshops will be held at CATIE's headquarter, one at the end of the second year of the project to inform about advances and the second one at the end of the third year to present results.

H. Consultants

CATIE does not have an ecologist or a climatologist among its staff members. Consultants in these two fields will help delimit the extension and main characters of the Central American semi-arid zones using available information and some field trips to further ascertain the data.

TABLE 1

OPERATIONAL BUDGET

IDRC Contribution
(Thousands of Canadian Dollars)*

I T E M	Y E A R 1	2	3	TOTAL
SALARIES AND ALLOWANCES				
Agronomist (1)	8.4	8.8	8.9	26.1
Field Assistant (1)	3.6	4.3	4.5	12.4
	12.0	13.1	13.4	38.5
RESEARCH EXPENSE				
Casual labor (2)	3.0	3.6	3.6	10.2
Small Field Equipment	1.7	1.7	1.7	5.1
Fertiliz.& other field supplies	1.4	1.9	1.9	5.2
Office supplies	0.3	0.3	0.3	0.9
Maint.& Oper. vehic.& equip.	2.2	3.0	3.9	9.1
	8.6	10.5	11.4	30.5
TRAVEL				
International (C.A. & identif. & recollec. of world germplasm	7.8	4.2	4.2	16.2
Local (in El Salvador)	1.7	2.2	2.2	6.1
	9.5	6.4	6.4	22.3
PUBLICATIONS AND WORKSHOPS				
Publications (6)	0.4	0.9	1.7	3.0
Seminars (2)	-	4.3	1.7	6.0
	0.4	5.2	3.4	9.0
CONSULTANCIES (includ. travel costs)				
Consultors (150 man/day)	8.6	8.6	4.3	21.5
	8.6	8.6	4.3	21.5
TRAINING (Thesis B.S. or M.S. level)	-	5.0	5.0	10.0
	-	5.0	5.0	10.0
SUPPORTING SERVICES (18%)	7.0	8.7	7.9	23.6
	7.0	8.7	7.9	23.6
T O T A L	46.1	57.5	51.8	155.4

* Exchange rate applied: Ca$1.00 = US$0.81

TABLE 2

CAPITAL BUDGET

IDRC Contribution
(Thousands of Canadian Dollars)*

ITEM	YEAR 1	YEAR 2	YEAR 3	TOTAL
Vehicles (1)	8.5	-	-	8.5
	8.5	-	-	8.5

TABLE 3

BUDGET SUMMARY

IDRC Contribution
(Thousands of Canadian Dollars)*

OPERATIONAL BUDGET	46.1	57.5	51.8	155.4
CAPITAL BUDGET	8.5	-	-	8.5
	54.6	57.5	51.8	163.9

* Exchange rate applied: Ca$1.00 = US$0.91

TABLE 4

SCHEDULE OF LOCAL CONTRIBUTIONS

CATIE Contribution*
(Thousands of Canadian Dollars)

ITEM	Year 1	Year 2	Year 3	TOTAL
SALARIES AND ALLOWANCES				
Project Leader - Ph.D. - (8m/m)	9.1	9.1	9.1	27.3
Agronomists - Ph.D. - (8 m/m)	9.1	9.1	9.1	27.3
Auxiliary Personnel (18 m/m)	4.2	4.2	4.2	12.6
	22.4	22.4	22.4	67.2
RESEARCH EXPENSES				
Laboratory supplies/services	1.2	1.8	1.8	4.8
Computer services	0.6	1.4	1.4	3.4
Operation & Maint. vehicles	1.5	1.5	1.5	4.5
	3.3	4.7	4.7	12.7
TRAVEL				
International	2.4	2.8	2.8	8.0
PUBLICATIONS AND WORKSHOPS				
Publications	0.3	0.4	0.6	1.3
T O T A L	28.4	30.3	30.5	89.2

* Several agronomists working for the SFCS project will be contributing their time and skills to this project. CATIE resident agronomists at El Salvador (1), Honduras (2) and Nicaragua (1) will dedicate at least one fourth of their time to the field work of this project.

ANNEX 1. Some results of the SFCS Project (1977).

At the Institutional Level.

