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FARMING SYSTEMS IN ACOSTA-PURISCAL COSTA RICA

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2. INTRODUCTION

Johannes Lagemann[1]/

In Central America, 50% of the entire population lives in the tropical dry-humid zone[2]/. The topography of this zone ranges from undulating hills to very steep inclines (more than 100%) and constitutes a severe limit on agricultural production. It is under these conditions that the majority of small farmers forming the "target group" work. The area of Acosta-Puriscal is found in this ecological zone, situated approximately 60 Km from San José (see Map 1).

This study describes the results of the third phase of a research and development project (see Figure 1). Two principal activities form the central part of the investigation realized in Acosta-Puriscal. The first, an analysis of farming systems, has the following objectives:

- Description of the principal agronomic practices (How it is done and why).
- Identification of labor use and its limitations.
- Identification of the production-influencing factors.
- Identification of production and productivity of the principal farm enterprises and the whole farms.
- Identification of cash availability and its variation during the year.

The second activity consists of a preliminary test of innovations with the purpose of verifying the hypothesis that there are technological packages adaptable to the work zone that are superior to the farmers' technology.

The results of these two components allow recommendations to be made in light of the priorities of agricultural research and extension.

1/ Agricultural Economist and Coordinator of the CATIE-GTZ Project "Farming Systems".

2/ CATIE: Research and Training for Developing Production Technology of Small Farms in CATIE's Mandate Region, Turrialba. 1981.

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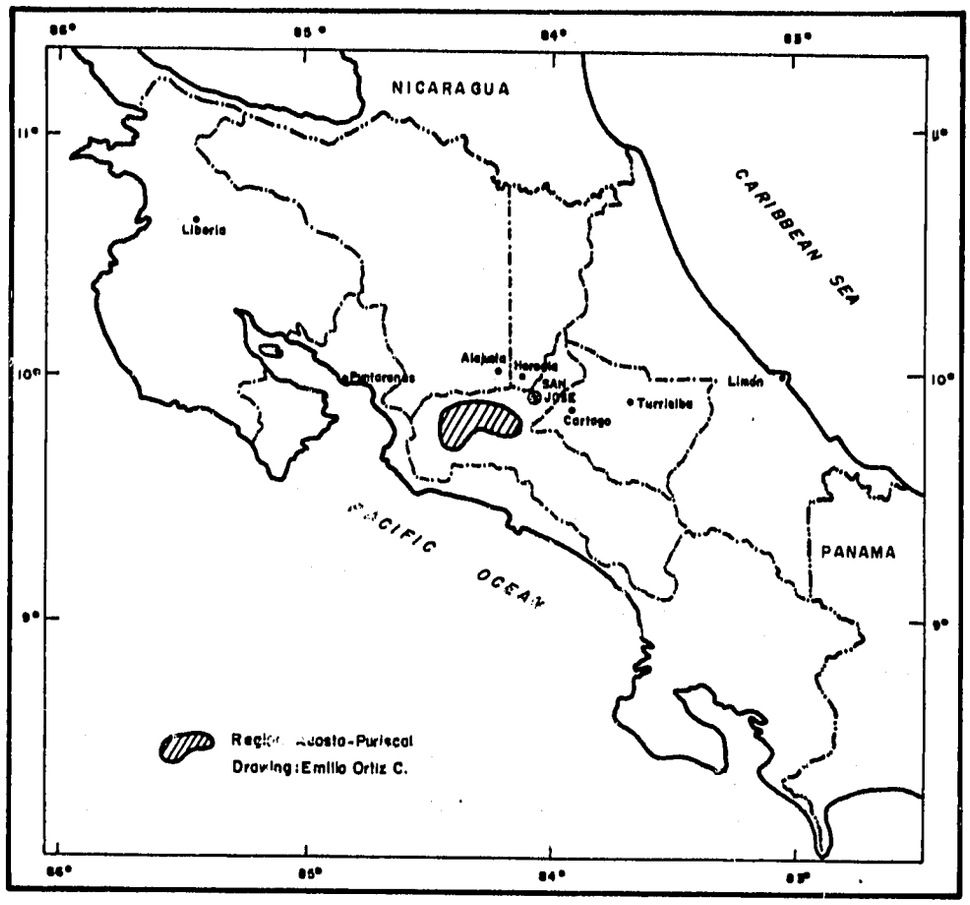
Map I General map of Costa Rica and project region



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2. METHODOLOGY

Johannes Lagemann[1]/

To obtain the long-run objectives "Development and Diffusion of Production Systems", the activities have been divided into different phases as can be seen in Fig. 1. The *Selection of the Project Region* (Acosta-Puriscal) was based on the following criteria:

- Population density and number of small farmers
- Living standards
- Area of national preference
- Accessibility
- Agricultural potential

The second phase of the project consisted of the *Description of the Project Region,* with emphasis on the physico-biological and socio-economic environment[2]/. During this period, a preliminary survey was conducted of 286 farmers of the region, selected at random and stratified according to topography which seems to be the most important factor in determining land use.

The *Farm Analysis* and the *Preliminary Testing of Innovations* were realized simultaneously during the third phase of the project. The data was collected in a survey of 69 farmers and from the use of technological test plots with these same farmers.

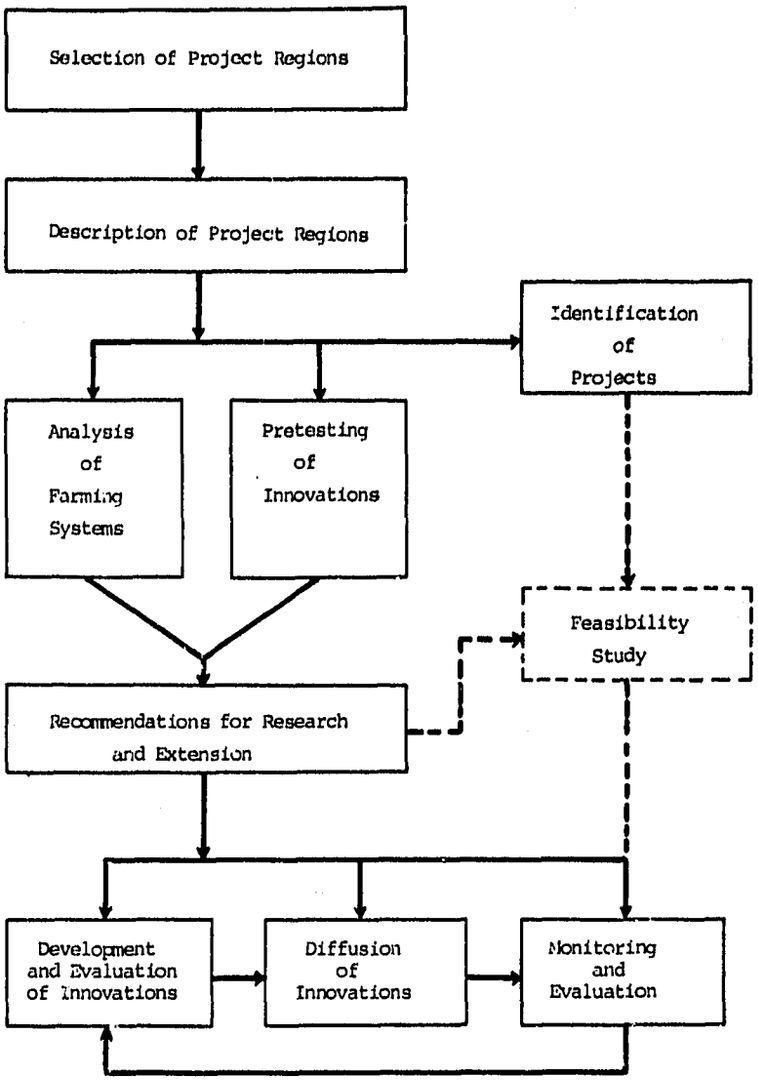
The farmers involved in the preliminary survey formed the population for the sample. The farms with less than 1 ha[3]/ and larger than 50 ha

1/ Agricultural Economist and Coordinator of the CATIE-GRZ Project Farming Systems.

2/ See: PLATEN, H. von and LAGEMANN, J: Agricultural production in Acosta-Puriscal, Costa Rica: Physico-biological aspects and socio-economic conditions. Technical Series No. 13, CATIE, Turrialba, 1981.

3/ After precise measurement, it was noted that some farms had less than 1 ha; these are included in the analysis.

Figure 1: Sequential Stages of the Farming Systems Project



were excluded before determining the sample of 75 farmers. During the year-long survey, the collaboration of 6 farmers was lost. One was excluded in the final analysis because of a lack of activity.

2.1 MULTI-VISIT SURVEY

2.1.1 Methods of information collection

During the year-long survey, three different methods were employed depending on the type of information required.

Direct observation: During the field work, the investigator lived in the study area to observe cultural mores, lifestyles, social customs, and to discuss with the farmers their reasons for various techniques, their objectives in agricultural production and the limits of that production as viewed by them. The observations facilitate the interpretation of the quantitative data and add (in our experience) to the relevance of studies of this type.

Survey: The majority of the collected data are of the type, "resource identification" and "inputs and outputs" of the various farm activities. Most of the questionnaires used[4]/ were precodified to facilitate review of the data and rapid analysis of all information. One part of the questionnaire examined opinions which required open answers, for example: "In your opinion, what were the principal reasons for low yields? ". In this case, there were no restrictions placed on possible replies, and therefore, analysis was more time-consuming.

Measurements: The critical data –in the sense of importance for analysis and problems the farmers encountered with memory of exact knowledge– such as size of plots, plant population density, topography, and yields were measured by the enumerators.

2.1.2 Survey intensity

After selecting the data collection methods, a decision was made regarding the intensity of information collection. The data was divided into the following groups:

a) **Data Collection with one visit**

- farm resources
- crop and cropping pattern
- crop rotation

4/ The questionnaires are available at CATIE for interested persons or institutions.

- financial liabilities
- farmers' opinions on constraints
- objectives of agricultural production
- investment preferences

b) **Data Collection with weekly visits**

- crop yields
- quantity and prices of used inputs
- labor and draft animals
- product sales
- general farm activities

c) **Data Collection with monthly visits**

- inputs and outputs of livestock
- activities and income outside the farm
- changes in inventory

2.1.3 Collection of different types of data

a) Field measurement

At the beginning of the survey and on initiation of planting, all fields and plot[5]/ were identified according to ownership, rental, or shared. Each field was assigned a number for reference, painted on a rock or tree. The investigators measured the fields using a metric tape and a compass and noted the data of distances and angles in a sketch of the field. The calculation of the surface was done using a modification of the program written by DIEHL[6]/, which can be applied using a hand calculator.

b) Crops and crop associations

Between two and four weeks after planting, a determination was made of crops, varieties, the form of planting, and the population density of the crops. To accomplish this, a randomly selected 100 m^2 area within each

5/ Field: a piece of cultivated land with one or various crops systems. Can consist of one or more plots.
Plot: a piece of land with homogeneous vegetation.

6/ DIEHL, L.: Computer and desk calculator programs to calculate plot areas from compass and tape, IITA, Ibadan, 1978.

field was selected and marked with four stakes[7]. Then all plants within the outlined area were counted.

c) Inputs and outputs in crop production

Information on labor use whether family, contracted, or shared was collected weekly for each field and differentiated according to the various activities. Obtained in the same manner was the data on quantity and value of inputs such as seeds, fertilizer, herbicides, etc. The estimate of production of annual crops was realized with measurement of the harvest from the 100 m^2 (see b) above) and by extrapolation of results for the remainder of the field. For perennial crops, principally coffee, citrus, and bananas and plantains, production estimates were made from data reported by the farmers themselves. The production of sugar cane is a special case. Cane is consumed and sold only in the form of unrefined brown sugar. The production data of cane in the field and of the processing of it into brown sugar was collected weekly and combined as one activity.

d) Inputs and outputs in livestock

The livestock component is an extensive activity compared with that of crops. For this reason, the data was collected monthly. Included was information on the purchase, sale, and consumption of animals. Also evaluated was labor dedicated to livestock, the purchased alimentation in the form of grain or concentrate, veterinary costs, and production in the form of milk, cheese, eggs or meat. The investigators also registered births and deaths of the different types of animals.

7/ The random selection was made in the following steps:

- measurement of the field's perimeter
- selection of the first number in the range 1 to the middle of the perimeter on a list of random numbers (to identify the point of entry into the field)
- selection of the first number of a list of random numbers in the range from 1 to the distance between the first point and the other side of the parcel
- measurement of this distance in meters from the border of the parcel to the interior. The center of the 100 m^2 was located at this point.

e) **Sale of products**

This information was listed by type of products and type of purchaser in order to identify the relative importance of the buyers (middlemen, cooperatives, etc.) for the different products. Included were the quantities sold, the prices received, the form of sale (harvested or in the field), the conditions of payment, and the transportation costs in cases of direct sale by the farmer.

2.1.4 Supervision of the survey

During the survey, the supervisor lived in the work area to train and motivate the five enumerators, to resolve problems that arose in completing the questionnaires, and to mediate in problems of cooperation between the enumerators and farmers. The questionnaires were checked weekly for incorrect coding, lack of data, and consistency of information (for example, the input "fertilizer" requires additionally, the input "labor" for its application). Also, from this check in the office, the supervisor controlled all the work realized in the field such as surveys, field measurement, and yields.

The data analysis by plot and by type of animal was executed simultaneously and permitted complete control over a lack of information, the execution of the principal activities in the field, and the quality of the data. Information falling outside "the normal" could be returned for reevaluation immediately.

2.1.5 Estimation of man-equivalents

At the beginning of the study, information on available labor for farm work was collected.

In the calculation of available labor in man-equivalents, the farmer was included with the value 1, less the time spent in work outside the farm, and men between 15 and 60 years who worked principally on the farm also received the value 1.

To compare labor used in the fields or for animals, values of man-equivalents were assigned to each class of labor, as can be seen in Table 1. Children between the ages of 10 and 14 years and the elderly (more than 60 years), have the value 0.5 signifying the supposition that they can execute one-half the labor of an adult. Women are assigned the same value as the men because they participate only in the coffee harvest and minor tasks relating to the upkeep of livestock, and it is assumed that they accomplish these jobs with the same efficiency as a man.

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Table 1: Man-equivalents used to calculate labor utilization in the fields and on the whole farm.

Class of labor	Age	Man-Equivalents
Children	10-14	0.5
Men	15-60	1.0
Women	15-60	1.0
Men	> 60	0.5
Women	> 60	0.5

2.1.6 Processing and analysis of data

The processing and basic analysis (analysis by plot, type of livestock, and by farm) was executed using the program developed by FRIEDRICH[8]/ after adaptation to the utilized questionnaires. The results of this basic analysis were later entered in a data file for sorting according to areas and activities and for further analysis with a statistical package (SAS).

Data processing began three months after the survey's initiation in order to check the collected data and to allow a first analysis at the end of the first planting.

For the principal parameters, average, variance, and distribution were calculated. This gave a first impression of variability and extreme values. The differences between averages and distributions were subjected to the t-test (in the case of 2 classes) or the F-test and the chi-square-test respectively.

To calculate the averages, the arithmetic formula was employed. Consequently, the values of small and large fields received the same weight in the calculation, and the labor and other input values are in comparison to the weighted average– usually higher. Nevertheless, the values of the arithmetic mean seem more adequate because the majority of farmers have small plots.

With the accumulative frequency, estimates can be made of the probability of receiving a production or net income higher or lower than a

8/ FRIEDRICH, K. H.: Farm Management Data Collection and Analysis System, FAO, Rome, 1977.

given selected level. This calculation serves, for example, to identify activities that have a strong probability of producing a high net income[9]/.

The next step was the calculation of the partial budget for the principal farm activities. The gross margin per hectare or per man-day were two criteria used to compare the efficiency between activities.

In a comparative analysis, estimates were made between the economic efficiency of the parcels with and without fertilizer and between two different methods of land preparation. Additionally, a comparison was made between the best and the worst quartile in all farm enterprises. This analysis served as a first method for identifying limits on agricultural production.

The analysis of the whole-farm budget includes the gross margin, net farm income, and the calculation of economic efficiency indicators. This analysis was complemented by a cash-flow budget during one year.

For the various farm activities, regression models were used to attempt to explain the differences observed in yields and to estimate the relative importance of different factors which influence yields. However, the results of this survey, as in others[10]/ demonstrate that a high percentage of observed variance cannot be explained. The effect of uncontrollable factors (climate, soil, insects, etc.) seems to be great.

2.2 PRELIMINARY TEST OF INNOVATIONS

The first technology test was executed simultaneously with the phase "analysis of farming systems". In the previous phase an environmental description of the work area was made. This information together with the results obtained through experiments done by national institutions in the same or similar areas served as a base from which to identify components of the technological packages. After designing the packages with technicians having knowledge of the area, they were discussed in meetings with the farmers who participated in the testing in order to include their experiences in the crop management and to motivate them by this collaborative process. In this way, the farmers formed an active element of the working group.

9/ FLINN, J. C.: Opportunities for economic analysis of component technology at field sites, In: Proceeding of the Workshop on the Economics of Cropping Systems, Manila, 1980.

10/ DIEHL, L.: Small holder Farming Systems with yam in the southern Guinea Savannanh of Nigeria, Ph.D. Thesis, University of Hohenheim, 1981.
NORMAN, D. W.: Economic Analysis of Agricultural Production and Labor Utilization among the Haussa in the North of Nigeria, African Rural Employment Paper No. 4, East Lansing, Michigan, 1973.

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The farmer participants were the same ones who collaborated in the multivisit survey. This permits a direct comparison of the "Recommended Technology" with the "Farmers' Technology". With the objective of giving an incentive to the farmers for collaborating with the survey, inputs necessary for the testing of the technological packages were provided to them.

2.2.1 Execution of the preliminary test of innovations

The farmers selected the fields for planting and later divided these in two parts: one of 1000 m^2 was utilized for the "Recommended Technology" and the other for the "Farmers' Technology". The surveyors assisted in establishing these fields to assure that the components of the package were correctly applied; but the execution of all activities was accomplished by the farmers. Data collection (varieties, plant density, type of planting, labor, inputs, yields, insect attack, etc.)[11] was done weekly by the surveyors who visited the fields with the farmers. All special events were reported to the project agronomist who lived in the area, and could, therefore, monitor the parcels in the field on a bi-weekly basis.

In order to identify those factors influencing yield, soil samples were taken from all fields and precipitation data from each area was summarized.

Harvesting was done with the farmers, and their opinions sought about yields and components of the technological package.

2.2.2 Evaluation of the technological packages

The packages were designed with the supposition that their adoption is possible with available resources in the area[12], and the adoption does not necessarily provokes a significant change in farm management. Therefore, the evaluation concentrated on a direct comparison between the recommended and traditional technologies. However, the analysis of the different agricultural enterprises reveals that the variation in productivity is great. Consequently, the conclusions regarding the possible degree of adoption of the packages, with grains, for example, can be drawn only after a comparison with the other alternatives available in the specified areas.

The evaluation of the recommended technologies was done on the basis of agro-economic aspects and incorporated the opinion of the farmers

11) For further information, see: CATIE: Questionnaires utilized in the CATIE-GTZ Project "Farming systems in Central America, CATIE, Turrialba, 1982.

12/ This includes the availability of credit in the areas.

with respect to technological packages. The first analysis consisted of a comparison between plant density, insect attack, disease, weeds, labor utilized, and the yields of all crops in Kg/ha. To compare averages between the two technologies, the t-test was employed. One important criterion for the package was the variation in obtained yields. The relative importance of the yield-influencing factors was estimated with regression models.

Calculation of the gross margin (gross income less cash costs) was the first stage in the economic calculations. To compare the technologies, the following statistics were used: arithmetic mean, mode, and variation coefficient. Another evaluation criterion was the productivity of the resources with limits at the level of the small farms. Beside taking into account all utilized resources, an analysis of productivity for labor in a specified time period was done, because the limiting factor could be the required resource in a critical period rather than of the total period[13]/.

To estimate risk, the concept of "stochastic dominance" was used; that is the recommended technology must demonstrate a probability of receiving a higher gross margin at all levels[14]/. Estimation of risk was based on only one year. As a result, the conclusions are limited because climatic risk, one of the most important, cannot be evaluated in a single year.

With regard to the economic evaluation, the impression of the farmers with respect to the tested technology played an important role in the final evaluation. The inclusion of farmers' opinions placed more light on the aspects of management of the recommended packages.

13/ FLINN, J. C.: Opportunities for economic analysis of component technology at field sites, In: proceedings of the Workshop on the Economics of Cropping Systems, Manila, 1980.

14/ ANDERSON, J. R.: Sparce data, estimational realibility, and risk efficient decisions, In: American Journal of Agricultural Economics, 56:564-572, 1974.

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3. STUDY REGION[1]/

Henning von Platen[2]/

3.1 PHYSICO-BIOLOGICAL ENVIRONMENT

3.1.1 Location and climate

The study region is located in the central highlands on the southeast slope of the mountains forming the southern limit of Costa Rica's, Central Valley.

As part of the warmer areas, it includes vegetable life zones ranging from the moist tropical forest to pre-montane rain forest, with altitudes from 800 meters to 1200 meters asl[3]/.

The project region was stratified into two areas which differ mainly in topography (slopes are steeper in the Acosta area) and consequently in land use.

Annual rainfall ranges from 1,300 mm to 3,400 in Acosta with an average of 2,300 mm. In Puriscal, the range is from 1,600 mm to 3,500 mm annually with an average of 2,100 mm[4]/. The rainy season in the two areas begins in May and runs until November (Acosta) and December (Puriscal) with about 90% of the year's total falling during this time.

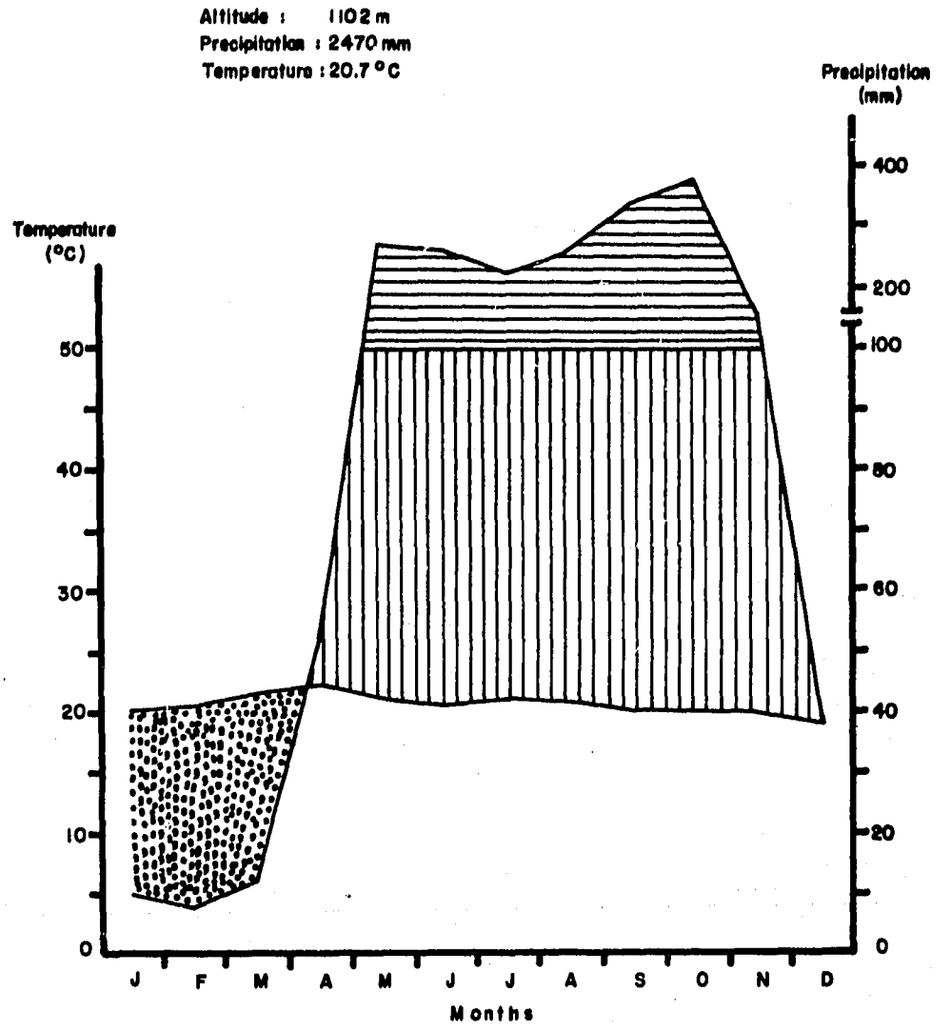
1/ Detailed information can be found in: PLATEN, von, H. y LAGEMANN, J. Op cit.

2/ Agricultural Economist of CATIE–GTZ project: Farming Systems in Central America.

3/ Classification following HOLDRIDGE, L. R.: Life Zone Ecology, rev. Ed., Tropical Science Center, San José, 1957.

4/ INSTITUTO METEOROLOGICO NACIONAL. Datos pluviométricos de Puriscal (1940-1973) y Acosta (1950-1978). Sin lugar y fecha. And: HARGREAVES, G. Tables showing Climate and Potential Evapotranspiration for Central America and Panama. Working Paper 76-E166, Utah State University, 1976.

Fig. 2 Climate of Puriscal



Source: Instituto Meteorológico Nacional op. cit. p344

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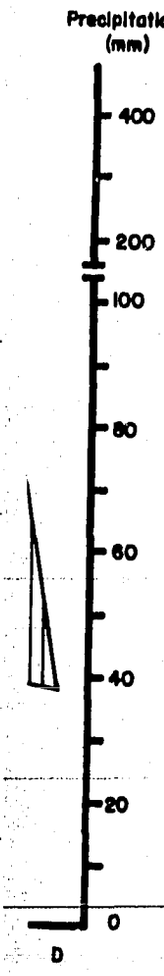
Temperatures vary between monthly averages of 19.6°C to 22.4°C. The minimum monthly average of Puriscal was measured at 14°C during June and December; the maximum average was 27.7°C[5]/.

Figure 2 shows the excesses and shortages of water during the course of the year as a function of rainfall and temperature. The excess of water is largely lost in surface run-off to the rivers.



3.1.2 Topography and soils

The topography of the area is very rough with "moderate" slopes from 30% to very steep inclines of more than 80%; a few locations in Puriscal are more or less flat. All of Acosta is extremely sloping. Soils of the types ultisols, oxisols, and in few places, inceptisols are characteristic of tropical soils, that is, poor in minerals, clayey and with low phosphorus and nitrogen content. They are generally acidic (pH from 5 to 6)[6]/.

The soil type and the topography favors erosion, particularly on the exposed bare land during strong rains. This is the case in the first cropping season for annual crops (April) as well as during the second (October) when the quantity of the rain reaches its maximum.

3.2 SOCIO-ECONOMIC ENVIRONMENT[7]/

The two urban centers —San Ignacio de Acosta with approximately 1000 inhabitants and Santiago de Puriscal with approximately 2,500— are the centers of the area for socio-economic and socio-cultural activities. The Costa Rica capital is less than one hour away by car or bus.

Population density, with approximately 100 persons per Km^2 in Acosta and 77 per Km^2 in Puriscal, is high when compared to the approximately 42 inhab/Km^2 for Costa Rica as a whole[8]/. Comparing the population growth in Acosta (2.25% per annum) and Puriscal (2.12% per annum)

5/ INSTITUTO METEOROLOGICO NACIONAL. Op. cit.; different years. No data for Acosta.

6/ Compare: DIAZ-ROMEU. Evaluación Preliminar de la Fertilidad de Suelos. In: PLATEN, H. von y LAGEMANN, J. op. cit. p. 11-16. See also WEISCHET, W., Die oekologische Benachteiligung der Tropen. 2. Aufl., Stuttgart, 1980, p. 18 ff.

7/ See also PLATEN, H. von; p. 24 ff. In: PLATEN, h. von and LAGEMANN, J. op. cit.

8/ 1978: INSTITUTO DE FOMENTO Y ASESORIA MUNICIPAL (IFAM); Cantones de Costa Rica, San José, 1980.

with that of Costa Rica's average (2.58% per annum)[9], a negative migration is noted. The high population density means a dense net of roads and trails, electrical supply and potable water as well as institutions such as schools and health services distributed throughout the region. Besides this, the migration to the capital city, as well as to other rural areas of the country[10], and the number of people who travel daily to jobs in the capital indicate that the area is not sufficiently attractive or does not support the population it currently claims.

3.3 HISTORICAL DEVELOPMENT[11]

The Puriscal area and parts of Tabarcia were populated in the pre-Colombian era by indigeneous groups. They farmed (maize, tubers, pejibaye), but it is not known in what form. The Acosta area (except for Tabarcia) was unpopulated and almost the entire area of Puriscal was covered with forests.

About 100 years ago, colonization began in Acosta; 25 years before that in Puriscal. The colonialists left the Central Valley because of population pressure and because of the extension of coffee cultivation which left little space for the planting of annual crops.

In Acosta as in Puriscal, they planted principally maize and beans to feed themselves.

Although they came from a different zone (less mountainous) and in spite of the fact that they brought their own knowledge of agriculture to a zone of very broken terrain, the farmers, at least to the north of the Puriscal area, attained such a high production that they were able to supply the Central Valley even with its dense population. Later, the cutting of trees and

9/ DIRECCION GENERAL DE ESTADISTICA Y CENSOS, Ministerio de Economía, Industria y Comercio. Censo de población de 1973, Tomo 1, San José, 1974, and: INSTITUTO DE FOMENTO Y ASESORIA MUNICIPAL (IFAM); Cantones de Costa Rica, San José, 1980. Various pages.

10/ Particularly in San Isidro de El General and Guápiles.

11/ Literature cited in this section: BONILLA, D. A.: Municipalidad de Puriscal. Monografía del Cantón. 1976. p. 13 ff; SANDNER, G.: La colonización agrícola de Costa Rica. Vol. 1. San José, Costa Rica, 1962, p. 23, 53 ff.; SANDNER, G.: Turrubares. San José, Costa Rica, 1960. p. 49 ff.; THRUPP, L. A.: Deforestation, Agricultural Development and Cattle Expansion in Costa Rica. Honors Thesis, Stanford University, 1980.

repeated burning impoverished the soil. In Puriscal, a new movement started into the south and southeast of the area. Two stages, in Puriscal, preceding the current situation can be clearly defined:

–The easy access to the San José markets generated a specialization in maize, beans, and to some extent, sugar cane. At the same time, in the south, much land was converted to pasture, and many small colonies abandoned the zone and moved to the south, leaving their lands to much larger farms.

–Between 1930 and 1940, the cultivation of tobacco (small farms) and coffee (medium and large farms or those with good capital) was initiated[12]/.

The raising of livestock was greatly developed in the area backed up by protectionist laws.

The extent of historical development in Acosta is unknown. From the beginning, agricultural production was done, above all, for subsistence. Only with coffee was there an important cash crop which brought periods of high income. In Acosta, due to the more broken terrain than in Puriscal, the penetration of cattle was impeded, although in some places in the west of Acosta, this development today seems equivalent to the south of Purical.

In both areas, migration still plays an important role. First, there were areas of immigration and later "transient colonies". Currently, the situation is one of negative migration. Numbers from the Instituto de Fomento y Asesoría Municipal seem to be high (1978: 14.5% in Acosta and 19% in Puriscal[13]/ but do give an impression of the considerable movement outside the region.

12/ Today the situation is different. There is no relation between size of farms and coffee.

13/ INSTITUTO DE FOMENTO Y ASESORIA MUNICIPAL (IFAM); Cantones de Costa Rica, San José, 1980, p. 36 and PLATEN, H. von and LAGEMANN, J. (Eds.). La producción agrícola en Acosta-Puriscal, Costa Rica. Aspectos físico-biológicos y condiciones socio-económicas. Serie Técnica, No. 13, CATIE, Turrialba, 1981. Calculation: Migration %= immigrants-emigrants x 100.

4. CHARACTERISTICS OF THE FARMING SYSTEMS

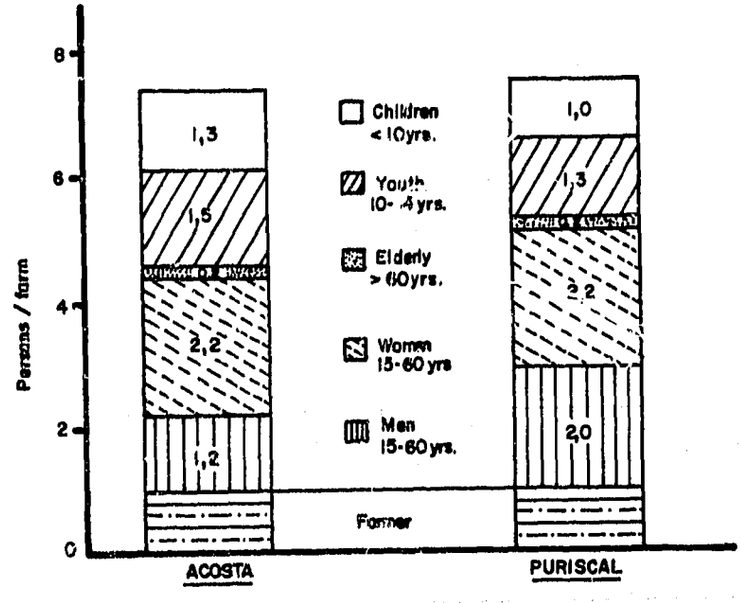
Henning von Platen[1]/

4.1 RESOURCES

4.1.1 Human resources

Family structure: Family members are considered to be all persons related to the farmer and residing on the farm. The average is 7.4 people in Acosta and 7.6 in Puriscal (Figure 3).

Fig. 3 Family structure. Average of persons per farm



1/ Agricultural Economist of the CATIE-GTZ project, Farming Systems in Central America.

The average number of women on a farm are the same for Acosta and Puriscal, but in Puriscal there are many more men and fewer children and youths. This signifies that the relationship between dependents and those who work is better in Puriscal –as important for alimentation as for other expenses (almost all children attend school).

The farmer: The responsibility and decisions on the farm normally fall on the farmer or head of the family (two farms in the area are managed by women).

The average age of the farmers (women included) is almost 51 years in Acosta and 48 years in Puriscal, with a variation from 26 to 79 years. (Figure 4).

The average age is relatively high. Two explanations for this are evident: the farmers turn the land over to their heirs very late, usually at death; and high levels of health raise the average age of the heads of the farms.

Almost all of the farmers have worked in agriculture all their lives, except for the time they were in school.

The average education level is 2.9 years in Acosta and 3.1 years in Puriscal. As might be expected, a relation can be observed between the age of the farmer and his education level. (Figure 5).

68% of the farmers in Acosta and 32% in Puriscal do not work only on their own farms, but also on others. This is very important, particularly on the various farms in Acosta, which can be considered part-time farms. On the Acosta farms, the average workdays outside the farm are 92[2]/, in Puriscal 27 days/year.

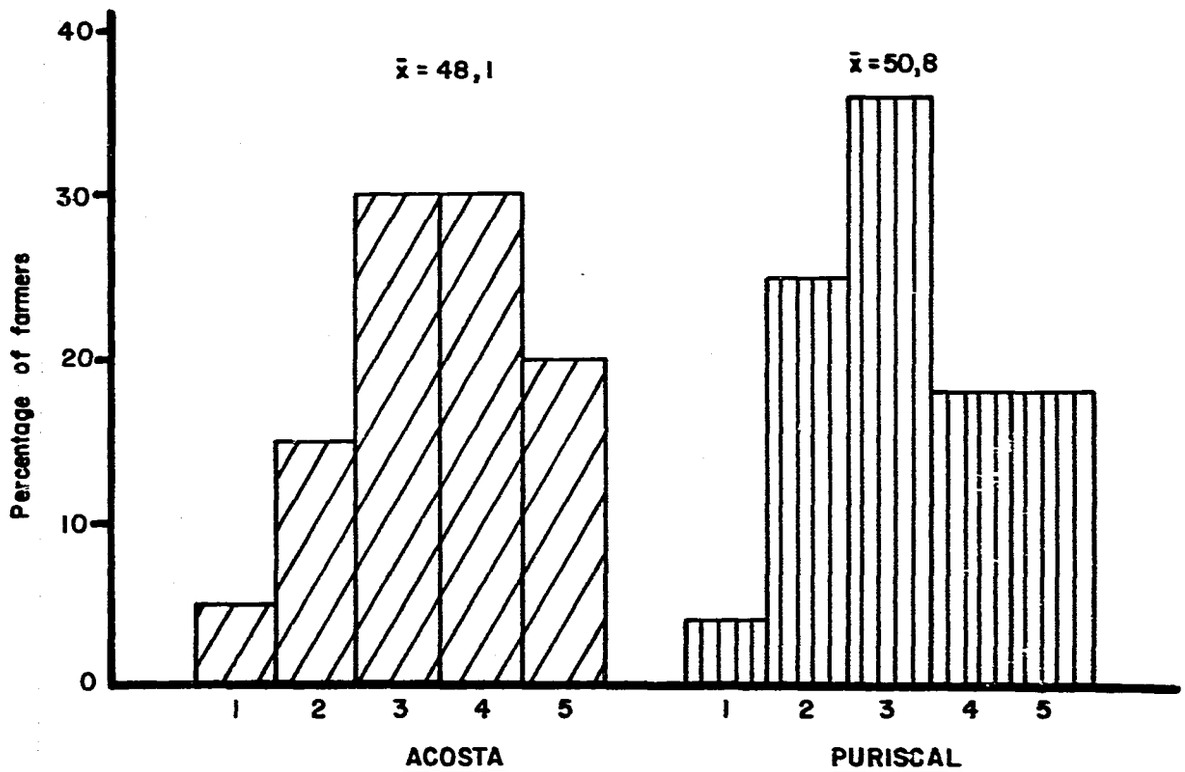
Labor: In addition to the farmer, other family members also work on the farm as well as outside. The farmer, particularly in Acosta, to provide additional income. Commonly, work in the fields is divided between the farmers and his sons. Women are responsible for the care of the small animals and the milking chores. The entire family works in the fields only during the coffee harvest and the sorting of tobacco.

In order to have an idea of the labor force in the farms, "man-equivalents" have been calculated. This is all males between 15 and 60 years who work permanently on the farm less the time that they spend in outside work[3]/. The result is 1.4 and 2.4 men-equivalents for Acosta and Puriscal respectively, or one person more per farm in Puriscal.

2/ This includes the entire family, although the majority corresponds to the farmer.

3/ The time that the farmer spends away from the farm was specifically inquired about, thus determining his on-farm work time. 25 work days per month were considered as the basic month's work

Fig. 4 Age structure of the farmers



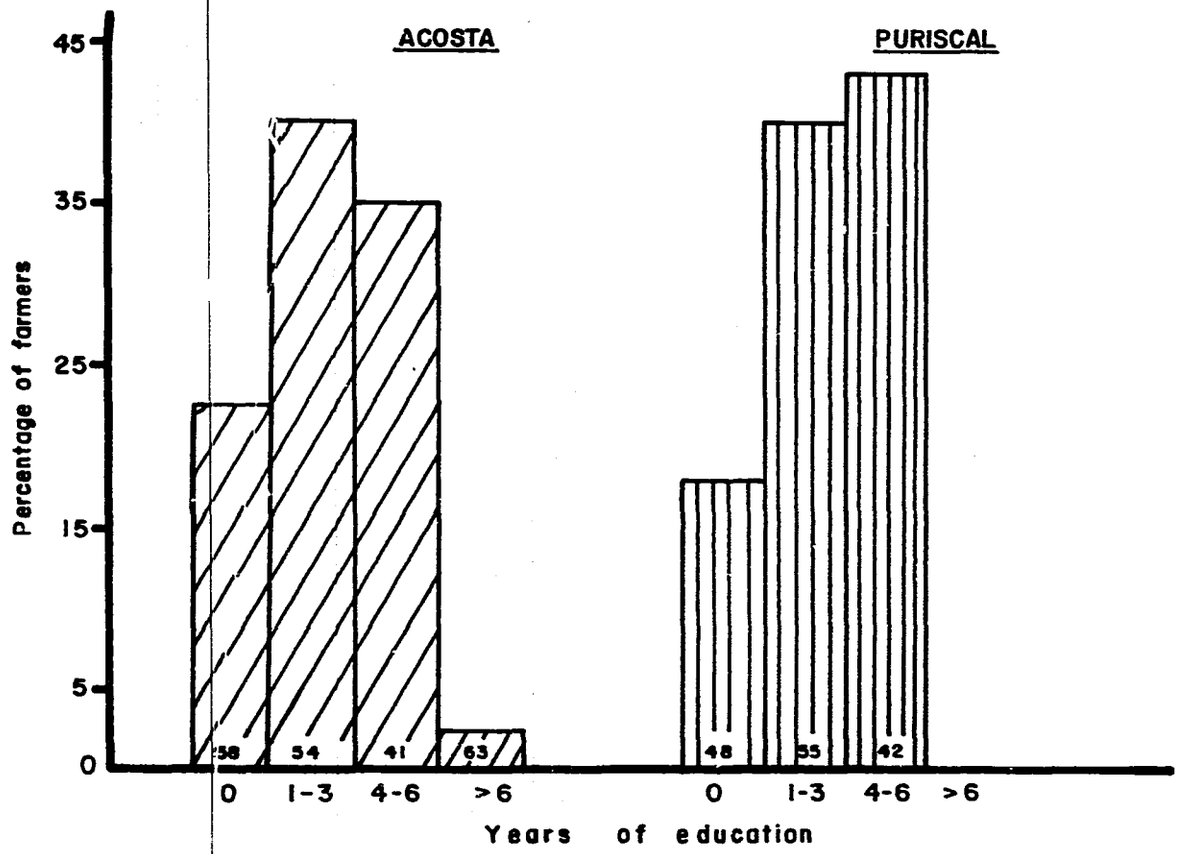
Classes: 1 =< 31 yrs.; 2 = 31-40; 3 = 41-50; 4 = 51-60; 5 = >60 yrs.

Fig. 5 Education structure of the farmers. (The numbers in the bars indicate the average age per class)

ACOSTA PURISCAL

Classes: 1=< 31 yrs.; 2=31-40; 3=41-50; 4=51-60; 5=>60 yrs.

Fig. 5 Education structure of the farmers. (The numbers in the bars indicate the average age per class)



Hired labor: Additional labor is contracted throughout the year, principally during the coffee harvest, and in Puriscal also during the tobacco harvest (See Section 4.5).

There are four classes of hired labor:

- Cooperative labor in which normally none of those involved receive a salary but as compensation, the farmer or a member of the family repays in labor according to the needs of their neighbors.
- Contracted by job in which payment is made by supplying labor for specific tasks (cleaning, harvesting, etc.).
- Labor paid by hour or by day.
- Permanent labor.

The majority of contracted labor on the farms is included in the first and second items above. Those who do this work are frequently farmers from the same area. Labor from outside the area is hired only during the coffee harvest, although many farmers lament the difficulty in hiring workers during the rest of the year. Assumedly, part of the problem is the low salary levels.

There are permanent employees on only two farms in Acosta.

4.1.2 Land

The survey farmers of Acosta and Puriscal own an average of 4.1 and 11.1 hectares of farm land respectively. They increase this with land rental[4]/ particularly for annual crops, and reach an average of 4.5 ha of managed land in Acosta and 11.7 ha in Puriscal.

The low rate of rented land (9.8% in Acosta and 5.4% in Puriscal) is due, on one hand, to the difficulties in acquiring land appropriate for use, principally for annual crops, and on the other, to the limited availability of labor (family or other) in Puriscal which is limited as described in Section 4.5.

Of managed land (which is the base of the calculations of the following sections) almost one-half are pastures in Acosta, and three-fourths in Puriscal which is due to some farmers in the south of this latter area having up to 30 ha in pasture. Land distribution in Puriscal (see Table 2) is reflected with 43% of the farmers having more than 19 ha, or 85% of the total land area. In Acosta, half of the farmers possess 2.99 or less hectares with most of the land (35.8%) falling into the class of 7-9.99 ha (See Table 2).

4/ Rented land, share-cropped land and loaned without payment.

Table 2: Distrib

CLASS
0-2.99 ha
3-4.99 ha
5-6.99 ha
7-9.99 ha
≥10 ha
TOTAL

a) One observation.

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Table 2: Distribution of managed land by classes

CLASS	ACOSTA Percentage of farms	ACOSTA Percentage of land	ACOSTA Average ha of class	PURISCAL Percentage of farms	PURISCAL Percentage of land	PURISCAL Average ha of class
0-2.99 ha	50.0	15.4	1.4	28,6	3,0	1.3
3-4.99 ha	15.0	13.3	4.0	17.9	6.0	4.0
5-6.99 ha	5.0	7.0	6.3	7.1	3.3	5.5
7-9.99 ha	20.0	35.8	8.0	3,6	2,3	7.7[a)]
>10 ha	10.0	28.5	12.8	42.8	85.4	23.4
TOTAL	100.0	100.0	4.5	100.0	100.0	11.7

a) One observation.

Comparing these numbers with those of the preliminary survey[5]/, the land surface areas per farm are higher in the former (Acosta = 7.2 ha, Puriscal = 13.3 ha). The reason for this lies in the selection of the farms for the multi-visit survey where very large or very small farms were not taken into account. Nevertheless, there are farmers included in the survey who are below the designated range (1-50 ha). These were discovered only when precise measurements were done.