- The SFCS project has established active working and technical assistance arrangements with each of the national agricultural research organization in Central America.
- The SFCS project has established an active exchange of information, plant material, technical assistance, etc., with research information organizations in Central America and with international organizations such as IRRI, CIAT, CIMMYT, IITA and ICRISAT, etc. and with support information organizations such as national meteorology and rural sector statistics agencies.
- Regional training and seminars in cropping systems, for national researchers increased demand for the SFCS project staff to assist the Central America and other tropical America national programs with research organization, design and implementation.
- Baseline studies have identified specific production and marketing problems, technology transfer considerations and research organization and design needs.
- The SFCS project has influenced the national research organization in Honduras and Nicaragua to re-organize in interdisciplinary groups and to add projects in small farm cropping systems research.
- University of Costa Rica students are assisting with SFCS project research, base line and case studies in Costa Rica.
- Experience gained in the SFCS project has enabled the staff to conceptualize variables which influence farmers cropping systems

and initiate planning preliminary integration of the sub-systems of horticulture, perennials, animals and pasture.

At Farmer's fields:

Honduras

- Corn and rice planted in association yielded more and involved less risk than either crop planted alone. More than 4 combinations of corn and rice produced an average land equivalent ratio (LER) of 1.13, indicating that the 2 crops in association yielded the same amount on one hectare as 1.13 hectares would have produced in monoculture.

  One of the new spatial arrangement of corn and rice, i.e. four rows of rice between double rows of corn, yielded twice as much as the best spatial arrangement alone. Corn yield in the association was 20% less. The corn and rice intercropping system was 1.3.

- Corn and squash in different combinations were more profitable than the traditional planting of two crops of corn alone in succession. Net income for the traditional system was US$156 per hectare while the best improved system, i.e. corn and squash, followed by squash gave a net income of US$451 per hectare. This represents an increase of 189 per cent. Another system, corn followed by squash, increased income by 161%. The introduction of squash to the system meant an added cost of six dollars per hectare.

- Cowpea introduced into traditional cropping systems has consistently yielded from 100 to 200 per cent above common bean yield. Cowpeas were a good substitute for velvet bean, a non-edible bean, traditionally intercropped with corn as a green manure crop.
- Cowpea intercropped with corn yielded 530 kilograms per hectare and corn yields were equal to those obtained from the traditional velvet bean-corn combination. The corn and cowpea cropping system produced a LER higher than 2.0. Farmers can use cowpea as a green manure plus harvest the crop of edible beans. Farmers appear to accept cowpea as a substitute for beans when the color and form of the variety are similar to those of common bean.
- Cassava and corn intercropping produced corn yields of 95% and cassava yield 3 of 64% as compared to the monoculture. Small farmers may be more willing to consider cassava as a cash crop in this type of a cropping system.

Nicaragua

- A modified system of corn followed by common beans yielded 150 per cent more corn and 60 per cent more beans than the farmers's system. Selected modifications of space distribution of the crops, thinning practices, above average management and use of insecticide increased net income 168 per cent and family income of 70 per cent over those of the farmer's system. Addition of a low level of fertilizer (17.5 per cent

of variable costs) increased net income 300 per cent above farmer's system.

- Sorghum and beans planted in alternate rows increased income, reduced risk and supplemented farm family diet. The farmer's cropping systems is a bean monoculture during the September to December growing season. Early dry periods cause crop losses frequently; inclusion of sorghum in the systems greatly reduced risk since this crop withstands drought better than beans. Two rows of sorghum alternated with 3, 4, 5 and 6 rows of beans gave the following percentages increases of relative sorghum yields: 100, 77, 71, 67 respectively. Relative bean yields, taking the 6 row yield as 100, were: 75, 76, 90 and 100, respectively. Treatments gave increases in net profits 283 to 319 per cent and family income of 69 to 78 per cent above bean monoculture. Farmers in the area of Esteli are now trying bean and sorghum intercropped on a commercial scale, after observing the positive results obtained from research plots in fields of their own. A new sorghum and bean cropping system, i.e. 2 rows of sorghum alternating with 2 rows of beans, planted in Samulali (a wetter area than Esteli) yielded 36 per cent, as compared to sorghum in monoculture and 113 per cent of the bean production as monoculture. Therefore this system had a land equivalent ratio (LER) of 1.49, indicating that the system yielded the same amount as 1.49 hectares produced in monoculture.