The analysis of land tenure by size classes demonstrates that:

- More non-owned land is cultivated on the small farms. The larger amount of owned land a farm has, the less land it must rent.
- The percentage of non-owned land is, in general, a little higher in Acosta than in Puriscal (6.6 and 5.3 percent) but this figure is higher for the small farms of Puriscal up to two hectares (55.1%) than in Acosta (26.9%).

5/ Effected to obtain an impression of the region prior to the multi-visit survey. See data in: PLATEN, H. von and LAGEMANN, J., op. cit.

Table 3: Percentages of lands according to size classes and types of tenure

CLASSES	ACOSTA				PURISCAL			
	Tenure				Tenure			
	owned	rented	share-cropping	loaned	owned	rented	share-cropping	loaned
0-1.99	73.1	20.1	0.7	6.1	44.9	31.8	0.0	23.3
2-3.99	87.1	10.1	0.0	2.8	80.9	11.1	0.0	7.9
4-9.99	93.3	6.7	0.0	0.0	80.4	13.6	0.0	0.0
≥10	100.0	0.0	0.0	0.0	97.5	0.7	1.6	0.1
TOTAL	97.4	6.5	0.1	1.0	94.7	3.0	1.4	1.0

The conclusion is that land is a more limited factor in Acosta than in Puriscal. This is supported by the high percentage of loaned land, that is rented without charge on farms of less than 4 hectares in Puriscal, and also by the high degree of work done outside the farms in Acosta (which represents a surplus of time and a lack of land), or a higher value for work outside the farm than for work within the farm.

The last point of this section is the internal infrastructure of the farms, which is the division of the enterprises (quantity of fields per farm and average size of fields) and the distance between the farmer's house and the fields. It is evident that the annual crop plots are (statistically significant at a one percent level) further from the house than those planted with perennials (Fig. 6).

An analysis of the division of farms is almost identical between Acosta and Puriscal with 4.7 and 4.6 plots[6]/ per farm respectively with variation coefficients of 39% and 45%. Three explanations of this division are apparent, taking into consideration that 42% of the farmers have more than one plot of the same crop:

- The risk distribution (climate, soils, pests and diseases) from one to various locations.

6/ A plot is a piece of land defined by its location and its producing system. Two different plots of coffee of different varieties or ages are referred to although they are the same.

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Fig. 6 Distc
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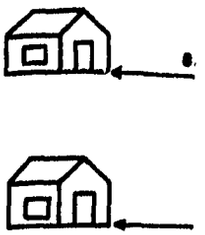
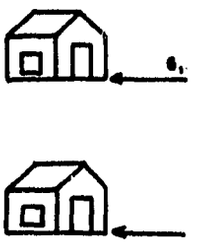
ACOSTA



PURISCAL



4.1.3 Capital

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- Perennial
- Livestoc
- Tools an

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hare-pping	loaned
0.0	23.3
0.0	7.9
0.0	0.0
1.6	0.1
1.4	1.0

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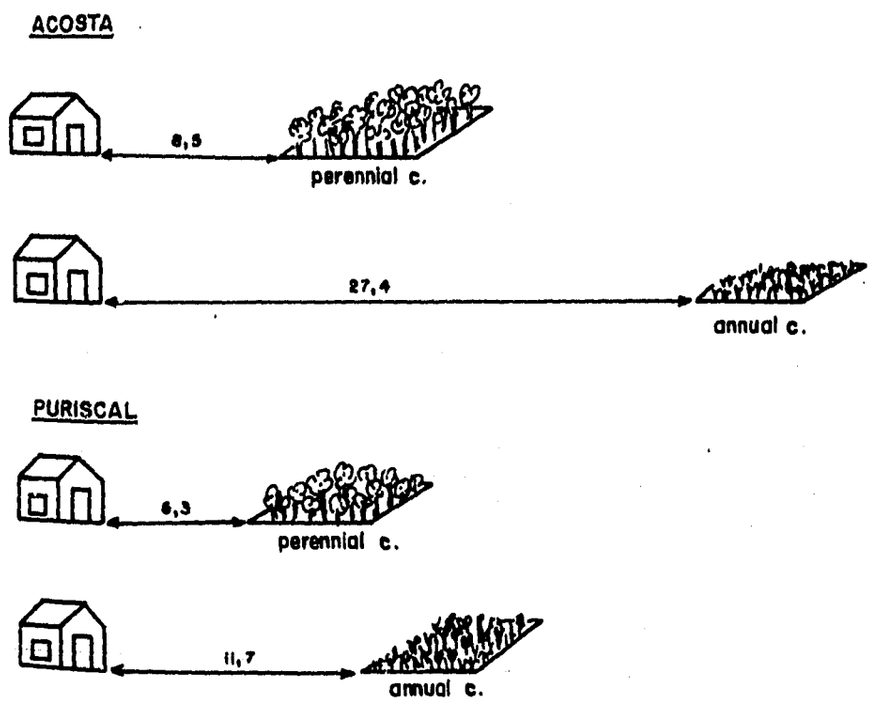
- The estate of the farms and the possible division of fields between heirs.
- The partial renovation (in the case of perennials, that is, coffee) of a field.

Fig. 6 Distances between houses and fields. (Minutes by foot, averages)



4.1.3 Capital

As farm capital or invested capital, there are the following:

- Fences
- Perennial crops
- Livestock
- Tools and machines

The initial value[7]/ on the farms is ₡ 35,970 per farm in Acosta and ₡ 71,255 in Puriscal, or more than twice that for Acosta.

Table 4: Farm capital initial value, changes and final value in colones).

	ACOSTA	PURISCAL
Initial value	34,775	76,842
Incoming value	3,601	5,735
Outgoing value	1,780	9,392
Depreciation	662	1,930
Final value	35,970	71,255

While there was a small increase of the total capital on the farms of Acosta during the year (3.4%) there was a decrease in Puriscal of 7.3% due principally to the sale of cattle which contribute the majority of the high initial capital value in that area.

The analysis of the capital structure (Fig. 7) demonstrates that in Acosta, livestock represents one-third, equal to tools and machinery which have a high average value due to the inclusion of some pick-ups. Perennial crops constitute one-fourth of the value.

The structure is different in Puriscal because livestock represents one-half of the total capital value. Tools and machinery (also including some vehicles) constitutes one-fourth, and perennial crops, one-fifth.

Figure 8 is instructive, demonstrating the distribution of capital. For Acosta, as for Puriscal, the higher frequency (50% and 43%) is encountered in the lowest classification to a capital sum of ₡ 20,000. 7.5% of the Acosta farms and 32% of those in Puriscal have a capital base of ₡ 100,000 or more, due to vehicles and cattle.

The origin of capital is found principally within the farms since outside financing in these areas is not usually significant. In Acosta only 16%, and in Puriscal only 3% of this capital is financed through credit.

Regarding in more detail the data on capital, the great importance of cattle in the category "livestock" can be noted (Table 5). This is truer in Puriscal than for those farms with cattle in Acosta.

Fig. 7 Structure of initial and final capital value. (Numbers in per cents)

7/ See calculation in the Glossary.

1 Acosta and colones).

PURISCAL
76,842
5,735
9,392
1,930
71,255

the farms of of 7.3% due of the high ates that in nery which s. Perennial

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Fig. 7 Structure of initial and final capital value. (Numbers in per cents)

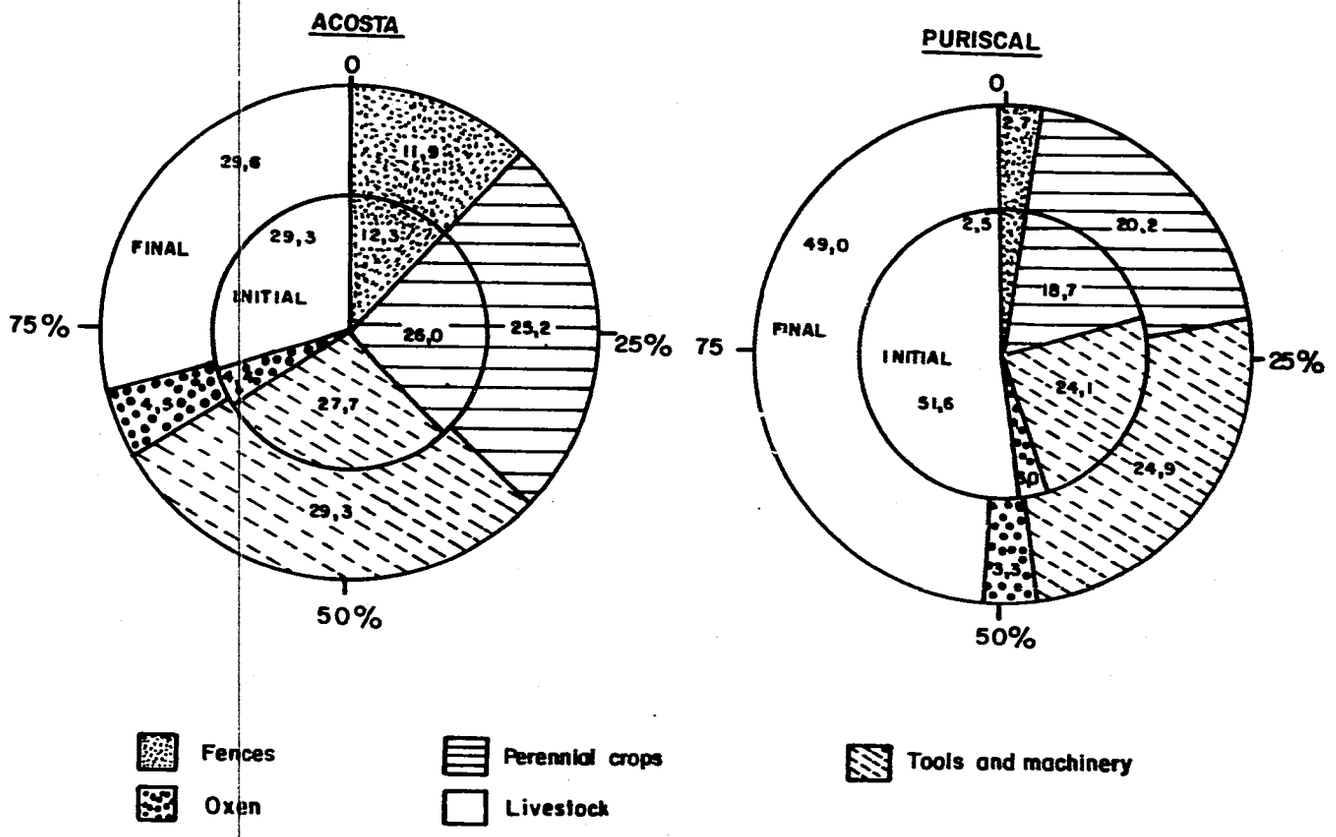
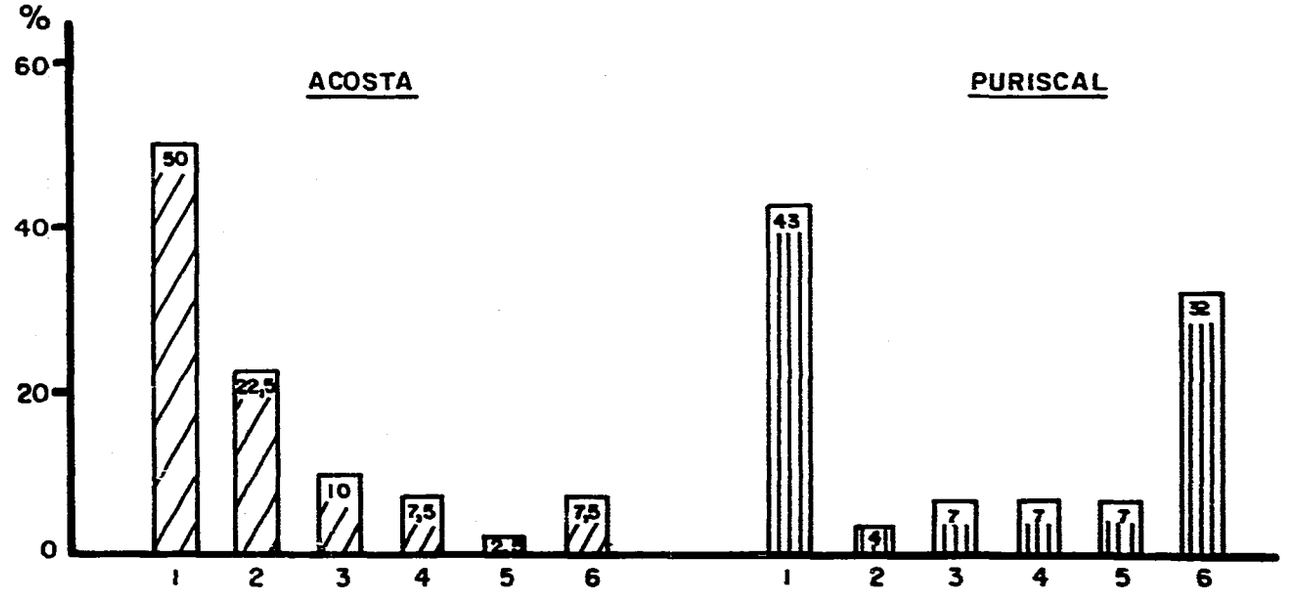


Fig. 8 Capital distribution (initial value) Percentages of farms by classes



Classes :

1 = 0 - 20.000
2 = 20.001 - 40.000
3 = 40.001 - 60.000
4 = 60.001 - 80.000
5 = 80.001 - 100.000
6 = more than 100.000 $

Table 5:

Cattle
Pigs
Chickens
Horses
Oxen

Total valu

a) One far lowers t
b) Includes

Table 6:

Vehicles
Sugar mill
Irrigation
Tools and

a) Averag
b) Of the
c) Plough

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total val

Table 5: Value of livestock (number of farms, average number and value of livestock)

	ACOSTA			PURISCAL		
	n	$\bar{x}$	value	n	$\bar{x}$	value
Cattle	22	4.8	15,550	18	15.6	57,428
Pigs	15	2.4	1,520	3	1,7	1,267
Chickens	36	28.4[a)]	832	16	22.8	910
Horses	4	1.3	2,750	10	1.9	4,850
Oxen	5	2.0	12,400	6	2.0	10,833
Total value, all farms	40	–	11,696	28	–	41,877[a)]

a) One farmer had 150 birds which were sold during the surveyed year. Without this, the average lowers to 24 animals per farm.
b) Included is the value of one farmer's 14 beehives.

Table 6: Value of tools and machinery.

	ACOSTA			PURISCAL		
	n	$\bar{x}$	%[b)]	n	$\bar{x}$	%[b)]
Vehicles	5	46,055	59.8	6	47,000	54.3
Sugar mills	7	8,656	15.6	7	4,509	6.1
Irrigation equipment	–	–	–	2	21,702	8.4
Tools and others[c)]	40	2,367	24.6	28	5,803	31.3

a) Average of farms having these
b) Of the total aggregate value
c) Ploughs, fumigators, powersaws, etc.

The high value of the tools and machinery category is due principally to vehicles which possess a 60% portion (Acosta) and 54% (Puriscal) of the total value of this category.

4.1.4 Conclusions

In Acosta, land availability is more limited compared to Puriscal. Especially farms with less than 3 ha in Acosta regard land scarcity as the main limiting factor whereas labor availability seems to be the major constraint on the other farms[8]/. The same occurs in Puriscal, but land does not seem to be a restriction. Capital is encountered in both areas. Consequently:

- An increase in production through extension to new land fails to occur because of limited labor availability in general, and the shortage of suitable land in parts of Acosta.
- Intensified production seems a promising route since the base for this exists in the form of capital and farmer's skills. Above all, an intensified coffee production with replanting and improved husbandry practices in addition to an intensified use of the area now devoted to pastures could augment production and therefore, income, considerably as can be seen in the next sections.

On the whole there exists a base for improvements and the possibility of benefiting principally from improved technologies.

4.2 LAND USE

4.2.1 Farm size and land use according to the preliminary and multi-visit surveys

In the multi-visit survey, only small farmers were considered (See Section 4.1.2).

It is to be expected that there would be a difference in farm size and land use between the two surveys.

Figure 9 demonstrates the land distribution according to the data from both surveys. The average farm size is higher in the preliminary survey (9.5 and 7.5). Nevertheless, the distributions are similar.

Generally, land use is defined by six crops: coffee and tobacco (only in Puriscal) as cash crops; maize and beans for subsistence; sugar cane and pastures which can represent cash crops (sugar and cattle) depending on their use on the farm.

8/ Compared Section 4.5.2.

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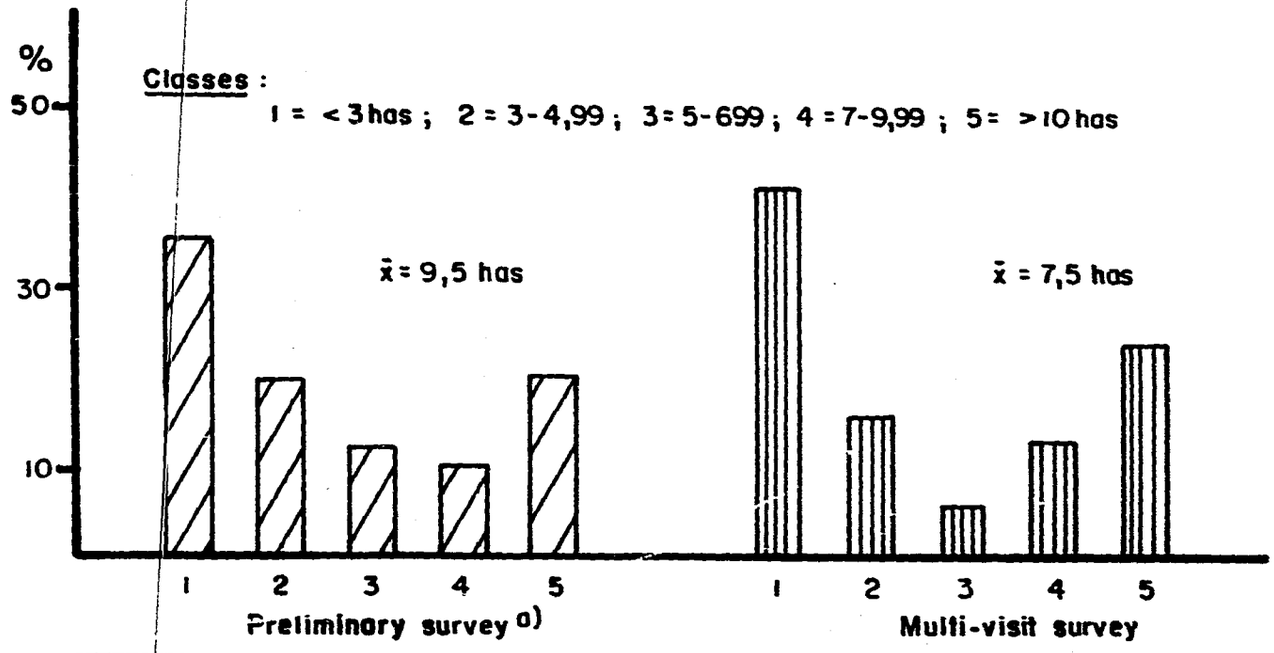
Fig. 9 **Comparison of land use in the two surveys. Percentage of farms per class**



a) PLATEN, H. von y LAGEMANN, op. cit., pag. 68

Additionally, but of less importance, both Acosta and Puriscal have fruits (citrus, mango, bananas and plantains, and in some places, avocadoes) and sporadically, cassava, rice, and vegetables.

Table 7 indicates the land use according to the preliminary survey compared to the multi-visit survey. As can be observed, the percentage of the cultivated surface averages per farm are almost identical.

Table 7: Land use in the region according to the two surveys. (Percentages of averages per farm).

	Preliminary survey	Multi-visit survey
Coffee	15.1	15.8
Sugar cane	2.4	2.7
Annual crops	67.5	64.2
Pastures and other lands	15.0	17.0

4.2.2 Land use on the farms in the multi-visit survey

Land use on the surveyed farms is different for the two areas of Acosta and Puriscal.

- While pastures occupy 72% of the Puriscal farm area, in Acosta, the figure is 41%. The hectare/farm average is 1.8 in Acosta and 8.5 in Puriscal although one-fourth of the farms have no pastures.
- The most important cash crop in Acosta is coffee, occupying 29% of the terrain. In Puriscal, coffee occupies only 8% of the land, and the average for the area per farm is less although the farms are larger (average of 4.5 has. in Acosta and 11.7 has. in Puriscal). In contrast, tobacco as a second cash crop occupies 7% of the land.
- The area of grains again reflects as much the different sizes of the farms as the greater availability of labor in Puriscal: while an average of 1.7 has. of grains are planted (both seasons) in Puriscal, in Acosta this figure is only 0.9 has. Figure 10 summarizes these relationships.

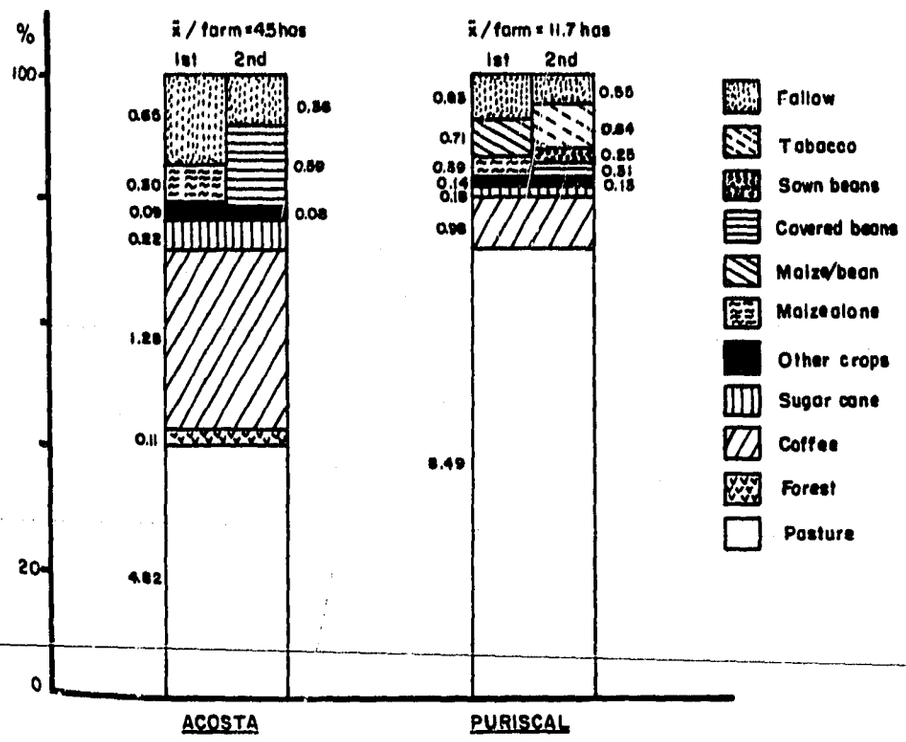
In Acosta, grains are planted principally for home-consumption and are not diversified. Apart from a few plots of cassava and rice, maize is planted only during the first cropping cycle and covered beans[9]/ during the second.

9/ The planting methods of beans are described in Chapter 4.3.1.2.

Due to the terrain where the beans are planted (in large part, very steep), and the requirements of the covering system, this land is not used during the first cropping cycle.

The total land available for annual crops reflects a use of 107% for two planting in the same field[10]. In Acosta, in contrast to Puriscal, other annual crops are not cultivated. In Puriscal, besides the grains (maize alone, maize/bean, sown beans and covered beans in the second cycle) there are also vegetables (two farmers of the 28), and tobacco in addition to some less important crops (cassava, rice). (Figure 10).

Fig. 10 Land use on the farms. (Percentages per crops[a])



a) The numbers at the sides indicate average area per farm

10/ The maximum use would amount to 200%.

Maize alone and maize/beans planted in the first season (See Figure 11) is often followed by tobacco in the second and at times by sown beans. This results in a total land use of 138% for annual crops. Apart from coffee, among perennial crops, there is moreover, sugar cane on small areas (4.9% of the land in Acosta and 1.6% in Puriscal). The principal use of the cane is for the production of unrefined brown sugar which is sold or consumed on the farm. Citrus can be considered among the cash crops as well as one for home-consumption. Although there are only small extensions of mono-crops (1.2% of the land in Acosta, 0.1 in Puriscal), these have a great importance as coffee-associated crops: 60% of the coffee fields are mixed with citrus. Bananas and plantains are less important as cash crops but are also mixed with coffee (40% of the fields).

To summarize land use according to size-classes of the farms, the following table is presented.

Table 8: Land use according to farm size (percentages of managed land)[a]

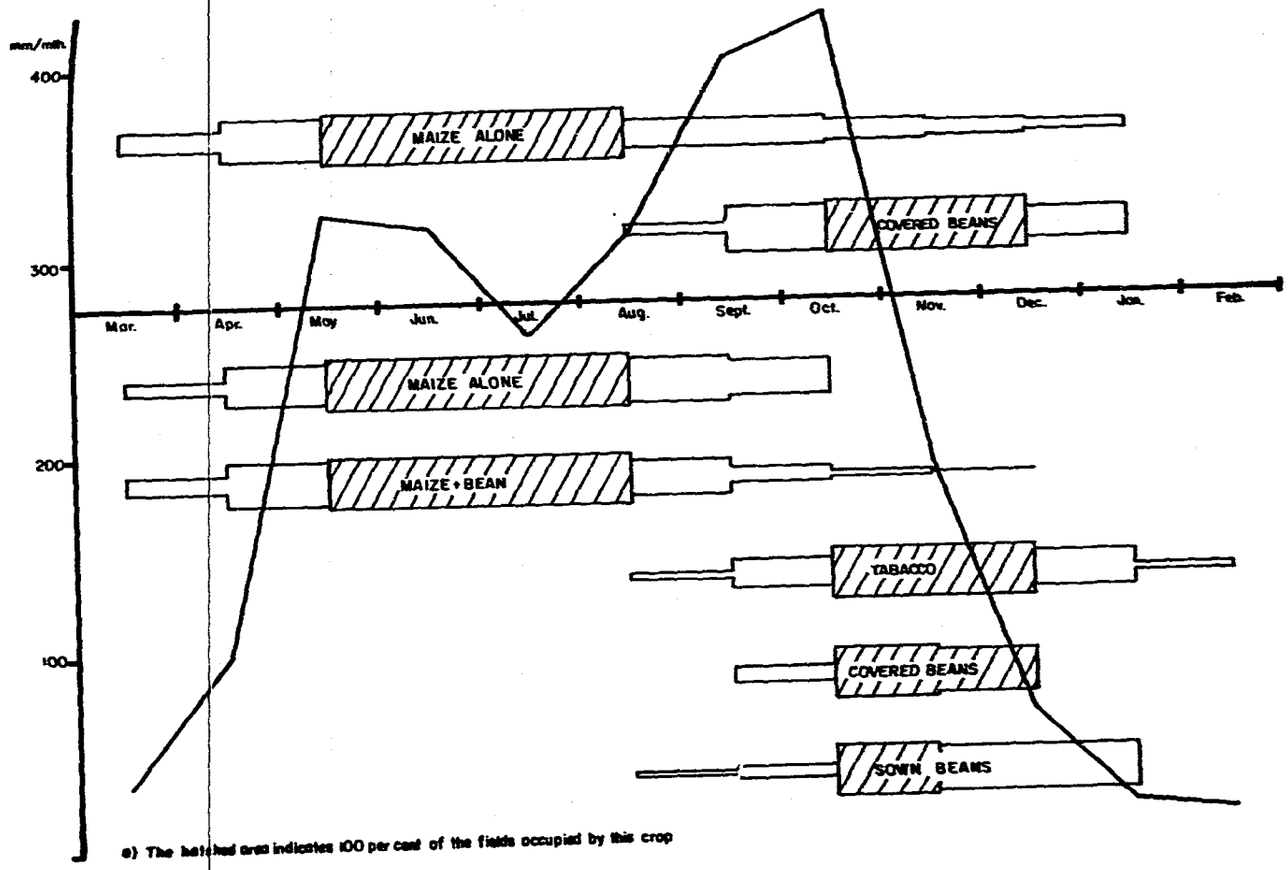
	ACOSTA		PURISCAL	
	< 3 has	> 3 has	< 3 has	> 3 has
Grains[b]	36.5	17.3	45.3	12.4
Other annual crops	–	–	32.5	5.8
Perennial crops	54.5	30.3	21.4	9.3
Other lands	9.0	52.4	0.8	72.5
TOTAL	100.0	100.0	100.0	100.0

a) Managed land surface increased by two plantings.
b) Including cassava.

- The pasture area on farms with less than 3 hectares is quite small.
- In Acosta the area devoted to perennial crops is very high on the small farms (54% compared with 29% for all farms); in Puriscal farmers dedicate more land to annual crop production. Counting tobacco as a cash crop equal to coffee, 54% of the land on the small farms is utilized for these.

Fig. 11 Land occupation during the year for the most important annual crops[a] and rainfall distribution per month

Fig. 11 Land occupation during the year for the most important annual crops[a)] and rainfall distribution per month



a) The hatched area indicates 100 per cent of the fields occupied by this crop

4.2.3 Adaptation to the environment

The most important factors influencing agricultural production over which the farmers have no control are environmental factors such as the climate (especially the quantity and distribution of rainfall) and conditions of terrain (of which only slope will be discussed due to a shortage of more detailed information).

Of these, rainfall has the greatest influence on production and is, at the same time, a fixed consideration for the farmer. Annual crop production is done according to the rains. As can be appreciated in Figure 11 (previous section)[11]/ the planting of maize begins as the rainfall increases in April/May. Normally, the soil is prepared before the first hard rains. The dry-spell in July/August allows the farmers to harvest the beans which are planted together with maize in Puriscal. In years of heavy rainfall (such as the surveyed year) there is a danger of losing the bean crop. In Acosta, beans are not planted with maize because of the excessive May/June rains which increase the risk of losing everything.

During the second cycle of the year, covered beans and tobacco are planted in September/October. Figure 11 shows clearly that rain is necessary for growth in tobacco but that a dry period is needed at the end to facilitate drying (all grown tobacco is of the "sun-dried" type).

The adaptation of the crops to the type of terrain is less obvious than the distribution of rainfall. The relation between degree of slope and annual /perennial crops is not very clear. In Acosta the percent of fields of perennial crops on steeper areas is higher when compared only to the fields planted with annuals. Covered beans are frequently planted on sloping land. There is a slight tendency to plant annual crops on the steeper land, and the most frequently grown are maize and tobacco[12]/. Surprisingly, covered beans are planted on the less steep inclines.

The explanation of this phenomenon of perennial crops on flatter land is the observation that farmers prefer to plant coffee closer to the house (see Section 4.1.2) which is normally located in the flat areas.

11/ Only the Puriscal rainfall is demonstrated, but this is similar in Acosta.

12/ Due mainly to the agronomic requirements of tobacco (See Section 4.3.2).

Table 9:

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Table 9: Distribution of annual and perennial crops by slope classes (percentage of plots in the respective class)

SLOPES IN%	ACOSTA			PURISCAL		
	Annual crops		Per. crops	Annual crops		Per. crops
	Cov.	sown		Cov.	sown	
0-10	–	7	7	9	5	7
10-30	19	45	20	27	31	37
30-50	62	36	48	45	34	28
50-80	19	12	22	9	32	26
80	–	–	2	9	6	2
TOTAL	100		99[a)]		99[a)]	100

a) Due to rounding.

4.3 HUSBANDRY PRACTICES AND ITS PROBLEMS

4.3.1 Annual crops

In Puriscal, tobacco determines the crop-rotation on the farms. Its quality of being a cash crop gives it predominance in the preparation of the land as in determining the date of harvest of the previous crop –maize– which is done in light of the needs of the tobacco.

On the other Puriscal farms, as on all of the Acosta farms that plant maize, there is no need to adapt the form of cultivation to the requirements of tobacco. Therefore, terraces necessary for tobacco are not encountered with varying success due to a lack of appropriate techniques by the farmers. It is also observed that in Acosta the majority of the land is used only once per year. The covered bean crop is completely different in that no soil preparation is required (although field preparation is done)[13]/ nor are there any care-taking tasks. Also vegetable crops differ from tobacco in that they may be produced –at risk– throughout the year. This enterprise has a low importance in Puriscal and none at all in Acosta.

13/ See the following section.

4.3.1.1 Tobacco

The essential part of soil preparation for the tobacco planting is the establishment of terraces. In Puriscal, the use of mechanization for this crop is prevented by the slopes of the area. In the few flat fields, the plough can be (is) used at least to turn the soil, the building of raised terraces being done manually.

To establish or maintain the terraces in August/September, the vegetation growth is cutted and added to the terraces, covered with a layer of soil. This lessens the maintenance work throughout the year. In this way, the maize from the first season may be left in the field although it has already been prepared for tobacco. The field must be completely cleaned if a total renovation of the tobacco is planned.

Rarely, herbicides are used to prepare the field for tobacco. 25% of the fields were treated in this way before planting; 15% as a substitute for manual weeding. Table 11 compares the use of herbicides on the most important crops in Acosta/Puriscal.

Calling attention to the fact that tobacco is frequently planted on very steep slopes is the following: 77% of the fields are greater than 30% inclination; 36% are fields of more than 50% inclination. There are two principal reasons for this:

- As mentioned earlier, the flat areas are preferred for coffee.
- Tobacco is very exacting with respect to establishment, and particularly, to the hydraulic system of the soil. The slopes provide good drainage.

The planting of tobacco is done first in seedbeds because the delicate seeds require very careful sowing. Normally, home-produced seed (Burley) is used and replaced irregularly with improved seed. Often the farmer rejects growing his own seed in beds and purchases seedlings which are ready for transplanting directly in the field.

At the beginning, recently sprouted plants are kept under shade (under gauze). Compared to a planting directly into the field, the seedbeds permit better attention to the seedlings from the start. The input costs (fertilizer and, when necessary, chemical protection) as well as the time involved in care are kept low. In addition, this gives the maize more time to mature in the field.

At four to eight weeks, the strongest seedlings are transplanted to the prepared field terraces. The distance between plants is normally form 1.20 cm to 60 cm, up to 1.50 to 40 cm depending on the terraces which in

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Table 10.

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turn are dependent on the terrain. The plant density average is 16,560 per hectare. (See Table 13)[14/].

When the transplanting is done, the first fertilization is accomplished with a special tobacco fertilizer (Formula N-P.K-Mg, 12-12-17-12) placed in a hole right next to the plant.

The second fertilization takes place four to six weeks later using a total of 351 kg of fertilizer per hectare (See Table 10). Because of industry requirements, pure nitrogen (for example, urea) is not used. It contributes to good plant growth but produces a lower quality of tobacco.

Table 10. Quantity of fertilizer per hectare in different crops (in kg of pure nutrients; only fields where applied).

	ACOSTA					PURISCAL				
	n	%[a)]	N	P_2O_5	K_2O	n	%[a)]	N	P_2O_5	K_2O
Maize alone	17	53	21	45	15	9	69	61	72	25
Maize/beans	–	–	–	–	–	19	73	63	44	15
Beans sown[b)]	–	–	–	–	–	7	70	14	44	14
Tobacco[b)]	–	–	–	–	–	19	100	119	114	118

a) Of the fields of this crop
b) Only for the second cropping cycle

In the majority of the fields (55%) weeding is done twice: 15% weed three times, and 15% weed only once. This is principally necessary at the beginning of planting when the tobacco plants are still developing. After weeding, the field is completely clean of any other vegetation and exposed to the environment. 15% of the fields were treated with herbicides rather than manually weeded. In these cases, the plant residues offer some protection for the soil.

Besides fertilizers and herbicides, insecticides and pesticides are also used as is indicated in Table 12; insecticides are used on 40% of the fields and fungicides on 60%. The last tasks before the harvest are pruning and banking up the soil.

14/ It must be kept in mind that this number refers to a measurement of the surface; on a plane projection, the area of the field is diminished, for example, by 4% on a 30% slope; with a slope of 50% inclination, the area is diminished by 10%, etc., the density increases, therefore, by this percentage.

The harvest requires more than one-fourth of the total labor necessary during a year (27%); and when grouped with sorting, almost one-half (47%). Harvesting and drying are critical periods; on the one hand, it is important to harvest the leaves at the correct moment since this influences the quality.

Because of this consideration of quality, harvesting is done in various steps which increases the total time necessary for this job. Drying is done in sheds closed on two sides or open, and at times the leaves are placed in the sun to hasten drying. This latter is probably also done to prevent excess fermentation and the development of fungi which develops easily in the very humid and hot microclimate between the recently harvested and closely spaced leaves.

4.3.1.2 Basic grains

In Acosta-Puriscal the important basic grains are maize and beans. In Acosta maize is planted alone, in Puriscal it is planted alone and in association with beans. The most important period for beans is the second cropping cycle.

The type of planting of the maize reflects the relation between maize and tobacco in Puriscal, especially when compared to the type of planting in Acosta.

Table 11: Type of soil preparation[a] (Figures indicate percentage of fields for each type).

	ACOSTA n=32	PURISCAL n=39
Flat, ploughed	–	13%
Flat, without ploughing	84%	26%
Ridges (terraces)	16%	61%

a) Maize alone and maize/beans

While the majority of the fields in Acosta (84%) were planted "simply", that is, without terraces or ridges, 61% of the fields in Puriscal were terraced ones from the previous tobacco crop. Only two of 24 fields were

not previously planted with tobacco; of the 15 fields planted simply, four had previously been tobacco fields, but two of these were ploughed, destroying their ridges.

Land preparation consists basically of a cleaning, sometimes aided with an herbicide. Table 12 shows herbicide use with various crops.

While there is almost no application of herbicides to basic grains in Acosta, 33% of maize fields and 40% of the bean fields in Puriscal were treated. Herbicides are used principally before planting (in 9 or 13 fields), but in no case did their use replace cleaning or clearing. This is done with a machete by cutting the vegetation and breaking the ground surface. In some cases ridges are mounded up (16% in Acosta, see Table 11). The intensive crop rotation in Puriscal is reflected in the time necessary for soil preparation: while 26 man-days/hectare are required in Acosta (30% of the total time).

Because of this consideration of quality, harvesting is done in various steps the land is under cultivation during the second season is most cases.

Table 12: Herbicide use on various crops (number of fields, percentage and value per hectare).

	ACOSTA			PURISCAL		
	n	%	value[a)]	n	%	value[a)]
Maize and maize/beans	1	3	384	13	33	389
Sown beans[b)]	—	—	—	4	40	550
Tobacco	—	—	—	9	47	365
Coffee caturra	7	54	514	14	88	469
Coffee, others	8	14	646	3	23	466

a) An average of ¢ 300/gallon can be calculated.
b) Second crop cycle.

The vegetation cut during the cleaning process is normally removed from the field because it is not able to be incorporated into the soil. Burning is prohibited and the majority of the farmers obey this law (although at times, smoke is evident during the land preparation period). It is also necessary to remove the tobacco stumps from the fields in Puriscal to avoid the transference of disease. These stumps are frequently destroyed through controlled burning for the same reason.

After the cleanning (in March/April for maize and maize/beans and September/October for planted beans), which is normally done before the hard rains begin in the first season, there follows the planting when the rain begins, a failure in this schedule can result in the necessity of a second cleaning, although with less invested time.

The maize planted from the middle of March until mid-May in both areas. In mid-March there was a week of rain which led some farmers to believe that the rainy season had begun, but there followed a dry spell lasting until the end of April (longer in Puriscal than in Acosta). Consequently, some fields had to be replanted.

Seed from the previous harvest is used primarily (maize and beans). At times improved seed is used in small quantities. This is supplied by the National Production Council through the agricultural stores. Farmers also buy seeds (produced in the same region) from neighbors and neighborhood stores).

The habit of using little improved seeds (which is sold cured or desin fected) (which is sold cured or desin fected) could change in the next few years. Although "seed does not receive as infected) could change in the next few years. Although "seed does not receive as much attention as other production factors . . . it is a relatively cheap, and many times decisive input . . ."[15], it has been noted that farmers who are open to new techniques consider seed to be an important factor. 73% of the farmers who participated in a technology test of covered beans in 1981 considered the seed as a reason for a good harvest; 63% of those who were not satisfied with the field blamed it on the unadapted variety[16]. Also, increases in sales of improved seeds in the Acosta-Puriscal stores is an indication of the growing interest by the farmers. Another influential factor is that in the last few years, the quality of the seed offered for sale has improved, as well as its adaptation to the regions where it is sold[17].

Seed use is shown in Table 13.

15/ GOLDBACH, H. E. in: PLATEN, H. von and LAGEMANN, J. op. cit. p. 60.

16/ See Section 5.2.

17/ Communications with individual farmers and stores.

Table 13: Quantities of seed in basic grains (Averages in kg/ha)

	ACOSTA	PURISCAL
Maize alone	20.3	21.0
Maize/bean	–	17.1/15.5
Sown beans	–	36.2
Covered beans	40.1	38.3

As much in Acosta as in Puriscal is done with a planting stick, used to make more or less two or three cm deep holes for both maize and beans. Two types of planting sticks are used, one with a blunt tip, the other long and pointed. The disadvantage of the blunt spikes is that it compacts soil at the bottom of the hole. On the other hand, it makes a larger hole which facilitates placing the seed without stooping. The distances between holes and between furrows depend on various factors:

- In Puriscal, for the tobacco-maize rotation, the requirements for tobacco also determine the distance between the maize furrows. To obtain the required density, the space between furrows has to be reduced in comparison to other fields, or more seeds must be planted.
- There are no such conditions for the other maize fields; distances between holes is often according to the stride of the person who is planting. The distance between furrows, therefore, depends on the distance between holes in order to obtain the required density.
- Distances in the bean fields depend on the system of planting. If there are ridges, the beans are planted in two lines on either side of the top of the ridges; if the land is flat the only requirement is a uniform seed distribution.

The same person using the planting stick or, if preferred, a second person following behind, puts the seed into the hole; in 10% of the maize and maize/bean fields an insecticide[18]/ against soil pests is placed with the seed. Between two and four maize seeds are placed per hole with or without beans. In Acosta, the average is 2.6 grains per hole, and in Puriscal 3.2. As a

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mono-crop, two or three bean seeds are planted per hole; and two or three are planted when beans are associated with maize because there are always some seeds that do not germinante. When more than two maize seeds sprout, the excess ones are pulled to allow a determination of plant development.

The density that results from the above-mentioned crops are tabulated in Table 14, together with other annual crops.

Table 14: Densities in various annual crops (Plants per hectare).

	ACOSTA		PURISCAL	
	Average	CV (%)	Average	CV(%)
Maize alone	22.800	25	37.600	22
Maize/beans:				
maize	–	–	30.400	27
bean	–	–	136.000	99
Sown beans[a)]	–	–	126.000	23
Covered beans	119.000	25	114.000	42
Tobacco	–	–	16.560	34

a) Second cropping season.

The increased density in maize in Puriscal compared to Acosta with 39% (taking Puriscal's as 100%) corresponds to a greater use of fertilizer. The farmers using higher levels state that increased density must go together with an elevated level of fertilizer[19]/. Compared with experimental results[20]/ these densities seem low in all systems of maize and beans.

As much for maize/beans as for maize alone, a complete fertilizer formula is used (10-30-10) as well as nitrogen (ammonia sulphate, 33%). In the past, urea was also used, but due to the high price, farmers changed to ammonia sulphate.

In Puriscal, four of the 21 fertilized fields were treated twice, at the time of planting (with N-P-K) and after 20 or 30 days (with N); four fields were treated with only N-P-K at the time of planting, and the rest only once

19/ Communication with various farmers.

20/ MAG: unpublished data.

at 20 to 30 days after planting with N-P-K or N. Maize alone in both areas and planted beans were fertilized at planting with N-P-K.

Table 10 shows the fertilizer levels for the mentioned crops in kg of pure nutrients per hectare. A high level of nitrogen for maize and maize/beans can be noted in Puriscal. Although 88% of the maize/bean fields were fertilized, this is lower (except for nitrogen) than for maize alone where fertilization is done less frequently (69%), but at higher levels. The level of fertilization in Acosta where 53% of the fields are fertilized, is one-third that of Puriscal. Also, less pure nitrogen is used in Acosta.

When fertilizers are used to increase yields, herbicides used to facilitate the work, and other agro-chemicals used to protect the harvest, there must be also a high input level to combat plagues. Table 15 shows the use of fungicides and pesticides on the more important crops. The use of harvest protectors for basic grains is low in Acosta where there is almost no use of any substance (one field in 32). Although this is a little higher in Puriscal (12% of all basic grain fields were treated), application seems marginal.

Table 15: Use of fungicides and pesticides on the most important crops (average of colones of treated fields)

	ACOSTA			PURISCAL		
	n (of fields)	%	Value	n (of fields)	%	Value
Maize alone	1	3	10	2	15	49
Maize/bean		–		3	12	75
Covered beans[a)]		–		1	10	133
Tobacco		–		12	63	373
Caturra coffee	7	54	560	10	63	418
Coffee, other varieties	14	24	493	1	8	1.343

a) Second cropping cycle.