- An average cost to benefit ratio of 2.96 to 1 has been obtained by comparing two levels of technology for corn production. A replicated trial with five small farmers clearly indicated a gross yield increase of 727 kilograms per hectare (US$102.8 per hectare) with an added cost of US$34.7 which includes fertilizer plus labor.

Costa Rica

- In the central experiment at CATIE, systems which include beans ranked high in protein production. The system with highest protein production (843 Kg per hectare per year) was beans intercropped with corn followed by corn. Assuming a relative value of 100 for this system the same arrangement with a high technology (higher fertilizer rate) had a value of 90. This indicates the advantage of associating species which do not compete heavily for plant food in the same environmental niche. The cropping system, corn intercropped with sweet potato in rotation with corn had a value of 70. This arrangement is at the bottom of the 10 systems which produced most edible protein. The system which produced the greatest quantity of energy was beans intercropped with cassava in rotation with green corn (fresh corn). This system gave 312.39 (relative value 100) megacalories (1×10^6 calories) per hectare per year. The range of relative values for the 10 systems with the greatest quantity of energy produced was from 100 to 76. Only two systems had values below 80.

- Economic analysis of 10 cropping systems indicated that the most stable systems have corn and beans as components. The prices of these two crops are fixed by government policies.
- As a result of SFCS experiments in Costa Rica (Guayabo), farmers of this area have adopted the short variety of corn, Tuxpeño. At present it is rare to find the former traditional tall corn variety (modified Rocamex).
- In Costa Rica (Palmares and Juntas de Pacuar in the Southern Pacific area) as in Honduras, cowpeas have shown great promise. Farmers are increasing cowpeas planting as seed becomes available. Experiments on farmer's fields in the area have shown higher yields and reduced risk due to better resistance to diseases, pests and lack of rainfall.

Annex 2. Some ecological and socio-economic characteristics of the "Las Peñas" and "La Trompina" villages in El Salvador.

"La Trompina Alta", according to the climatic classification of Koppen is a hot tropical savanna. Rain is the limiting factor for agricultural production in this area. Since no meteorological station exists in the village, information has been gathered from 4 nearby villages (Jocoro, Corinto, Sta. Rosa de Lima and Anamorós). Tables 1, 2 and 3 summarize the precipitation records of these areas and the average estimated for "La Trompina Alta". Figure 1 represents precipitation values. A period of lesser precipitation between July and August can be observed.

Basic crops in this area are maize and sorghum. Farmers usually associate these crops to reduce the risk of maize loss due to the uncertainty of precipitation. This association of crops is practiced by 85% of the farmers while 15% of them cultivate only maize. These crops are usually planted in May. A second crop of maize or corn may be planted in August. Some farmers intercrop different types of squash in their corn.

Planting is done by hand using a dibble. Sorghum is interplanted between corn rows 15 days after corn is planted. Table 4 summarizes the distribution of hand labor for the different cultural practices in this traditional cropping system. Most farmers (95%) use local seeds and 5% of the farmers mix local and improved varieties. CENTA is testing improved corn (H_5; H_3 and H_{101}) and sorghum (S_1 and S_2) varieties. Fertilization is used mainly for corn. Seventy per cent of the farmers fertilize with a formula of 20-20-0 (N, P_2O_5, K_2O) 8 days after planting and with ammonium

TABLE A-1

Mean monthly precipitation (mm) for Jocoro, Corinto, Santa Rosa de Lima and Anamoros and estimate for La Trompina*

	JOCORO	CORINTO	SANTA ROSA DE LIMA	ANAMOROS	LA TROMPINA (estimate)
January	3	12	2	2	4.7
February	0	1	2	0	0.75
March	0	20	14	14	12.0
April	46	65	31	30	43.0
May	250	275	249	266	260.0
June	335	412	355	341	360.7
July	258	299	236	281	268.5
August	250	348	252	286	284.0
September	390	353	401	398	385.5
October	305	357	300	339	325.2
November	52	54	92	40	59.5
December	19	7	25	13	16.0

* Source: Almanaque Salvadoreño, 1977

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TABLE A-2

Monthly absolute maximum precipitation (mm) for Corinto, Santa Rosa de Lima and Anamoros and estimate for La Trompina*

	CORINTO	SANTA ROSA DE LIMA	ANAMOROS	LA TROMPINA (estimate)
January	23	0	14	12.3
February	16	12	0	9.3
March	44	51	76	57.0
April	226	125	103	151.3
May	423	321	398	380.67
June	620	560	692	624.0
July	477	442	774	564.3
August	645	462	902	669.8
September	848	475	730	684.3
October	622	598	733	651.0
November	204	111	111	142.0
December	15	89	26	43.3

* Source: Almanaque Salvadoreño, 1977

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TABLE A-3

Monthly absolute minimum precipitation (mm) for Corinto, Santa Rosa de Lima, and Anamoros and estimate for La Trompina*

	CORINTO	SANTA ROSA DE LIMA	ANAMOROS	LA TROMPINA (estimate)
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	10	51	142	67.67
June	222	132	109	154.3
July	73	83	106	87.33
August	99	110	79	96.0
September	140	182	272	198.0
October	117	85	124	126.3
November	0	0	0	0
December	0	0	0	0

*Source: Almanaque Salvadoreño, 1977

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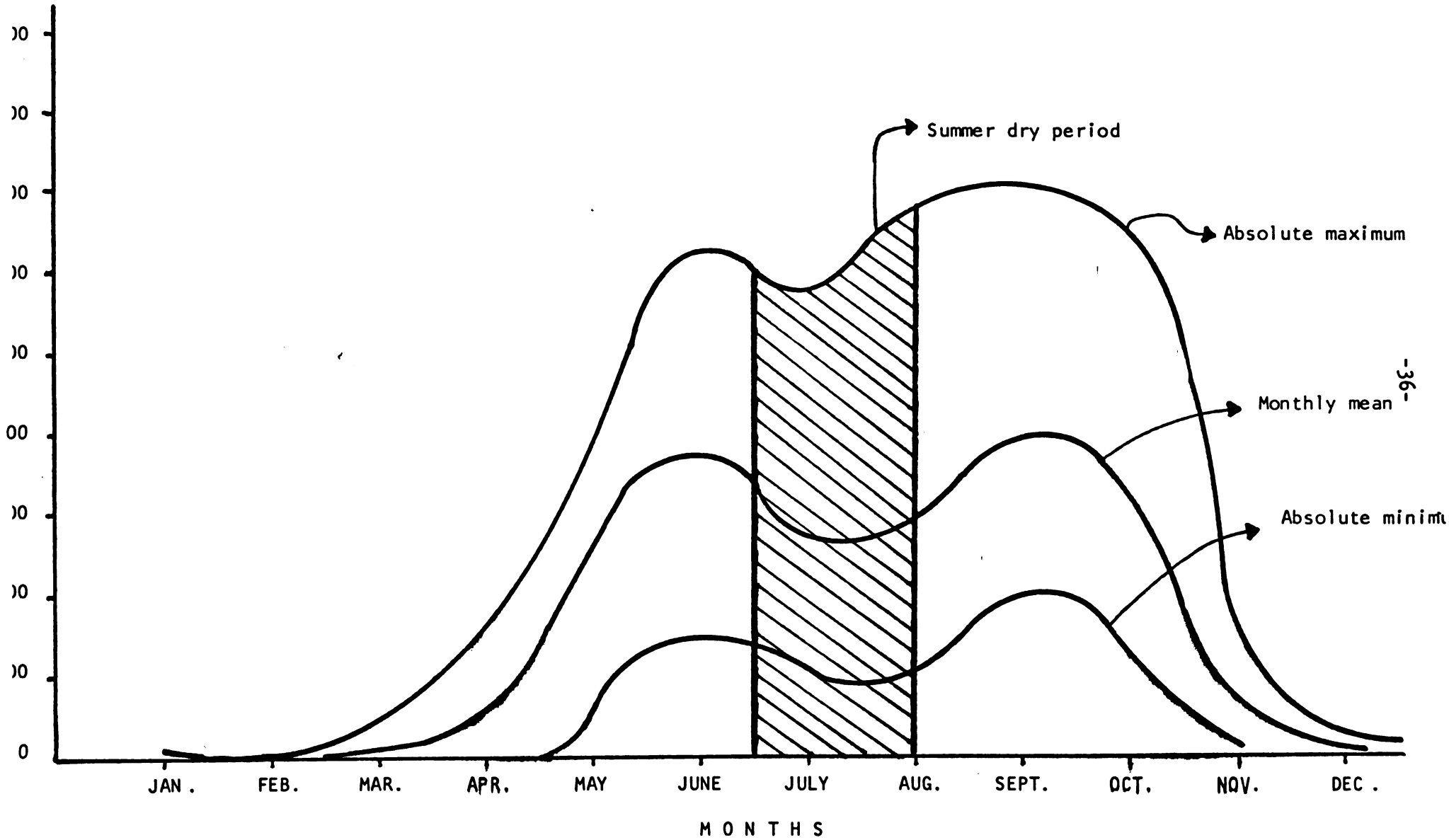