Other husbandry practices consist of weeding, hilling and shortly before harvest, the doubling of maize. Weeding, important in combating competition, particularly when the crops begin to grow, requires a quantity of labor comparable to that used in soil preparation (see Section 4.5.1). Weeding signifies completely cleaning the soil (with machete) of any other plant. Cleaning is more necessary for maize because it takes this crop longer

than beans to cover the ground and gain dominance over the weeds. In some cases, weeding also includes loosening the soil surface. The cut weeds are usually left in the rows; in some instances they are distributed over the soil.

Weeding is done between three and seven weeks after planting, according to necessity and herbicide application since a single herbicide application retards weed growth. The average time between planting and weeding of maize alone is 4.7 weeks in Acosta and in Puriscal 3.8 weeks.

For maize/beans the respective value is 3.9 weeks and for sown beans alone 3.7 weeks. A second weeding is done at times in the maize fields; 15% of fields of maize/beans in Puriscal and in Acosta 15% of the maize fields. Only in two of the maize fields or maize/beans in Puriscal is herbicide[21]/ substituted for weeding.

Hilling, done more or less one month before harvest, helps prevent the maize plants with large ears from falling over. This is accomplished by banking up the dirt and debris around the base of the plant.

The last work before the harvest is usually doubling of the plant (if this is not done, the maize is harvested before ripening). Doubling is done for two reasons: the ears dry more rapidly and the entrance of water into the ears is avoided. Doubled, the maize is sometimes left in the field until the rains lessen (see Figure 12), at least in Acosta. In Puriscal, the double use of the land prohibits this, and at times the ears must be harvested before ripening completely. The beans are harvested at maturity, and the entire plant is dried over a rope or fence; if climate does not permit this, then they are dried in the house, and later the pods are exposed to the sun.

Differing completely from the other basic grains is the "covered bean" system. This basically consists of casting the seed over the soil, cutting and chopping the weeds that are in the field, and returning to harvest the crop. The seed is the only input, apart from labor, and there are no caretaking tasks except for the sowing, cutting, and the harvest.

For the September/October planting, the seeds are cast over a field which has sufficient vegetation to provide a mulch covering. It is, therefore, preferable that the field was not cultivated during the first cropping season. After distribution of the seed (an average of 40.1 kg/ha in Acosta, and 38.3 kg/ha in Puriscal), the vegetation is cutted a little above the ground with machetes. The rapid growth of beans covers the ground well and supresses the growth of weeds until harvest. The average plant density per hectare is 119.000 in Acosta, 114.000 in Puriscal; lower than for planted beans.

The advantages of "covered beans" especially in sloping areas are[22]/:

21/ Gramoxone.

22/ PLATEN, H. von and RODRIGUEZ, P. G., La producción de frijol tapado en la región de Acosta-Puriscal, Costa Rica. Turrialba, Costa Rica, 1982.

- They can be sown in terrain that normally does not permit annual crops because of the excessive slopes. The land of the first planting (maize/beans) can be allowed to rest.
- The bean cover does not leave the land bare, reducing erosion.
- They require less labor than the planting of other crops with a relatively low productivity per unit of land, but high per work day.

The last reason is important due to the fact that the coffee harvest is begun at the same time.

4.3.1.3 Coffee

Coffee is the most important crop in Acosta, for various farms, it is the only source of income. In Puriscal, the situation is notas drastic since tobacco is also a cash source (see Section 4.6) However, agreat deal of attention is dedicated to coffee; the majority of farms, more than for the basic grains.

According to production systems, coffee plantation can be divided into four classes[23]/:

- Coffee caturra with fruit trees
- Coffee caturra without fruit trees
- Coffee of other varieties[24]/ with fruit trees
- Coffee of other varieties without fruit trees

The caturra fields as well as those of other varieties have, moreover, shade trees[25]/, with the exception of some recently planted fields.

Table 16 provides a resume of the coffee structure. In Acosta, the majority of the coffee are old varieties associated with fruit trees. In Puriscal, on the other hand, 40% of the coffee is caturra and 50% of this is in recently planted fields. However, it must be noted that in Acosta also, the plantations are being renewed with new plants among the old.

Generally, it can be stated that:

23/ The division between coffee caturra and other varieties was made taking into account production coefficients which are completely different.

24/ Which are mostly "Typica" and "Hybrido Tico" (Costa Rica).

25/ Among the 37 species are Poró (Erythrina poeppigiana). Guabas (Inga spp.), Madero Negro (Gliricidia sepium). For more detailed information, see: ESPINOZA, L.: Estructura de cafetales en pequeñas fincas en Acosta-Puriscal, CATIE, Turrialba, 1982 (en preparación).

- Coffee is the most important crop in Acosta but not in Puriscal
- Coffee management is at a higher level in Puriscal: fertilizer, use of other inputs, new varieties, yields; in Acosta coffee management is traditional.

Table 16: Land percentages for different coffee systems. Total coffee area = 100.

	ACOSTA	PURISCAL
	% area	% area
Caturra with fruit trees	8	31
Caturra alone	3	9
New coffee[a)]	–	10
Other varieties with fruit trees	84	17
Other varieties alone	5	33

a) Coffee less than one year or without harvest; the variety always is caturra.

The number of coffee plants is different in Acosta and Puriscal, as much for caturra as for the other varieties.

Table 17: Density of coffee and fruit trees per hectare[a)].

	ACOSTA		PURISCAL	
	Coffee	Fruit trees	Coffee	Fruit trees
Caturra with fruit trees	4.497	103	4.045	105
Caturra alone	4.818	–	3.998	–
Other varieties with fruit	3.747	163	3.039	95
Other varieties alone	3.712	–	3.169	–

a) Only coffee and trees in full production.

The density averages are higher in Acosta for all systems, but for both areas, the averages are inside the Ministry of Agricultural's recommended range[26]/. A considerable difference is seen only in the average of caturra plants in Acosta where the fields having fruit trees have less coffee plants.

Fruit trees have a frequency of around 100 trees per hectare of coffee fields. Only with the traditional varieties in Acosta does the average reach as high as 163 trees per hectare.

The description of coffee husbandry practices begins with pruning, which has a great influence on yield. Two methods are known in the region: pruning the plant, that is cutting shoots or exhausted branches, and complete pruning when the entire plant is cut to one-half meter above the ground, leaving sufficient space for the plant to grow again. However, during the surveyed year, none of the farmers employed the latter method.

Generally, pruning is done (after the harvest) on those shrubs with too high of a branch growth and on branches and shoots that are not productive. The intensity of the pruning can be observed in the labor invested in its accomplishement.

Table 18: Pruning intensity of coffee in man-days/hectare.

	ACOSTA	PURISCAL
Caturra with fruit trees[a)]	7.1	20.1
Caturra alone	12.4	13.7
Other varieties with fruit trees[a)]	12.6	6.9
Other varieties alone	11.5	15.3

a) Part of the work refers to the pruning of the fruit trees.

The most extensive pruning is done on coffee caturra in Puriscal (although a part of the work refers to the associated citrus). The corresponding value in Acosta is very low due to the younger plants which require less pruning. The low values for other varieties in Puriscal is because there are only four fields in this category and no pruning was done in two of these.

26/ 3500-5700 plants per hectare of caturra. 3000-4200 of other varieties per hectare. See: OFICINA DEL CAFE. Ministerio de Agricultura y Ganadería. 3a. Edición, San José, Costa Rica. 1978.

Shade regulation is more of a marginal practice, although all the fields have shade trees. Only 17% (Puriscal) and 44% (Acosta) of the coffee fields receive any shade regulation, most of this being done in the period between May and July[27].

Apart from the harvest, weeding is the activity which requires the greatest labor input. Rarely, this is replaced with herbicides (one of the 71 fields in Acosta, two of the 29 in Puriscal). Frequently, both herbicides and manual weeding are done (21% of the Acosta fields and 59% of those in Puriscal, see Table 12). Generally, the time for weeding is from June to August, but also soon before the harvest which begins in Acosta in September and October, and in Puriscal in August and September.

The level of fertilization is relatively high although not yet at the levels recommended by the Ministry of Agriculture[28].

Table 19: Fertilizer use on coffee in Kg/ha of fertilized fields.

	ACOSTA				PURISCAL			
	N	%	NPK[a]	kg N[b]	N	%	kg NPK	kg N
Caturra, with and without fruit trees	12	92	954	132	16	100	509	439
Other-varieties, with and without fruit trees	40	69	588	170	13	100	265	380

a) Formula of NPK: 18-20 of N, 5-10% p_2O_5, 10-15% K_2O;
b) 33% of N.

In Acosta the percentage of "other varieties" not fertilized was lower than for other categories in Acosta. In Puriscal, all the coffee fields were fertilized although with a lower level of N-P-K and a higher level of nitrogen than in Acosta. Moreover, four fields of coffee in Acosta and three in Puriscal were fertilized with organic manure (chicken manure) with an average of 3.000 kg (Puriscal) and 1.250 (Acosta).

27/ For more details on this aspect, see: ESPINOZA, L. op. cit.

28/ OFICINA DEL CAFE (Ministerio de Agricultura y Ganadería), op. cit. p. 27.

Fertilizing is done at the beginning of the rainy season (April/May) and again (usually with nitrogen) before the cessation of the rains.

The use of fungicides and insecticides is different for coffee than for grains with a tendency to make greater use of chemical methods. For the caturra variety which always receives the most care, 54% of the fields in Acosta are treated with a fungi/pesticide; for Puriscal the figure is 63%. The fields with other varieties receive 24% (Acosta) and 8% (Puriscal)[29]/. It must be considered that portions of the inputs are intended for their phyto-sanitary effects on the citrus, although the amounts are believed to be low.

There are coffee plantation renovations in both areas although using different systems. It is more common in Puriscal to do a complete renovation, that is, replant an entire field. It is also normal to use a field for annual crops until the coffee is one or two years old. The ratio of average land in coffee at harvest age (more than one year) and average land in new coffee is 4.7:1 hectares (Puriscal). In Acosta, this figure is 28.2:1 hectares, that is, for every 28.2 hectares of producing coffee, there is one hectare of new coffee. This wider range does not imply that there are no renovations in Acosta as can be seen in Table 20. The invested labor for replanting is much higher in Acosta than in Puriscal.

Table 20: Man-days for coffee renovation (average por ha).

	ACOSTA	PURISCAL
Land preparation	6,4	5,9
Planting	25,1	18,6
TOTAL	31,5	24,5

29/ Especially in the use of insecticides and fungicides, the presence of the Project's agronomist could have had an influence through his recommendations made with respect to coffee. Nevertheless, it is believed that the tendency to use these chemicals is standard practice.

Harvesting is the most labor-consuming activity in coffee production, beginning in Acosta between September and October and in Puriscal between August and September. Because the percentage of caturra is higher in Puriscal than in Acosta, less labor is required in the former area (see Section 4.5.1) due to the fact that caturra is harvested only twice since the maturity of the beans is more uniform.

The coffee processing is always done in small factories ("beneficios") which have receiverships distributed throughout the region.

4.4 ANIMAL HUSBANDRY

4.4.1 Animal husbandry and production coefficients

Animals (cattle, pigs, chickens) do not currently have as an important role as the various crops. On the small farms, as is to be expected, the base is lacking for a high cattle production. Husbandry practices are traditionally loose, that is with a low yield per land unit but a high yield per invested time.

Smaller livestock (pigs and chickens) on the other hand, require a relatively high capital input for marketable production and good management. However, the greatest limiting factors for small livestock are the necessity for special feeds and a high market demand. Both of these are encountered in Costa Rica's Central Valley. Thus, the transportation distances to the Acosta-Puriscal region considerably increase input costs and lower the prices received for products' sales.

The small farmers, working especially in chickens/eggs are largely excluded from the market by larger farms producing on a grand scale at prices which are not competitive for the small farmer.

Small livestock production, therefore, is generally for use on the farm, perhaps for sale to neighbors or local markets. There is also little doubt that many farmers simply do not like pigs.

The situation with cattle is a different matter. Here a differentiation can be made between farms with one or two cows which provide milk for the farm and those with sufficient pasture to have beef cattle. This last enterprise is quite significant, especially in the south of Puriscal but also in western Acosta where the largest farms are located. In this case, distances to markets are not of great importance since cattle represent a value worth transporting.

Cattle contribute 87% to the value of all productive animals in Acosta and 98% in Puriscal (see Section 4.1.3).

55% of the farms in Acosta have cattle, 64% in Puriscal. Table 21 defines the distribution of cattle on the farms.

Table 21: Distribution of cattle[a)] (number of farms and percentage of those having cattle)

NUMBER OF ANIMALS	ACOSTA		PURISCAL	
	n	%	n	%
1– 2	9	41	4	22
3– 5	4	18	3	17
6–10	6	27	2	11
>10	1	5	8	44

a) Discounting draft animals (oxen); discounting young (less than one year)

With an average of 4.8 head of cattle per farm (Acosta) and 15.6 (Puriscal) a pasture density of 1.34[30]/ livestock unit per hectare (Acosta) and 1.13 (Puriscal) is obtained. Nevertheless, these numbers must be read with caution for the following reasons:

- Part of the Puriscal herds are animals which were bought at the beginning of the rainy season (when pastures begin to grow) and were sold when food resources diminished (when the rains ceased).
- Especially those with few head and limited pasture allow their animals to forage at roadsides or in borrowed pastures.

Cattle breeds are mostly native and native/Cebú crosses; only with cows kept for milk are other crosses introduced since neither the native breeds or the Cebú give much milk.

18% of the farms in Acosta and 6% in Puriscal have milk-producing breeds (Holstein and Jersey).

27% of the Acosta farmers consider milk production as their principal goal with cattle; 59% regard meat and milk as equally important factors (double purpose). In Puriscal 22% of the farmers regard milk production as their prime goal, 39% have cattle for the dual purpose mentioned above. Moreover, 33% of the Puriscal farmers indicate that they have cattle primarily for breeding purposes.

The use of inputs in the entire region is extremely low. Table 22 reviews the use of inputs for cattle during the surveyed year.

30/ Counting cattle less than one year as one-half unit.

Table 22: Inputs for cattle. (Averages of ₡ /head/year).

CATEGORY	ACOSTA	PURISCAL
Minerals	10	19
Veterinary expenditure	42	9
Alimentation	25	2

Veterinary costs are considerably higher in Acosta because the costs of breeding are included. These expenses do not exist in Puriscal. In Acosta, the higher feed costs again reflect the shortage of adequate pasture. The most frequently used feed is molasses (residue from sugar cane processing).

The production coefficients of the herds are tabulated in Table 23. In Puriscal, the high rate of sales is due principally to three farmers who buy cattle, fatten them, and sell them immediately. The death rate reflects two factors of livestock production in Acosta/Puriscal: the low rate itself demonstrates that sanitary conditions are well developed; a high percent of old animals that die, do so in part, because of the terrain. Many farmers included in the survey, as well as others, report that the cattle slip on the steep inclinations of the pasture and as a result, fall into gorges or ravines where they die.

Table 23: Production coefficient of the herds (averages of the respective rates).

	ACOSTA %	PURISCAL %
Birth rate[a)]	62.4	69.9
Death rate[b)]	2.5	2.2
Of this: younger than 1 year	33.0	55.0
Sales rate[c)]	16.6	22.2

a) Number of births per cow of 3 and more years
b) Number of death in total herd
c) Number of sales in total herd

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The other product that the animals could provide for sale is milk which is used only in the house. The milk capacity is low due, on one hand, to the fact that the only feed is obtained in the pasture, and on the other, because the calf must have a part. However, cows do provide milk for the farm (frequently only one or two of the lactating cows are milked in order to provide milk for home consumption). Another factor is that the zone is not suitable for an exploitation of this product since other areas of the country offer much more favorable conditions.

The management of small livestock is principally characterized by its laxity. Chickens (owned by 85% of the Acosta farms and 54% of those in Puriscal) are normally left loose. Only in the case of one commercial breeder (a surveyed farm) were the animals penned and given regular concentrates in addition to bananas, plantains and maize. However, this farmer liquidated his business during the course of the study because of economic inefficiency.

The loose chickens are left to look for their own food around the farm; they irregularly receive maize (estimated at 10/kg/animal/year). However, the maize is often of low quality due to damage in storage and frequently is not suitable for human consumption. Kitchen scraps also contribute to the alimentation of these birds.

The major advantage gained from the chickens are the eggs; of lesser importance is meat for home-consumption. In general, chickens are not sold.

The situation with pigs is similar. These animals are owned by 38% of the Acosta farms and 11% of the Puriscal farms.

As with the chickens, pigs are normally loose and are maintained on kitchen scraps and farm products, particularly bananas and plantains which have no regional commercial value. In three cases, there are pigs kept in pens but with a low success rate. The high prices of concentrates prohibits extensive use. In addition, there are not of the best quality. The continuing change in the ingredients of the concentrate greatly affects fattening and weight gain.

4.4.2 Relationship to other enterprises

The most obvious overlap between agriculture and livestock is the use of oxen which are owned by 13% (Acosta) and 21% (Puriscal) of the farms.

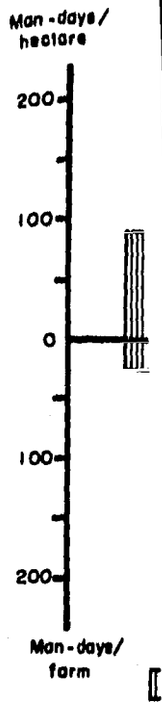
Although the steep terrain prevents ploughing in many locations, oxen are used as draft animals (with carts) and for grinding cane, that is, squeezing the cane for the processing of unrefined brown sugar.

As mentioned earlier, farm products are used for all types of animals but these are not produced, at any level, for the exclusive alimentation of livestock.

The regular use of manure is limited since the animals wander loose on most of the farms. There may be some benefit in cases where there is a coffee plantation near the house which functions almost as a home garden and is fertilized by the animals. When, in a very few cases, animals are kept in pens, the manure is not used on the fields since the corral is washed with water and the residues lost. There is a case of one farmer (outside the survey) who uses pig dung on a regular basis, but this requires a great labor input. He first shovels the manure from the pen, the mixes it with soil, and leaves it buried in the soil for some months. It is finally used principally on tobacco and coffee seedbeds.

Sometimes the farmers use chicken manure that they buy from large commercial farms, but this implies limited use since the supply is not great.

Fig. 12



4.5 LABOR USE

The third production factor is labor, the structure and origins of which are described in Section 4.1.1, along with land and capital. It has been shown that:

- Capital is not the greatest limiting factor
- Land is a limiting factor only on the small farms of Acosta since in some places it is difficult to rent land. Because of this, there is a growing tendency to give only partial dedication to the farm in this area. The small farms in Puriscal do not face this problem.
- On farms of more than 3-4 hectares, labor seems to be a limit since most of the land is used principally for pasture.

This section describes the use of labor in the different farm enterprises and on the entire farms as well as activities outside the farm. With this base, the calculations of the value of labor for particular farm enterprises as well as for the entire farm can be made which gives an impression of farm organization and its effectiveness.

4.5.1 Labor per farm enterprise

When time invested in the various farm enterprises are compared, the great importance of the demand on labor by the cash crops can be seen (coffee in Acosta and tobacco in Puriscal, see Figure 12).

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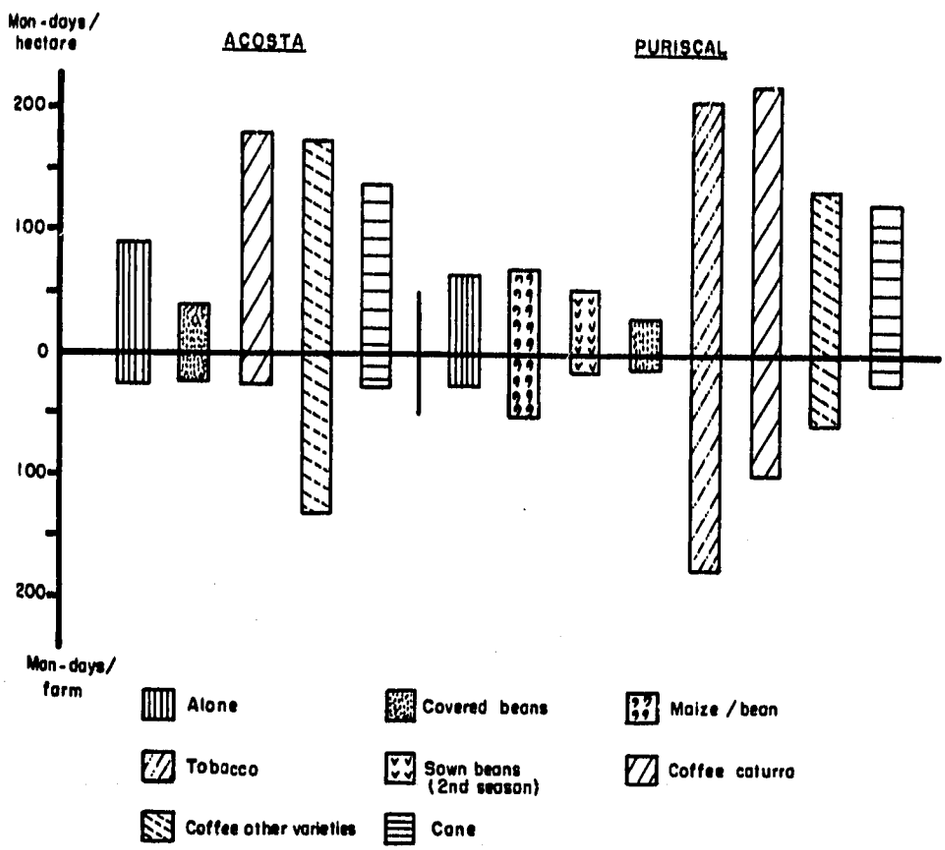
Fig. 12 Labor according to enterprise per hectare and per whole farm
(Averages of man/day)[a]



a) The numbers in the bars indicate respective man-days

In Puriscal, the highest labor input is given to tobacco and coffee caturra (207 and 221 man-days/ha respectively). When other coffee varieties are used, much less labor is invested (133 man-days/ha). This is verified by other observations where the current varieties are replaced with caturra and receive only basic care.

Figure 13 shows that the relative importance of the different activities (planting, care-taking, harvesting) doesn't change, although coffee caturra requires less labor per basket of coffee harvested (1.2 hours/basket for caturra, 1.5 hours/basket for other varieties). Also in Puriscal, the total labor for all coffee is higher than for coffee in Acosta (182 man-days/ha for caturra and 175 man-days/ha for other varieties).

The relationship between the types of work for caturra and for other varieties is similar as is the distribution in Puriscal. The only variance is in planting[31]/ of the plantation: in Puriscal there is almost no planting of other varieties (3.2 man-days/ha), while 19.1 man-days/ha is invested in caturra. In Acosta, the installation of the other varieties is more intensive (17.0 man-days/ha) compared to caturra (13.2 man-days/ha) since new plants are put in fields with older ones thereby allowing a harvest while the new coffee is growing (see Section 4.3.3).