Figure A-1 Estimate monthly mean, absolute maximum and absolute minimum precipitacion for the La Trompina Village. 1978

TABLE A-4

Labor distribution (%) in two cropping patterns. La Trompina (El Salvador) 1977

	Cropping Pattern	
	Corn Monoculture	Corn/Sorghum[1/]
Land Preparation	20	14
Planting	12	14
Weeding	46	41
Other[2/]	22	31

1/ Corn planted at the beginning of the rainy season.

2/ Pesticide application, fertilization, corn bending, harvesting labor, etc.

sulphate a month after planting. Pesticides are used only for seed treatment.

About one third of the farmers are organized in a cooperative which, according to an evaluation carried out by CENTA in 1977, is one of the most active cooperatives functioning in La Unión county.

About 42% of the farmers own the land they work and 58% rent it. Farmers who own some land and rent somewhere else are very common.

The San Sebastian Mines are located near the village and about 12% of the farmers work in these mines during the dry season.

The diet is composed mostly of corn "tortillas". Meat is excluded since the value of a pound is $0.96 and the daily salary in La Trompina is $1.00-1.25. The only source of proteins are common beans purchased outside the area since they are not presently cultivated.

Poor soils best suited for either forests or grassland are being farmed due to the scarcity of adequate land. This type of farming is degradating the land and causing a progressive desertification of the area. According to local farmers (the oldest is about 96 years old) "the dry season wasn't too bad some years ago". Data indicate that the dry period in July and August is also becoming more pronounced. Besides having low fertility, which is rapidly exhausted by intensive cropping with inadequate fertilization, soils are shallow and subject to serious erosion. Attention must be given to soil and water conservation practices if the present low level of agricultural productivity of the area is to be maintained, much less increased, since almost 60% of the families in the village do not own all the land that they work. Incentives for improvements of the land are slight, especially as most rental arrangements

establish that corn and sorghum stalks be left for the owner. It may be debated that the land tenure system in La Trompina Alta is an insuperable obstacle to any more rational land use. Yet the fact that more than 80% of the families in the village derive their livelihood from the land and the lack of other opportunities in the area makes a different solution to their situation equally untenable.

The "Las Peñas" county corresponds to a tropical hot savanna according to Koppen climatic classification. Tables 5, 6 and Figure 2 summarize the precipitation data of the nearby villages of El Paraiso, La Reina and Aguacaliente and the average estimated for Las Peñas.

Precipitation decreases between July and August. Most of the farmers in "Las Peñas" cultivate corn and sorghum similarly to the La Union county. In this area, beans are cultivated either at the beginning of the rainy season (April) or later in the cropping season (August-October).

Figure 3 represents some of the most important cropping patterns found in this area.

Some farmers incorporate organic matter into the soil and fertilize their crops with 20-20-0 (N, P_2O_5, K_2O) and ammonium sulphate similar to La Union farmers.

This area is more diversified agronomically and has more variability cultural practices than "La Union". It has more potential for improvement. Several types of squash plus cucumbers, orange trees, coffee, some sugar cane and some banana trees in backyards are very common.

TABLE A-5

Monthly mean precipitation (mm) for El Paraiso, La Reina and Aguacaliente and estimate for Las Peñas*

	El Paraiso	La Reina	Aguacaliente	Las Peñas (estimate)
January	1	4	4	3
February	2	3	2	2.3
March	12	13	12	12.3
April	70	60	39	56.3
May	190	170	158	172.6
June	310	300	277	295.6
July	314	315	290	306.3
August	279	298	260	279.0
September	371	395	370	378.6
October	167	215	225	202.3
November	28	32	21	27.0
December	8	6	11	8.3

* Source: Almanaque Salvadoreño, 1977

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TABLE A-6

Monthly absolute maximum and minimum precipitation (mm) in El Paraíso* (nearest meteorological station)

	Maximum	Minimum
January	15	0
February	20	0
March	56	0
April	260	5
May	347	106
June	640	172
July	482	119
August	386	213
September	576	294
October	347	54
November	97	0
December	66	0

* Source: Almanaque Salvadoreño, 1977

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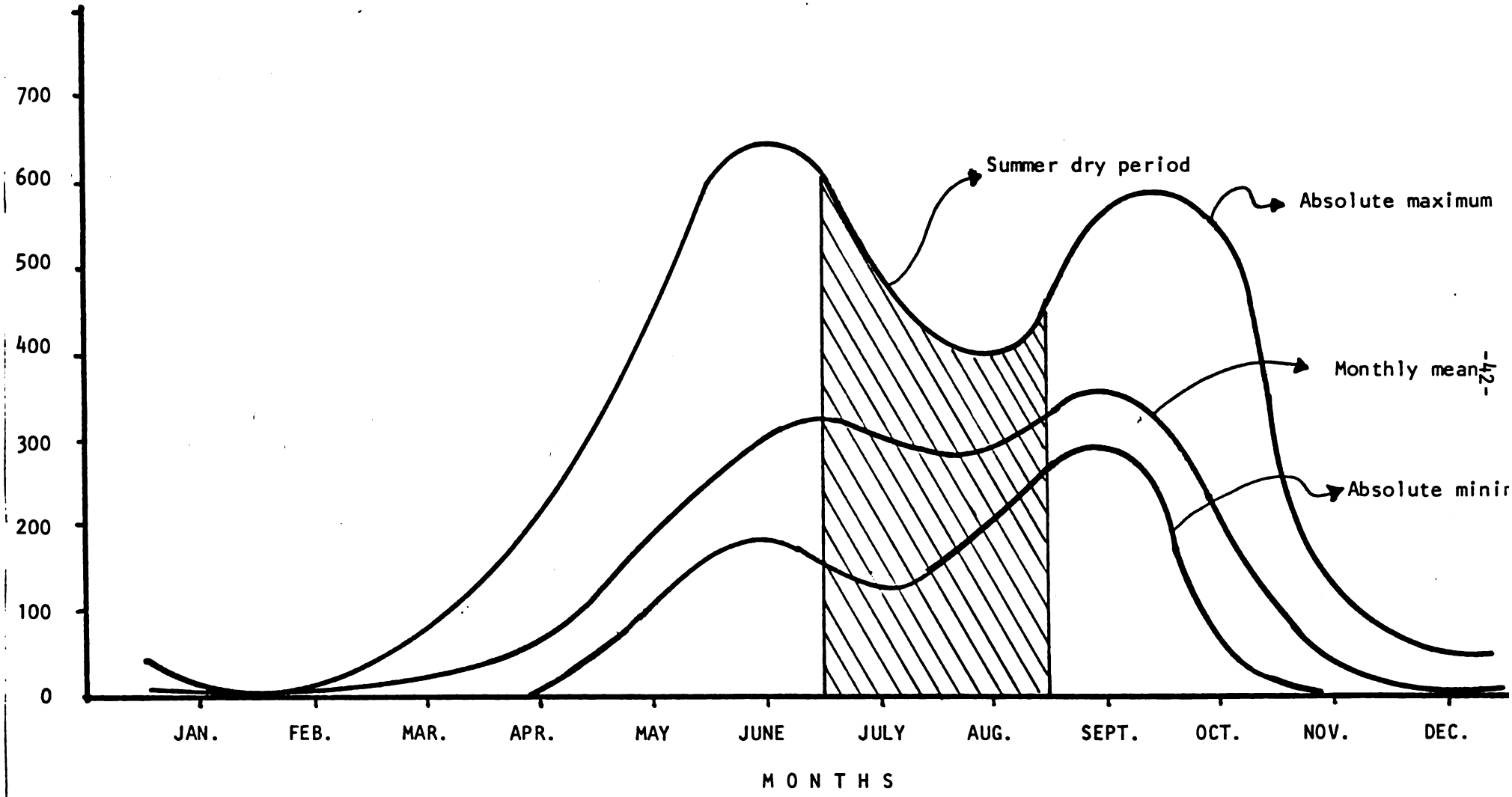