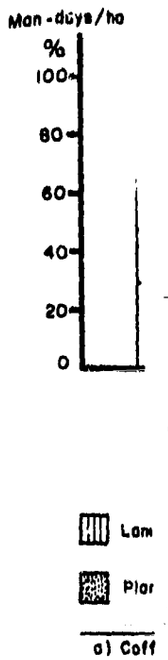
With 1.3 and 1.9 hours per basket of harvested caturra and other varieties respectively, a little more time is necessary in Acosta than in Puriscal, especially for the other varieties. Sugar cane also requires a significant labor input due mainly to the processing requirements which signifies 46% of the total in Acosta and 55% in Puriscal.

For annual crops, tobacco has the highest requirements with 207 man-days/ha and in this is similar to coffee. 20% of this total work or 41 man-days/ha is given to processing (sorting leaves according to quality). After drying, the leaves are sorted for sale.

In Acosta for maize alone, more time (89 man-days/ha) is spent than in Puriscal (66 man-days/ha for maize alone, 71 man-days/ha for maize/beans). Land preparation and care-taking are especially time-consuming due among other things, to the steep slopes. With a total of 38 man-days in Acosta and 31 man-days in Puriscal, covered beans required less labor input. With beans the activities are divided down the middle, one-half for planting, the other for harvest.

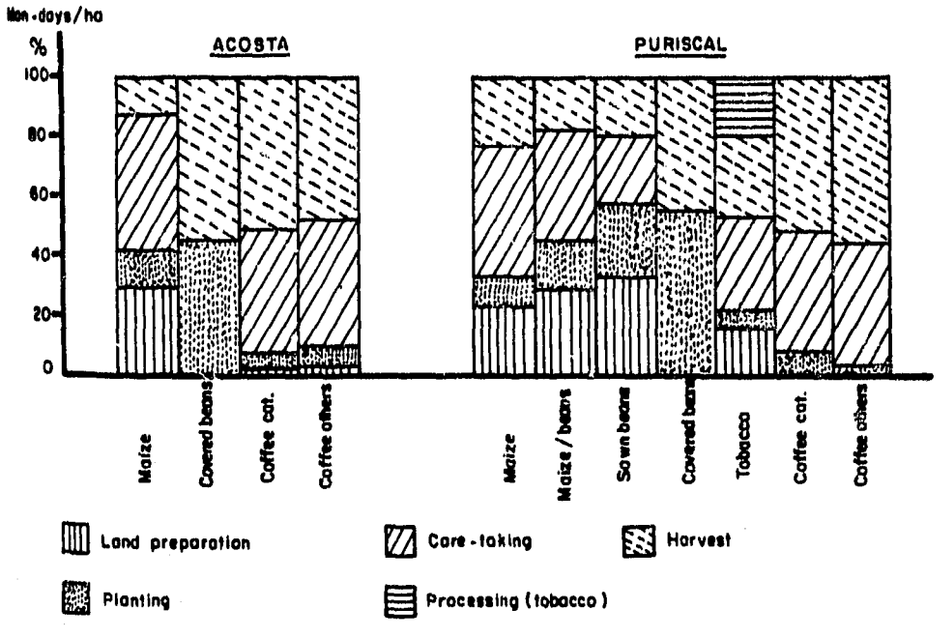
Figure 12 shows the labor necessary per hectare of crops as well as the relative importance of each enterprise in the annual work plan averaged from all the farms in the areas.

Fig.



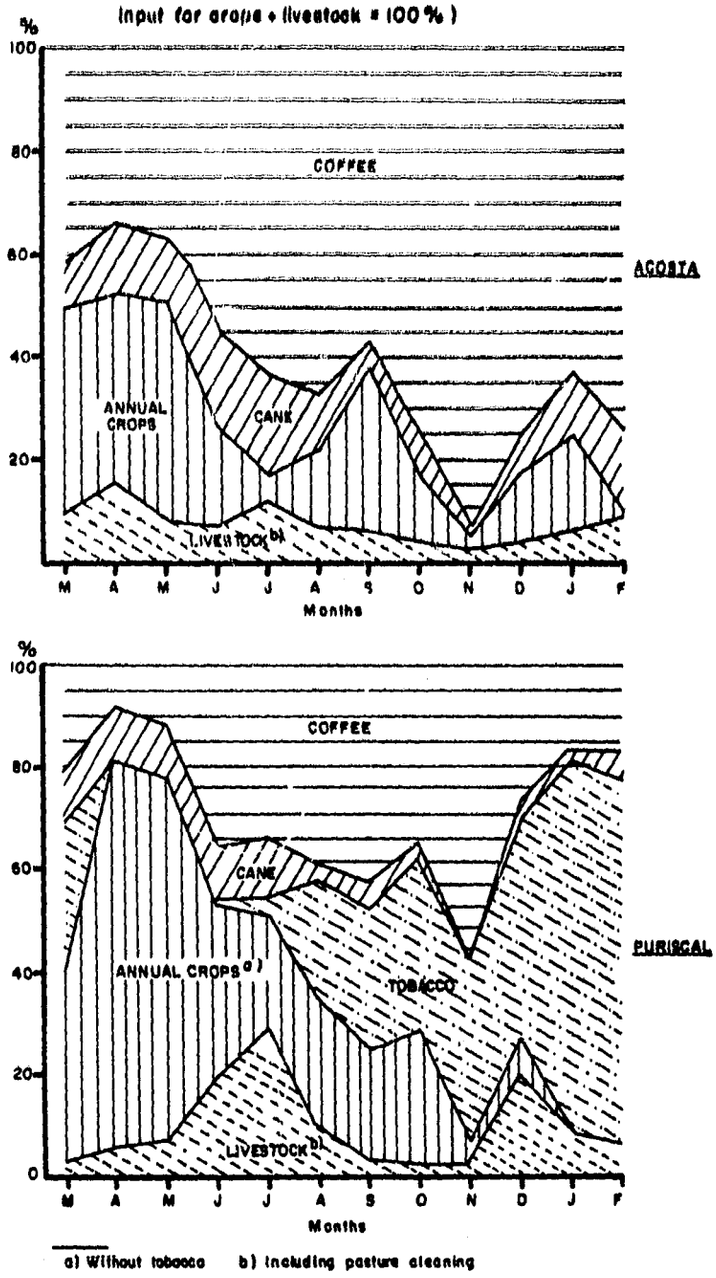
31/ Inclusive of land preparation.

Fig. 13 Labor in different agricultural enterprises according to type of work (Percentages of man-days per hectare)[a]



a) Coffee alone fields in harvest

Fig. 14 Labor use per farm enterprise during the year
(Percentages of mean man days per month, labor input for crops + livestock = 100 %)



a) Without tobacco b) Including pasture cleaning

In Acosta, the relative importance of other coffee varieties is greater than all other activities since invested labor is 132 man-days/farm/year. For coffee caturra, because of its limited area, the figure is only 24 man-days/farm/year.

The opposite is true in Puriscal because caturra, having wider coverage, uses 97 man-days/farm/year. Tobacco is the most important crop in the annual work plan because it requires more labor than the two coffee groups combined (174 man-days and 154 man-days respectively). Sugar cane has less importance due to its small area. Likewise, concerning the are planted, the other annual crops are of less importance in terms of total labor during the year. Nevertheless, analyzing the monthly work plant (Figure 14), one finds, for both areas, months in which annual crops (excluding tobacco) are of great importance. These are, above all, the months of preparation and planting of the first crop (from March to May) and the months of the first crop's harvest and planting of the second crop (from August to October). The second season's harvest is only important in Acosta, given that in Puriscal, the work with tobacco requires one-third of all work done on crops and for animals on a year's total basis.

ACOSTA

4.5.2 Labor input per farm and annual distribution

In order to analyze labor use, it is important to look first at its origin. In Section 4.1.1human resources on the farms was described. In the preceding Section labor requirements for the various crops were discussed.

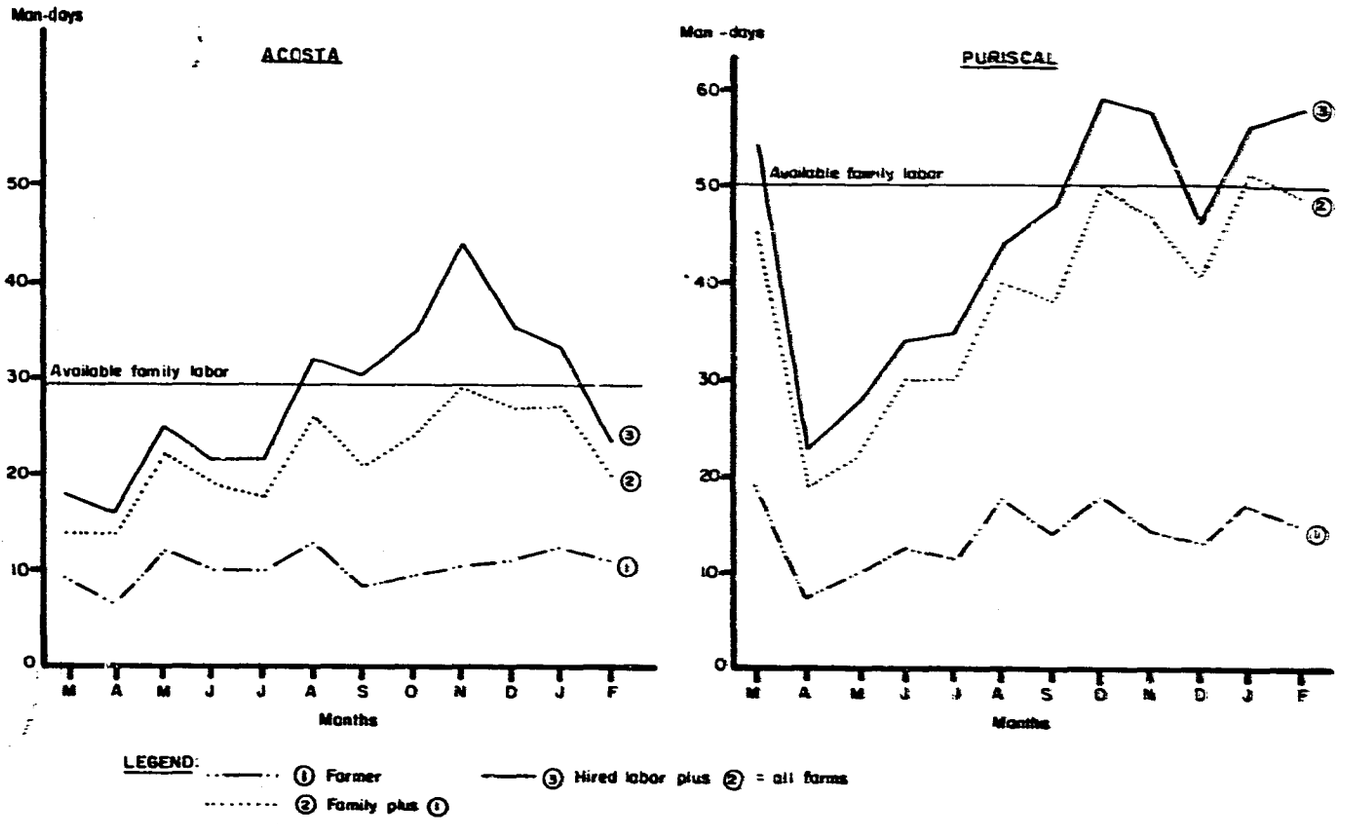
Figure 15 shows the origin of the invested labor on the surveyed farms. Firstly, it is obvious that more work is done on the Puriscal farms; but the work of the farmer and his family stays within the range of available family labor for the two areas.

The critical period, with respect to labor requirements, is August to January in Acosta. This time includes the coffee harvest and the harvest and planting of the second cycle of annual crops. Family labor during this period is completely occupied, and in order to complete all the work, additional workers must be hired. For the rest of the year, family labor is, theoretically, able to provide all needed input. Nevertheless, labor from outside the farm is hired, on the one hand because there are some farms in the sample which absolutely need it; on the other, it is done for convenience or to provide work at times when laborers have difficulty finding work.

PURISCAL

The situation in Puriscal is similar with respect to the total labor distribution throughout the year; the only difference being that the greater demand begins one month later. Also in Puriscal, family labor is almost completely occupied and because of the amount of work to be done which surpasses family capacity, outside labor is hired.

Fig. 15 Total labor origins during the year (Average of man days per month)



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Due to the higher number of man-equivalents in Puriscal (2.4) than in Acosta (1.4) the amount of total invested labor is higher in the former (541 man-days/farm) than in Acosta (333 man-days/farm). But also, the farmer himself works more in Puriscal (167 man-days/year) than in Acosta (130 man-days/year) since the Acosta farmers work more days outside the farm.

The total invested labor and its origins are found in the following table.

Table 24: Total of labor invested in the farms and origins. (Average of man-days per farm).

CONCEPT	ACOSTA	PURISCAL
TOTAL	333	541
Farmer	130	167
Family	142	294
Hired Labor	61	80

In Figure 16, year-round labor use is presented according to farm classes. As was seen in Figure 14, here again is evident the great importance of perennial crops in Acosta; while in Puriscal the annual crops require the majority of the labor. General and livestock activities do not play an important role except in Puriscal during the peak demands in July and December when the pastures are cleaned.

The labor peaks for annual crops in Acosta occur in May (planting the first crop), in September/October (first crop harvest, planting of the second), and in January (harvest of the second crop). The high peak in perennial crops in October/November reflects the coffee harvest with its enormous labor requirement occuring in November (40 man-days/farm).

This peak is compensated for by a minimum of work in annual crops since the "covered beans" require no care.

In Puriscal, the highest peak occurs in October with no compensating factors since this is the month in which:

- Most of the first cycle fields are harvested.
- The majority of the annual crops of the second cycle are planted, tobacco being most important.
- The coffee harvest continues to its culmination in November.

LEGEND: ..... ① Farmer ——— ③ Hired labor plus ② = all forms
..... ② Family plus ①

Fig. 16 Labor use during the year (Average man-days per month)

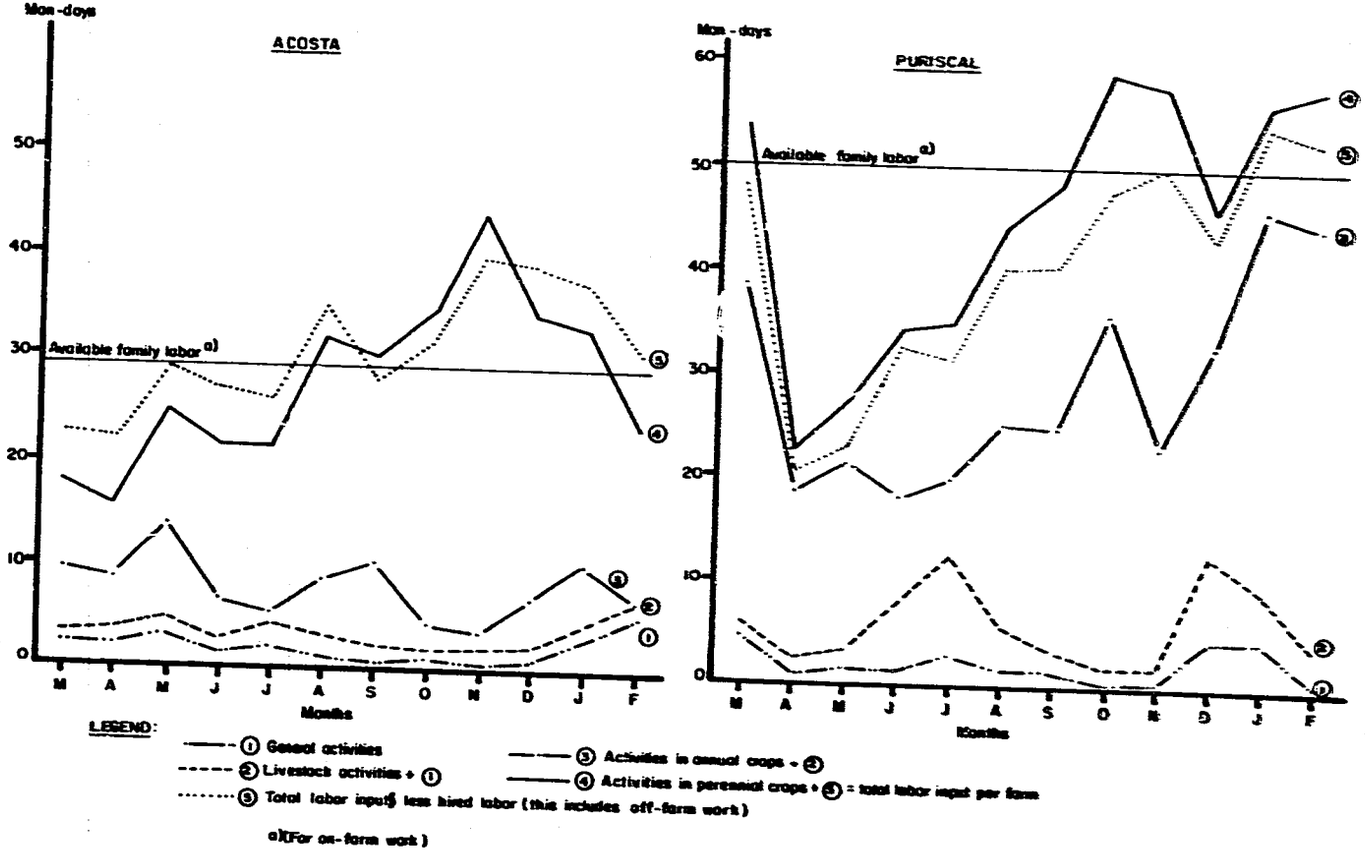

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Table 25:

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4.5.3 Work off-farm work

Work outside the farm plays an important role especially in Acosta. In total, a farmer works outside his own land an average of 94 days/year in Acosta compared with only 28 days in Puriscal. Comparing contracted labor with the total work on the farms (see Figure 17), only in the months from September to November is there a need for hired labor since during the rest of the year the number of days for work outside the farm is higher compared to hired labor.

This does not apply in Puriscal where hired labor is always greater in days than the time the farmer spends outside his farm. Nevertheless, one can explain more clearly labor off the farm and its relation to hired labor on the farm by dividing them into those farmers who contract labor on the farm and work off the farm, those who only work off the farm, and those who only contract labor and do not work off the farm (see Table 25).

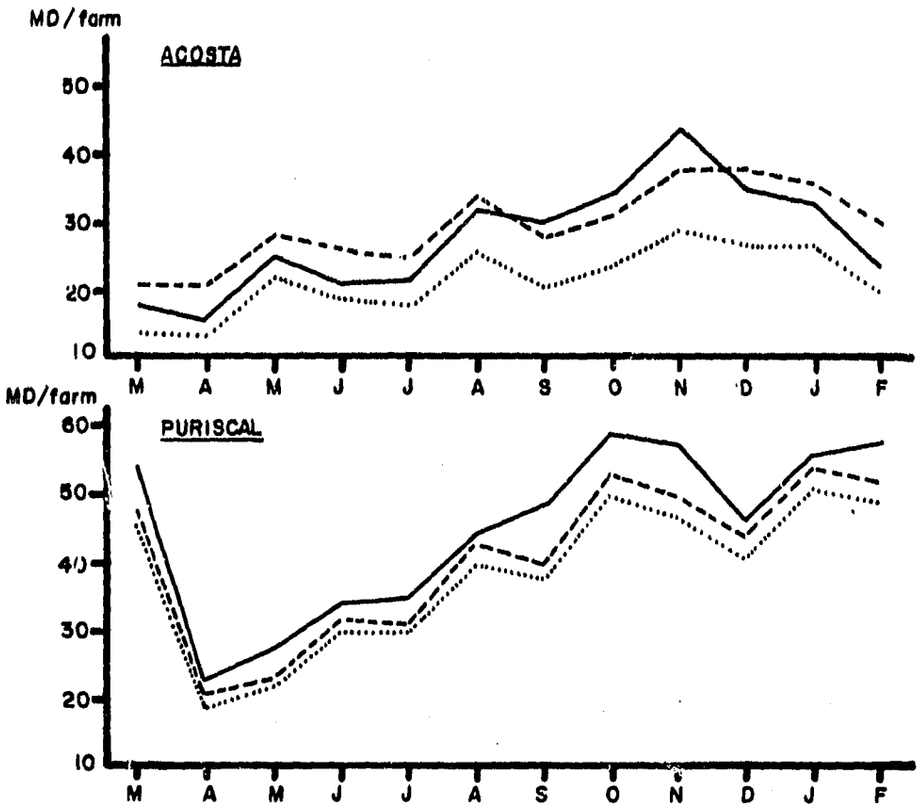
Table 25: Work outside the farm and hired labor. (Average in man-days MD per year according to farm type, number of farms and percentages).

FARM TYPE		ACOSTA			PURISCAL		
Outside work	Hired labor	n	% of farm	MD Per year	n	% of farm	MD Per year
No	no	7	18	--	1	4	–
Yes	no	12	30	96	2	7	26
Yes	yes	15	38	173/96	6	21	27/50
No	yes	6	15	190	19	68	131
TOTAL		40	101b)	94	28	110	28

a) In case of outside work and hired labor of less than 7 days/year, the value zero was assigned.
b) Error from rounding.

Furthermore, the fact must be considered that only one of the farmers in Puriscal worked outside the farm in an area other than agriculture (however, his sons work on the farm while in Acosta there were 8 (30% of those working outside). This is explained because in Acosta more work is done outside the farm than is hired because of obligations; moreover,

Fig. 17 Comparison between total farm labor input, family labor input and off-farm activities. Average MD/farm



LEGEND:

——— Total farm labor

– – – – Family labor input plus off-farm activities

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farmers earn more working outside the farm (per hour or day) than they can on their farms. 30% of the farmers working outside have little land and can usually do all labor on the farm with family resources. In Puriscal, the majority of farmers contract labor (68% of the farm) while outside work is of less importance.

4.5.4 Restrictions on labor availability

The analysis of labor use during the year shows that:

- Available family labor is sufficient in Acosta to take care of the current organizational requirements of the farms. Only during the coffee harvest is it necessary to contract additional workers.
- An intensification of coffee production could lead to labor shortages during the harvest. Taking as a base the work invested in coffee caturra in Puriscal and assuming that the work correlates with yield (see Section 4.6), an estimated increase of labor in November could reach 13 days per farm. There is no question that this additional input could be covered with the correspondingly high incomes since the negative migration from this area signifies that better salaries are available outside the area. The family structure, on the other hand, shows that the necessary labor potential does exist within the family.

On the whole, it can be said that labor is a limiting factor in the current organization of the farms. A mechanization which would reduce the labor demand is not possible. A considerable increase of income therefore requires:

- New production techniques and new plant varieties with increased production and/or
- A higher supply of available labor.

It is believed that both possibilities are practical. There are varieties with high production (caturra and others). The observations show that many farmers (among them young people) prefer to remain on the farm when the income is sufficiently high and stable.