Figure A-2 Estimate monthly mean, absolute maximum and absolute minimum precipitation for Las Peñas Village 1978

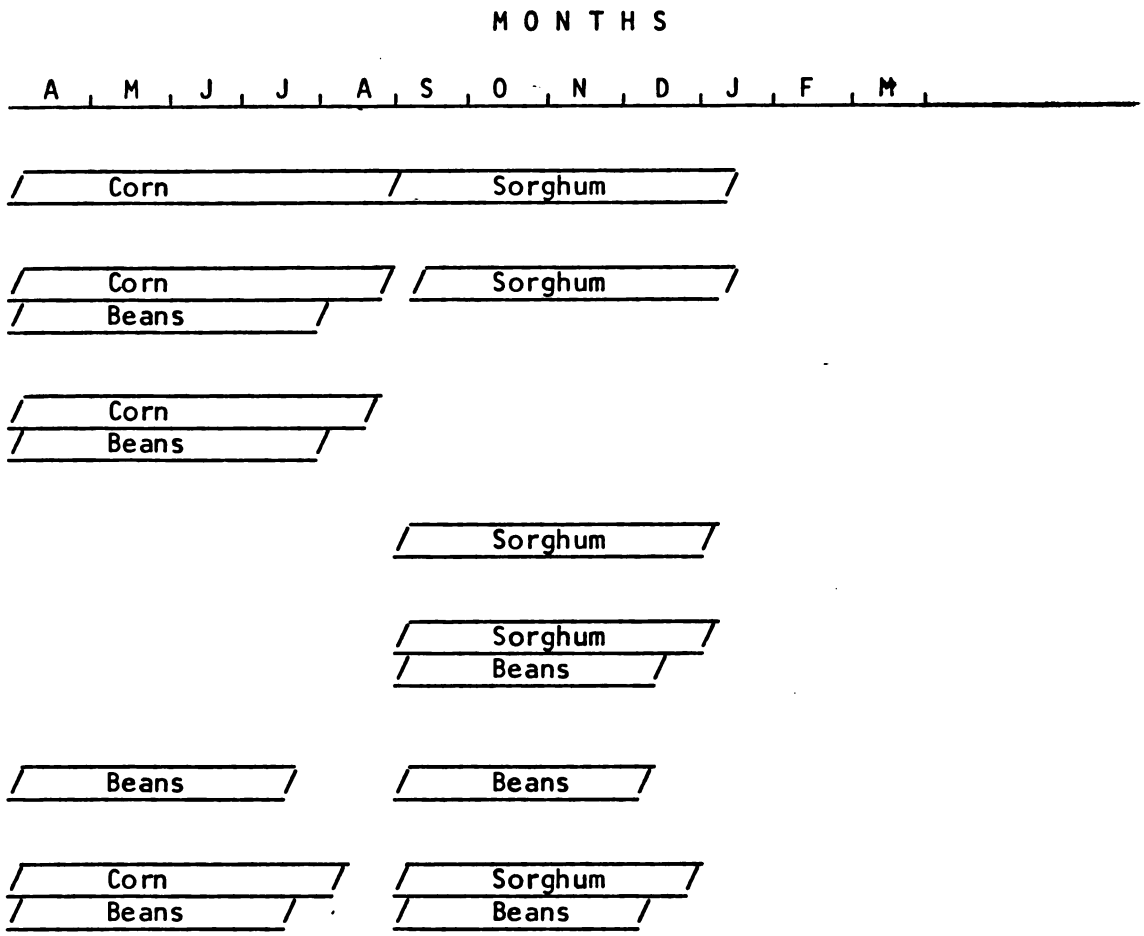

Figure A-3 Cropping patterns commonly used in Las Peñas Village