4.6 PRODUCTION AND PRODUCTIVITY

The following section describes the results of the economic analysis of the farms. Receiving equal attention are the land and labor productivities per farm enterprise, and the economic indicators of the whole farm. Also, factors influencing agricultural production will be presented.

4.6.1 Production and productivity per farm enterprise

4.6.1.1 Production per farm enterprise

The physical production (quantity/ha) is tabulated in Tables 26 to 29, according to the distribution of yields[32]/.

While the maize yield is higher in Puriscal (2.061 and 1.700 kg/ha) the yields of maize associated with beans is a little lower than in Acosta, but the bean yield must also be considered. It must be added that the surveyed year was, according to the farmers, bad for beans, and other years have produced better yields. The coefficient of variation for maize is relatively low in Puriscal (21%). On the whole, the production level is high, compared to the Agricultural Census of 1973[33]/ which gives a number for maize of 1.253 kg/ha (Puriscal) and 790 kg/ha (Acosta).

With respect to the "covered bean" harvest, better results were obtained in Acosta than in Puriscal with averages of 528 kg/ha and 463 kg/ha respectively. The "covered bean" without fertilizer and weeding has a higher yield in the two areas than planted beans in association with maize in the first season even if one takes into account only those fields in which there were no bean losses. The yields from the ten fields of planted beans seems very high with an average of 1.000 kg/ha in Puriscal, but this coincides with the elevated yields in "covered beans" where the harvest was better than in other years[34]/.

In tobacco, the yield averaged 1.144 kg/ha which corresponds to the number given by the Tobacco Protection Board for 1980-1981 (average of 1.130 kg/ha)[35]/. However, the yield distribution shows that it is possible to increase the yields considerably, since 42% of the fields give between 600 and 899 kg/ha in comparison with 26% which produce between 1.200 and 1.499 kg/ha.

32/ All figures for yield do not include storage losses.

33/ DIRECCION GENERAL DE ESTADISTICAS Y CENSOS: Ministerio de Economía Industria y Comercio. Censos Nacionales de 1973 "Agropecuarios". San José, 1974.

34/ According to the farmers.

35/ La Nación. Sunday, 15 November 1981. p. 16B.

ted in Tables 26 to

1 and 1.700 kg/ha) than in Acosta, but d that the surveyed d other years have maize is relatively l is high, compared mber for maize of

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Table 26: Distribution of the maize yield/ha (Percentages of fields per class and total average).

CLASSES (KG/HA)	ACOSTA	PURISCAL		
	Maize alone n = 32	Maize alone n = 13	Maize-bean n = 26	
0– 799	6	0	12[a)]	
800–1.599	44	15	35	
1.600–2.399	25	46	42	
2.400–3.199	19	38	8	
3.200–3.999	3	0	4	
TOTAL AVERAGE, $\bar{X}$	1.700	2.061	1.629[a)]	202[b)]
kg/ha CV%	47	21	45	118

a) Maize
b) Beans; the yield is low because 42% of the fields were lost, the average of the harvested fields is 349 kg/ha with a CV% of 60.

Table 27: Distribution of the covered beans and planted beans yield/ha (Percentages of fields per class and total average).

CLASSES (KG/HA)	ACOSTA	PURISCAL	
	Covered beans n = 42	Covered beans n = 11	Planted beans n = 10
0– 299	10	45	10
300– 599	50	18	10
600– 899	38	9	30
900–1.199	2	18	10
1.200–1.499	0	9	10
1.500–1.799	0	0	30
TOTAL AVERAGE, $\bar{X}$	528	463	1.000
Kg/ha CV%	37	93	54

Table 28: Distribution of yield/hectare of tobacco (Percentages of fields per class and total average).

CLASSES (kg of dried leaves/ha)[a]	PURISCAL n = 19
300– 599	5
600– 899	42
900–1.199	11
1.100–1.499	26
1.500–1.799	0
More than 1.800	16
TOTAL AVERAGE, $\bar{X}$	1.144
Kg/ha	50

a) Tobacco sold.

Table 29: Distribution of yield/hectare of coffee (Percentages of fields per class and total average).

CLASSES (BASKETS/HA)	ACOSTA		PURISCAL	
	Caturra n = 13	Other var. n = 58	Caturra n = 16	Other var. n = 13
0–149	31	29	0	31
150–299	15	28	13	23
300–449	0	19	25	15
450–599	15	12	31	8
More than 600	38	12	31	23
TOTAL AVERAGE, $\bar{X}$ baskets/ha[a]	477	318	764	400

a) One basket of freshily picked coffee beans is approximately 2.3 kg of dried coffee.

In the different stratas of coffee, one encounters great differences especially in Puriscal. While the harvest of other varieties was 400 baskets per hectare (920 kg/ha of dried coffee), caturra rendered almost twice that (764 baskets, 1.760 kg per hectare). In Acosta the difference is not as pronounced, since caturra, due to its younger age, gave 477 baskets per hectare (1.100 kg) and other varieties 318 baskets (730 kg). There exists in both Acosta and Puriscal, a great potential for an increase in production (taking into consideration the obtained yields from the best farms).

With sugar cane, it is more difficult to estimate the physical yield, since cane is processed right on the farm as unrefined brown sugar (the juice from the cane is boiled to remove the water). The remaining mass is left to cool in blocks of approximately one pound[36]/. However, the production of unrefined brown sugar has importance on only 12 farms and this, to a small degree (see Section 4.6.2)

Table 30: Production of unrefined brown sugar in kg/ha of sugar cane[a)]

CONCEPT	ACOSTA			PURISCAL		
	n	kg/ha	C.V.%	n	kg/ha	C.V.%
Kilogram brn. sugar	7	808[b)]	85	5	1.057	62

a) 1 block = 1 pound of 474 grams
b) Including one harvested field

Animal products consist of milk and meat (cattle), meat (pigs), eggs and meat, (chickens); one farmer also keeps bees. For the different products, production is expressed only in monetary terms (Table 31). The calculations were done on the basis of the following numbers:

36/ According to local measurement terms: 4 blocks = 1 "tamuga", 20 tamugas = 1 labor = 20 "weights". A "weight" is, according to the farmers, "that which one man can lift" of harvested sugar cane.

Milk: Cebú and native cattle breeds with an average of 1.9 liters/day/year; Holstein and Jersey breeds, 2.4 liters/day/year. The monetary value was ₡ 4.00/liter with averages calculated on data obtained in the survey. Only farms which milk their cows were taken into account.

Eggs: This was calculated with 44% of the chickens laying and a production of 0.5 eggs/day/chicken. Eggs were valued at ₡ 1.00 each.

Meat: Meat from chickens as well as cattle and pigs was taken into account according to sales and farm consumption.

Table 31: Animal production (Average in ₡ per farm and animal type).

	ACOSTA			PURISCAL		
	n	production	CV%	n	production	CV%
Cattle	22	6.381	83	19	16.914	125
Pigs	15	677	120	3	400	173
Chickens	36	2.438	113	16	2.637	70
Bees	–	–	–	1	5.575	–

Production itself does not say much about benefits obtained from each of the crops. Only the gross margin, that is, the value of the production reduced by the variable costs, gives information about what is effectively kept from each farm enterprise. Table 32 summarizes the respective values. On the whole, the production value must be reduced by 15% to obtain the gross margin, although this varies greatly: from 0.4% for "covered beans" to 27% for coffee (other varieties) in Acosta. One must take into account that these variables include hired labor as well as costs involved in coffee plantation renovations.

Table 32a: Production value, variable costs[a)] and gross margin per hectare by crop.

	ACOSTA		PURISCAL		t value
	₡/ha	CV%	₡/ha	CV%	
MAIZE ALONE					
Production value	7.641	47	9.277	21	1.95*
Variable costs	909	111	1.664	76	2.11**
Gross margin/ha	6.732	48	7.613	34	0.87
MAIZE-BEANS					
Production value	–	–	9.345	42	–
Variable costs	–	–	1.385	71	–
Gross margin/ha	–	–	7.960	55	–
PLANTED BEANS					
Production value	–	–	18.000	54	–
Variable costs	–	–	1.780	52	–
Gross margin/ha	–	–	16.220	56	–
COVERED BEANS					
Production value	9.502	37	8.336	93	0.49
Variable costs	947	78	637	52	2.04**
Gross margin/ha	8.555	46	7.699	99	0.36
TOBACCO					
Production value	–	–	35.821	49	–
Variable costs	–	–	7.251	46	–
Gross margin/ha	–	–	28.570	55	–

Table 32b: Continued from Table 32a.

	ACOSTA		PURISCAL		t-value
	₡/ha	CV%	₡/ha	CV%	
SUGAR CANE					
Production value	13.118	110	11.212	78	0.28
Variable costs	54	265	559	160	1.49
Gross margin/ha	13.064	110	10.653	81	0.33
COFFEE CATURRA					
Production value	39.592	79	62.331	71	1.55
Variable costs	5.930	69	7.604	52	1.12
Gross margin/ha	33.662	90	54.729	80	1.47
COFFEE, OTHER VARIETIES WITH FERTILIZER					
Production value	34.252	61	35.635	86	0.14
Variable costs	6.175	80	5.065	60	0.70
Gross margin/ha	28.076	63	30.567	91	0.28
COFFEE, OTHER VARIETIES WITHOUT FERTILIZER					
Production value	18.408	74	15.421	61	–
Variable costs	921	168	520	141	–
Gross margin/ha	17.488	80	14.901	59	–

a) For details see Annex.

4.6.1.2 Productivity by farm enterprise

Obtained with the gross margin per hectare was the land productivity which is presented in Figure 18, where is seen clearly the importance of the cash crops such as coffee, tobacco, and at certain land extensions, sugar cane. One can also see the superiority of coffee caturra in Puriscal (with or without fruit trees); the higher gross margin in Acosta (caturra with fruit trees) comprises only two-third parts of the gross margin of coffee caturra (without fruit trees) in Puriscal. The other coffee varieties have a clearly

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lower gross margin than caturra although the difference is not as pronounced in Acosta, since the traditional varieties still have major importance there, and the input intensity on caturra does not seem to be the same as in Puriscal.

For the food crops, planted beans is the most successful; two factors cause the good result —the favorable time of the planting, and the good prices received at harvest. These high prices[37]/ also influence the good results with "covered beans", which have a much lower yield than the planted beans, but also have lower variable costs (without fertilizer or other agro-chemicals).

Maize and maize/beans have the lowest gross margins of all the crops. In the case of maize/beans in Puriscal, this is due, above all, to the loss of the beans in 42% of the fields. It is assumed that in other years, without these losses, the result would be greater.

The labor productivity is described in Figure 18, and Table 33, (expressed as gross margin per man-day)[38]/.

The superiority of beans is clearly noted with an investment of 277, 217, and 317 colones ("covered beans" in Acosta and Puriscal and planted beans in Puriscal, respectively.

There is a different result with coffee which has a high productivity in labor as well as land. The greatest labor input is in coffee caturra, especially in Puriscal, which is reflected in the fact that the gross margin/man-day are more similar between the different strata than the gross margin/ha. The yield is higher in caturra, requiring more labor per harvested unit. Nevertheless, one expects that most important for the farmers is an increase in net farm income.

37/ ₡ 18.00/kg of grain compared to ₡ 10.00/kg at the time of the first planting.

38/ In this case, gross margin is calculated on a different basis than the others: The production value has not been reduced by hired labor costs since what was wanted was the total labor productivity.

Table 33: Labor productivity per enterprise. Gross margin/man-days according to enterprise (in colones/ha).

	ACOSTA		PURISCAL	
	GM/MD	CV%	GM/MD	CV%
Maize	111	94	152	53
Maize/bean	–	–	132	60
Planted beans	–	–	317	70
Covered beans	277	61	217	96
Tobacco	–	–	164	62
Sugar cane	92	103	104	95
Coffee caturra	167	58	240	64
Coffee, other varieties with fertilizer	154	52	208	59
Coffee, other varieties without fertilizer	203	116	178	59
Annual crops, total	194	85	168	85
Perennial crops, total	150	94	165	112
Animals, total	212	–	294	–
Cattle only	245	–	256	–

It is interesting to observe that the labor productivities are more similar between the various enterprises than are the land productivities. The lowest gross margin/man-day in Açosta (sugar cane) is 33% of the highest value obtained with "covered beans", in land productivity, this index is 18%. The same is true in Puriscal, where the gross margin/man-day for cane as the lowest value is also 33% of that obtained with planted beans. In land productivity, maize reaches only 13% of the gross margin of coffee caturra. Also, the labor productivity for the livestock, extensive as it is, stays within the range observed for crops in both Acosta and Puriscal. Only the productivity of cattle only is higher (₡ 290/man-day in Acosta, ₡ 412/man-day in Puriscal).

Thus:

– The cash crops (coffee and tobacco) combine a high productivity of land and of labor.

rgin/man-days

PURISCAL	
GM/MD	CV%
152	53
132	60
317	70
217	96
164	62
104	95
240	64
208	59
178	59
168	85
165	112
294	—
256	—

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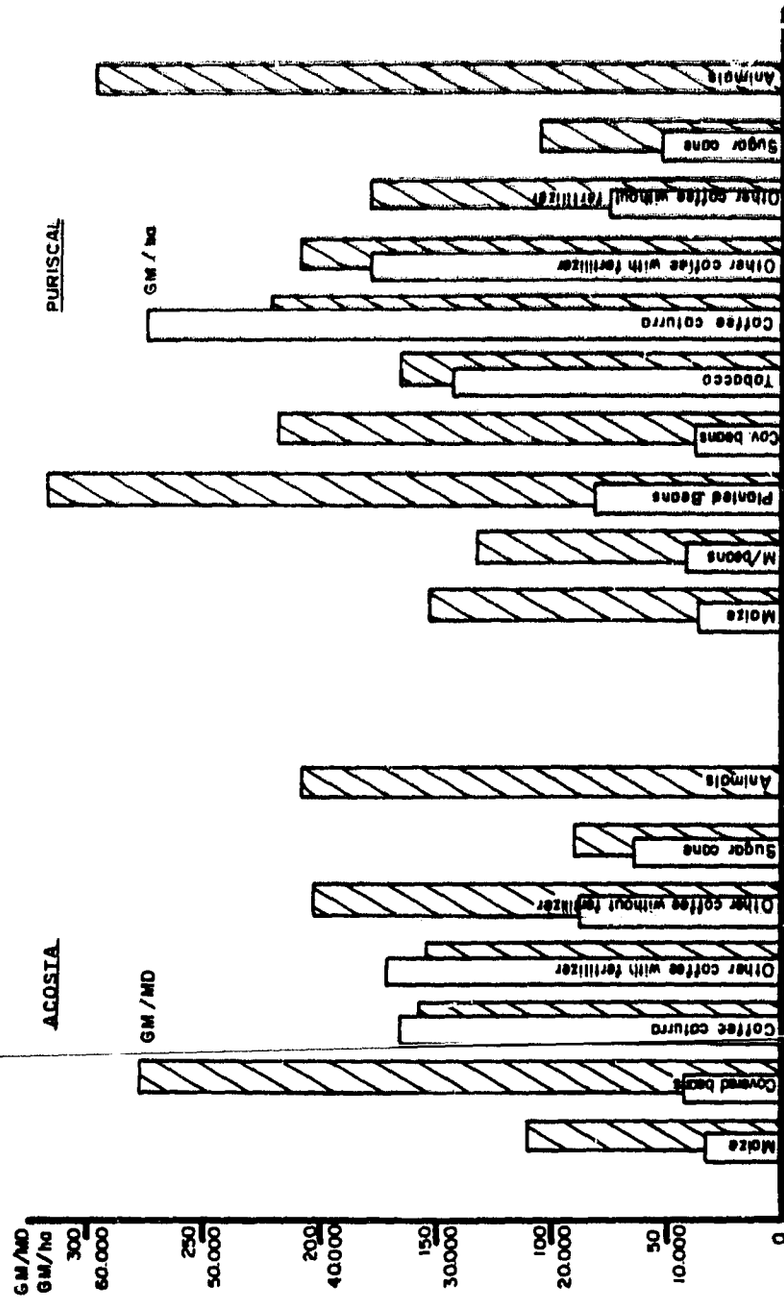
Fig. 18 Gross margin/ha and per man-day in the most important enterprises



- It is supposed that in coffee, the farmers fall into the range of decreasing marginal returns to labor since the difference between land productivity with different intensities of coffee is greater than for labor productivity.
- The farming system is principally organized with emphasis on the cash crops. Basic grains, although necessary and indispensable for the farmers, are directed according to the necessities of the cash crops, that is, to maintain the labor requirement at a low level for the former during the important periods for coffee and tobacco.

4.6.1.3 Yield influencing factors

For an analysis of the factors that influence production, regression models were calculated with various factors (see Table 34) such as invested labor, plant densities, etc. Regression models, linear and Cobb-Douglas type, with one or more variables were used. As a result of the analysis, linear regressions explain the relationships best.

Table 34 summarizes the best obtained results, that is, the functions with an R^2 of more than 0.35. These results indicate that:

- There are significant relationships and, with an R^2 relatively high, particularly in cash crops, tobacco and coffee. The exception is planted beans in Puriscal in which plant density, labor for weeding, and fertilizer explain 93% of the observed variation.
- In the different stratas of coffee, pruning seems to be an important factor since it enters into four of the five functions; three times with a high significance (1%). The other factors encountered in the functions are: number of trees, fertilizer, labor for weeding, and age of the coffee plants. However, with one exception (coffee of the other varieties with fertilizer) the R^2 does not exceed 50%.
- Taking coffee as a whole, in Acosta and Puriscal, one observes that three independent variables, "labor for weeding" (X_7), "labor for pruning" (X_8), and "fertilizer" (X_1) are the principal yield influencing factors.
- In the other basic grains, one encounters sufficiently clear relationships only in "covered beans" (Acosta), and maize as a sole crop (Puriscal). The plant density in "covered beans" explains 38% of the observed variation, at a high level of significance (1%). For maize three variables enter: "value of other agro-chemicals" (X_2), "time between planting and first weeding" (X_5) and "date of planting" (X_4), however, the significance level is higher than 10%.

Table 34: Regression models estimated by stepwise regression to explain the production of the crops in the

Table 34: Regression models estimated by stepwise regression to explain the production of the crops in the areas.

CROP	EQUATION[a)]	n	R^2	F
ACOSTA				
Covered beans	$Y_1 = 34.9 + 4.1^{***}x_3$	42	0.38	24.6***
Coffee caturra	$Y_2 = 1.968.6 + 600.8^{*}x_7 + 7.8x_{10}$	13	0.42	3.7*
Coffee, other varieties with fertilizer	$Y_2 = 10.127.3 - 540.6^{***}x_8 + 21.2^{***}x_9$	39	0.47	16.4***
Coffee, other varieties without fertilizer	$Y_2 = 8.875.3 + 1.226.5^{***}x_8$	19	0.47	14.9***
Total coffee	$Y_2 = 9.006.6 + 158.1x_7 + 560.3^{***}x_8 + 16.4^{***}x_1$	71	0.42	16.0***
PURISCAL				
Maize	$Y_1 = 2.397.2 + 0.7x_2 + 76.0x_5 - 70.9x_4$	13	0.37	1.7
Planted beans	$Y_1 = 2.050.2 - 5.9^{**}x_3 + 22.8^{*}x_7 + 5.9^{***}x_1$	10	0.93	30.8***
Tobacco	$Y_2 = -5.579.1 + 5.7^{***}x_1 + 250.5^{*}x_4$	19	0.43	6.0***
Coffee caturra	$Y_2 = 105.501.9 + 1.344.4^{*}x_8 - 9.6x_{10} + 4.550.3x_9$	16	0.44	3.2*
Coffee, other varieties with fertilizer	$Y_2 = -14.533.2 - 629.1^{*}x_7 + 1.926.2^{***}x_8 + 1.305.8x_9$	11	0.83	11.1***
Total coffee	$Y_2 = -526.7 + 492.7^{*}x_7 + 1.036.2^{**}x_8 + 19.9^{*}x_1$	29	0.47	7.5***

a) Y_1 = Yield in kg/ha
Y_2 = Production value ₡/ha
x_1 = Fertilizer kg/ha
x_2 = Value of other agro-chemicals ₡/ha
x_3 = Plant density/10 m^2
x_4 = Planting date in weeks
x_5 = Time between planting and first weeding (in weeks)
x_6 = Labor for planting (man-days)
x_7 = Labor for weeding (man-days)
x_8 = Labor for pruning
x_9 = Age of coffee plants
x_{10} = Number of coffee trees per hectare

* = Significant to 10%
** = Significant to 5%
*** = Significant to 1%

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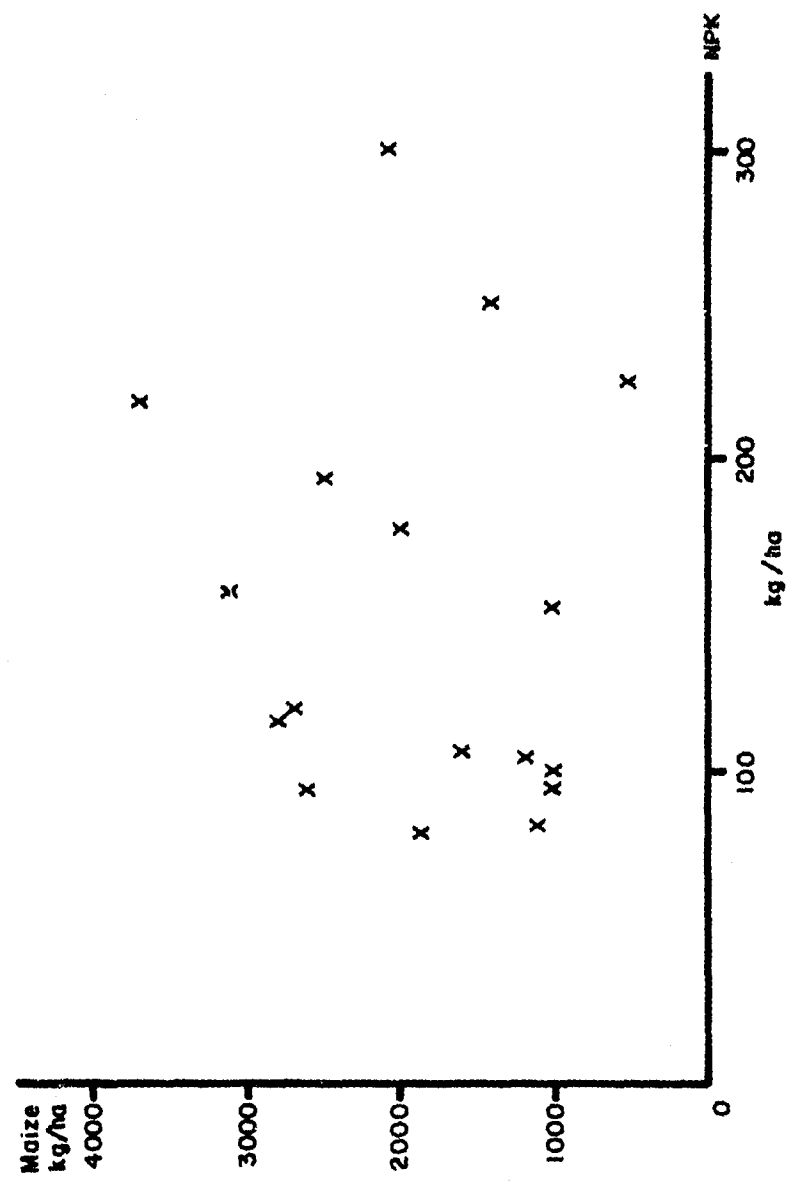


Fig. 19 Relation between maize-yield and level of NPK fertilizing in Acosta

The fact that the linear functions best describe the relationship between the production factors and production itself, indicates constant marginal returns within the range of observation.The production is, therefore, not at its optimum level.

Because the measured husbandry factors are executed with greater care in cash crops, they give a better explanation of observed variation in the yields.

Here the production level is sufficiently high that the influence of factors under the farmers' control (such as pruning, weeding, fertilization, etc.) are more important than the influence of erratic variation and natural factors (rainfall, soil, plague infestation, etc.) which were not measured.

In basic grains, on the other hand, although they have a relatively high production level, the influencing factors used in the models explain only a small part of the observed variation in yields. Only in the case of planted beans which have a very high production level, is the situation different. Figure 19 gives an example of the ample dispersion of the relation between yields and fertilizer input that was encountered frequently in the production of basic grains in the study region.

4.6.2 Production and productivity per farm

4.6.2.1 Production value, gross margin, and net family income of the farm

The total value of production is tabulated, with its origins, in Table 35.

In Puriscal, it is twice that for Acosta (₡ 118,722 and ₡ 57,214 respectively), a proportion that somewhat increases the gross margin and the net family income in favor of the Puriscal farms.

Figure 20 shows the gross margin components. It can be observed that the diversification on the Puriscal farm is better than on those in Acosta, since the two cash crops (coffee and tobacco) do not contribute –in percent– as much of the gross margin as only coffee does in Acosta. Nevertheless, in absolute numbers, the production value of coffee is higher on the Puriscal farms than on those in Acosta.

The variable costs diminish the average production value by 20% in Acosta and 18% in Puriscal, although with great difference on the farms, since the variation coefficient is 111% for Acosta and 91% in Puriscal. The gross margin thus obtained, is reduced by the general costs (that is, costs that cannot be assigned to particular farm enterprises) and depreciation[39]/ to arrive at the net family income of the farm. This average at almost ₡ 43,000

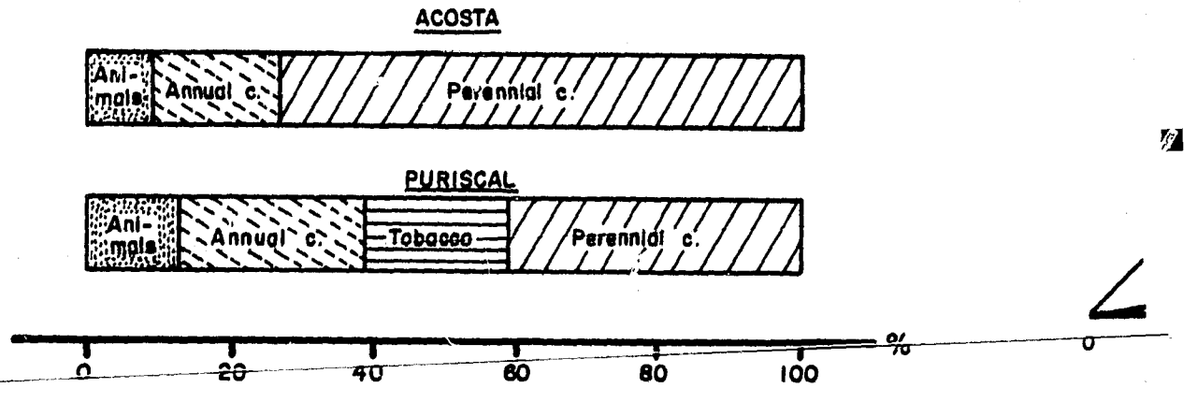
39/ For the calculation, see the Glossary.

Table 35: Total production value, origin, gross margin and net family income from the farm (averages in colones per farm).

	ACOSTA		PURISCAL	
	$\bar{x}$	CV%	$\bar{x}$	CV%
Production value of:				
Annual crops	9,650	137	56,039	114
Perennial crops	41,354	104	49,092	146
Animals	6,210	111	13,591	142
Total value	57,214	79	118,722	75
Variable costs	11,418	111	21,683	91
Gross margin	45,796	78	97,039	77
General costs[a)]	1,303	358	298	433
Depreciation	1.615	119	3.284	148
Net family income from the farm	42,878	76	93,457	77

a) All those costs which cannot be assigned to a certain enterprise, for example rent, general transportation, etc.

Fig. 20 Composition of gross margin per farm



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PURISCAL	
$\bar{x}$	CV%
56,039	114
49,092	146
13,591	142
118,722	75
21,683	91
97,039	77
298	433
3.284	148
93,457	77

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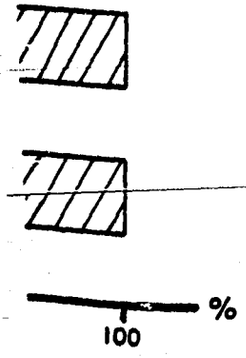
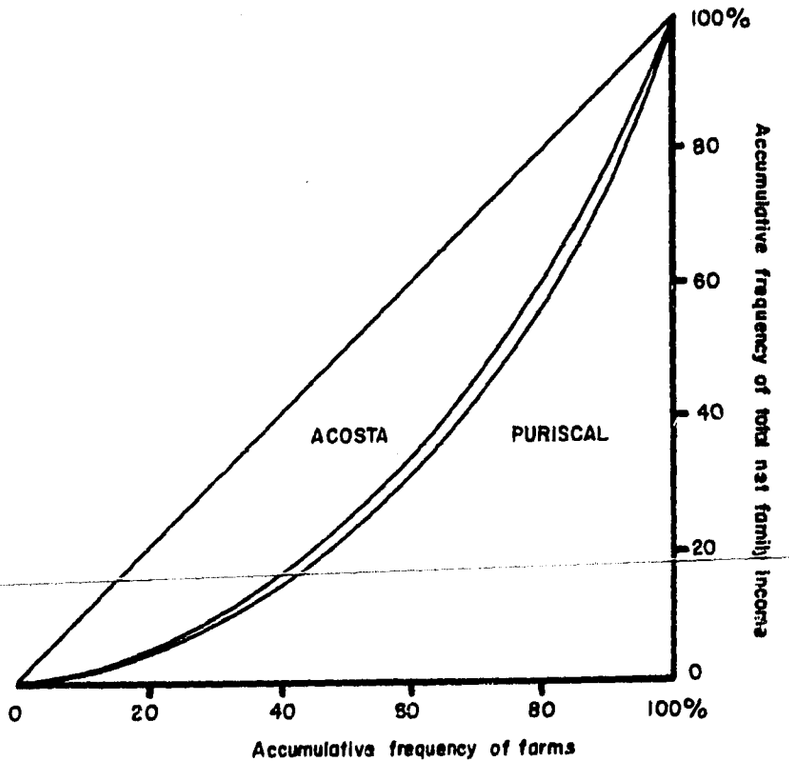


per year in Acosta and ₡93,500 in Puriscal. The distribution can be noted in Figure 21 (accumulated frequencies) and in Figure 22 (classes), compared with the total family incomes (including income from outside the farm).

Although the incomes in Puriscal are double than those in Acosta, one can see that the line of concentration is very similar to that of Acosta. This signifies that the income level of all farms in Puriscal is higher than those of Acosta.

Another criterion for evaluating the farm situation is the gross margin per man-equivalent of the farm, which indicates the productivity of available labor. This value is ₡ 60,300 in Acosta (V.C. = 161%) and ₡ 55,000 (V.C. = 109%) in Puriscal[40]/. Comparing this with the total gross margin of the farms per total work day that is accomplished on the farms (₡ 137 in Acosta and ₡ 180 in Puriscal), it is assumed that the men-equivalents in Acosta are underestimated. Consequently, there is possibly more available labor than is indicated in Figures 15 and 16.

Fig. 21 Distribution of total net family income



40/ There is no statistical significance: T=0.28.

4.6.2.2 Off-farm income

The incomes earned outside the farm play an important role on the small farms particularly (less than three hectares), as much in Acosta as in Puriscal. Table 36 gives the respective indexes: in absolute numbers, the farmers with small farms contribute ₡ 8,163/year (Acosta) and ₡ 3,479/year (Puriscal) in off-farm income to the total income of the farm. On farms with more than three hectares these figures are ₡ 7,592 in Acosta and ₡ 1,193 in Puriscal[41]/. The relative indexes demonstrate more clearly the importance of the off-farm incomes: on 50% of the farms of less than three hectares in Acosta, the off-farm income contributes 26% of the total net family income. In Puriscal, this number is 11% compared to 1% for farms of more than 3 ha.

Table 36: Off-farm income compared to total family income according to farm size (averages per farm).

CONCEPT	ACOSTA		PURISCAL	
	Farm size		Farm size	
	< 3 ha	3 and more	< 3 ha	3 and more
Total family income[a)]	31,078	37,660	33,114	124,776
Off-farm income	8,163	7,592	3,479	1,193
V.C.%	92	177	120	233
Off-farm income as % of total family income	26%	10%	11%	1%

a) Without deductions for depreciation.

41/ On one farm in Acosta, two older sons work full-time outside the farm, but contribute their entire income to the farm. Without this circumstance, the average for the over three hectare class would be reduced to ₡ 5,704/year.

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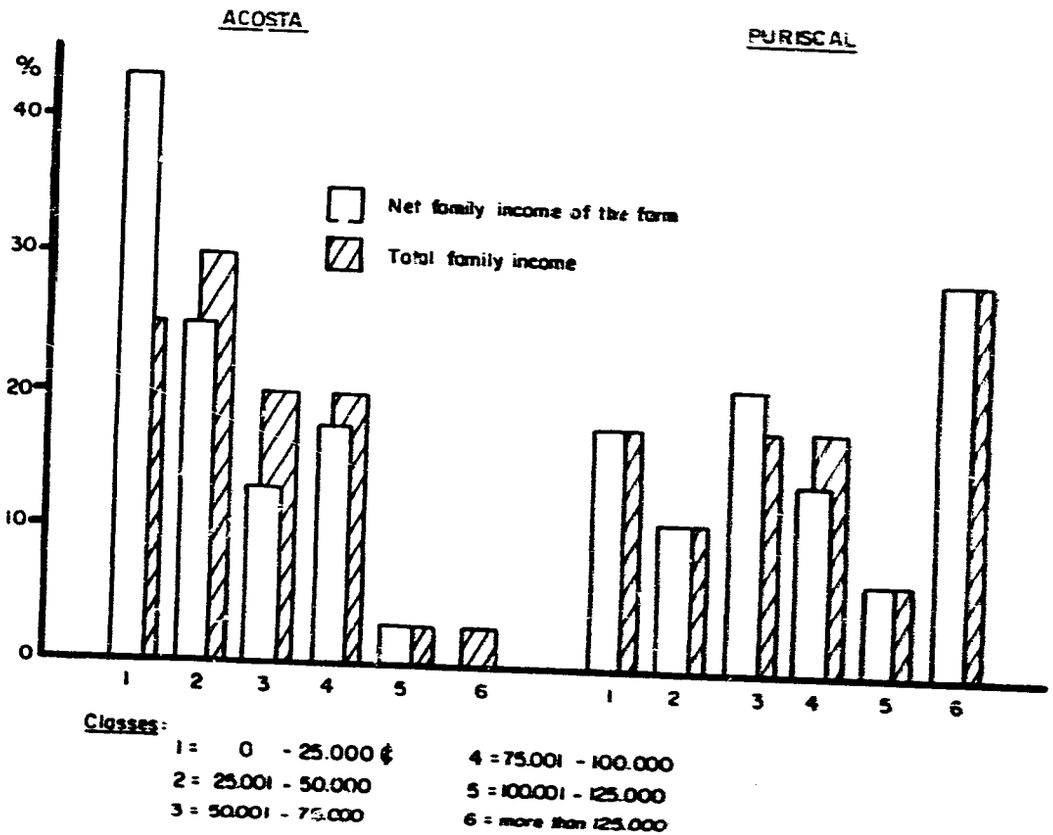
Table 37 shows, in more detail the participation of off-farm income as part of total family income.

Table 37: Contribution of off-farm income according to importance (percentage of farms by classes).

Income from outside the farm in % of total family income	ACOSTA	PURISCAL
0	27.5	64.3
1–25%	40.0	28.6
26–50%	20.0	7.2
more than 50%	12.5	0

Figure 22 demonstrates the change in the income structure for the farms. Particularly in Acosta, the farms with a net family income from the farm of less than ₡25,000 (43%) improve their balance with the additional incomes. This group includes only 25% of the farms. In Puriscal, on the other hand, the additional income is of less importance as it has been seen earlier.

Fig. 22 Distribution of net family income of the farm and total income per farm (percentage of farms per class)



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4.6.2.3 Factors influencing net family income from the farm

Of the factors that influence the net family income from the farms, the following have been included in regression models.

- Total labor input (X_1)
- Managed land (X_2)
- Total variable costs (X_3)
- Land under crops (X_4)
- Owned land (X_5)
- Off-farm income (X_6)

In all cases, the Cobb-Douglas functions[42]/, rather than linear functions, better explain the relationships. Table 38 summarizes the obtained results and shows that:

- All the relations are positive which indicates that in no case is there an exaggerated use of resources.
- In both Acosta and Puriscal, only the total labor input had a elasticity above 1, signifying that the marginal return increases within the observation range.
- The marginal return to land under crops is almost constant (elasticity approximately 1).
- Managed land and variable costs have an elasticity less than 1. Their marginal returns decrease but remain positive.
- The combination of the factors, land under crops (X_4) and labor (X_1) show a high R^2 value. However, the low elasticity value in Puriscal for the variable "land under crops" shows that, *ceteris paribus*, labor is more important. In Acosta, with its smaller farms, the elasticities for land under crops and labor input are equal. The sum of the two coefficients is greater than 1. This signifies increasing returns to scale, which implies that if the farmer increases the use of these two production factors, he will receive a higher proportional increase of the net family income from the farm.

In general, it can be stated that the production level and the level of input use is high in the Acosta-Puriscal region compared with other regions[43]/. It was found that resources are being rationally used.

42/ $Y = abx^n$

43/ See: van TIENHOVEN, N. , ICAZA, J., and LAGEMANN, J.: Farming Systems in Jinotega, Nicaragua, CATIE, Turrialba, 1982.

Table 38: Regression models (Cobb-Douglas) to explain net family income from the farm.

AREA	EQUATION	R^2	F
AGOSTA			
	$Y = 4.3\ x_1\ 1.1^{***}$	0.64	67.9
	$Y = 9.7\ x_2\ 0.6^{***}$	0.48	35.5
	$Y = 5.8\ x_3\ 0.5^{***}$	0.37	22.2
	$Y = 9.7\ x_4\ 0.99^{***}$	0.65	71.5
	$Y = 6.7\ x_4\ 0.6^{***}\ x_1\ 0.6^{***}$	0.73	50.7
PURISCAL			
	$Y = 4.4 x_1\ 1.1^{***}$	0.76	82.8
	$Y = 10.3\ x_2\ 0.5^{***}$	0.46	22.3
	$Y = 4.4\ x_3\ 0.7^{***}$	0.57	35.2
	$Y = 9.9\ x_4\ 1.04^{***}$	0.57	34.9
	$Y = 4.7\ x_4\ 0.09\ x_1\ 1.04^{***}$	0.76	40.1

Y = Net family income from the farm
x_1 = Total utilized labor
x_2 = Managed land
x_3 = Total variable costs
x_4 = Area under crops (ha)

4.7 STORAGE AND MARKETING

Storage is important only for basic grains:

- Coffee is taken on the day of harvest to the receivers who operate the different factories ("beneficios") in the region.
- Although tobacco is kept on the farm after harvest for drying and classification, it is taken as quickly as possible to the tobacco companies.
- Vegetables are sold immediately after harvest.
- Sugar cane as blocks of unrefined brown sugar is sold immediately or consumed on the farm. Its production throughout the year avoids the need for storage.
- Citrus is also sold immediately.

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R^2	F
0.64	67.9
0.48	35.5
0.37	22.2
0.65	71.5
0.73	50.7
0.76	82.8
0.46	22.3
0.57	35.2
0.57	34.9
0.76	40.1

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4.7.1 Storage[44]/

The farmers of the entire surveyed region are accustomed to store their crops in sacks (61%), in wooden boxes (27%) and in metal bins (12%).

Maize is dried in the field (doubled) and in different types of cribs without husking. The ears are also hung under the roof of the house.

To reduce losses from the storage of beans, it is usual to use insecticides (Formicida or Phostoxin), (85% of the farmers) and/or mix the crop with lime (6%).

With maize there are no exact numbers, but there are observations of the use of lime or chlordane to prevent insect damage.

In addition to insects, rodents can cause damage, above all, in maize which is more susceptible to animal infestations because of its form of storage.

To summarize, the farmers' opinions with respect to bean losses and reasons for it is found in Table 39.

Table 39: Maize and Bean loss estimations by the farmers and causes throughout the region.

CONCEPT	PERCENTAGE OF FARMERS	
	Maize[a)]	Beans
Losses of		
0%	–	12
10%	50	50
20%	40	30
30%	10	3
Reasons		
Chewing insects		54
Moths		14
Rodents		8
Others		4

a) Data on "reasons" does not exist for maize.

44/ Parts of this Section are from: PLATEN, H. von and RODRIGUEZ, P., G., op. cit. p. 13 and GOLDBACH, H. in PLATEN, H. von and LAGEMANN, J. op. cit. p. 59 ff.

4.7.2 Sales and marketing channels

The total value of sales of all agricultural products reached an average per farm of ₡ 39,990 in Acosta and ₡ 91,652 in Puriscal during the surveyed year.

The superior importance of the cash crops (coffee and tobacco) is reflected in their greater sales (see Table 40). For the rest, the structure between Acosta and Puriscal is different: while fruit and brown sugar account for 14.3% of the sales in Acosta, these are less important in Puriscal (0.1%). On the other hand, in Puriscal, livestock, vegetables and honey account for 12.9% of the sales; in Acosta only 3.3%.

Generally, there is greater diversification on the Puriscal farms. Considering only the incomes from farm product sales (that is, without taking into account off-farm income), there is a danger in the mono-structure of the Acosta farms. A decrease in coffee prices, for example, by 1% reduces farm income in Acosta by 0.82%. In Puriscal, this would be only 0.47% since tobacco assures 38% of the income.

Table 40: Sales according to products (percentages of sales according to product groups).

PRODUCT GROUPS	ACOSTA	PURISCAL
Basic grains	0.3	1.3
Tobacco	–	38.2
Fruit[a)]	6.9	–
Brown Sugar	7.4	0.1
Coffee	82.0	47.5
Animals	3.2	8.1
Others[b)]	0.1	4.8

a) Especially oranges
b) Vegetables, trees, honey

With respect to marketing channels, the percentage that each one represents in sales value have been tabulated in Table 41. Coffee and tobacco have not been included since their marketing channels are well defined. All coffee is bought by five firms operating in the region (one cooperative and

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four private factories). Tobacco is purchased by two tobacco companies with which the farmers have contract for fixed quantities. (However, over production can be sold. Depending on the national and international market, these quantities pay an equal or inferior price than is paid for the contracted amounts).

In Acosta, at least[45]/ 45% of the products (according to value) are kept in the same area, more than one-third being sold through local markets and neighborhood stores. In Puriscal, 35% of the products sold remain in the area (nevertheless, the value in absolute numbers is higher than in Acosta).

Table 41: Marketing channels. (percentages of sales value according to purchaser, without coffee and tobacco).

	ACOSTA	PURISCAL
Neighbors	8.7	6.2
Middle-men	11.2	0.6
Small storeowner, Puriscal[a)]	5.1	–
Small storeowner, Acosta [a)]	36.2	–
Small storeowner, outside the region[a)]	1.6	0.1
Fair in Puriscal[b)]	0.2	19.2
Fair outside the region	25.1	–
Public market, Puriscal	3.7	4.4
Public market, outside the region	1.6	7.9
Livestock arena, Puriscal	0.4	20.6
Livestock arena, Acosta	–	–
Livestock arena, outside the region	2.3	32.2
Other buyers	3.8	2.2

a) For example, neighborhood stores, supermarkets, etc.
b) Institution for direct sales between farmer and consumer.

The products which remain in the area are, for the most part, basic grains, fruit, brown sugar, and vegetables which are sold in the mentioned location. Outside of the area, fruit is sold in great quantities in Acosta (fair, outside the region) and cattle from Puriscal.

45/ For sales to middle-men, for example, the final buyer is unknown.

One observation of interest from Table 41 is that the middle-men do not play a very important role. They account for only 11.2% of the sales in Acosta and 0.6% in Puriscal. This is due principally to the fact that farmers are —normally— well informed about prices and possibilities of selling their products outside of their farm, and the middle-men frequently offer less favorable prices. In addition, some farmers are able to transport their products to a preferred region for sale with their own vehicle, a truck, or bus. The quantity of possibilities produces a competition which favors the farmer.

4.7.3 Prices

To determine the value of the harvests on the surveyed farms, three different methods were used:

- Fixed prices based on price averages obtained by the farmers. Thus, the following values were obtained: maize (₡ 4.50/kg of grain), beans (₡ 10.00/kg of grain in the first season, and ₡ 18.00/kg in the second), milk (₡ 4.00/liter), eggs (₡ 1.00/each). This allows a comparison of the two areas.
- Prices obtained by the farmer at the moment of sale. This was used for vegetables, fruit, brown sugar and animals. Products which were consumed on the farm were given the price that would have been received during the week of harvest.
- Prices given by the buyers: in the case of coffee and tobacco, renumeration is a long process since the products are paid for in stages according to the prices obtained by the buyers (coffee factories or tobacco companies). They were, therefore, assigned values based on expected return (₡ 1,600/measure of coffee, equivalent to ₡ 34.80/kg of dried coffee and ₡ 30.43 per kg of dried tobacco).

For those products having no fixed price, there is a price variation of substantial degree throughout the year.

In the case of oranges, the price depends on two factors: time of year and location of sale. The price of oranges is better when sold closer to the principal markets (San José). During the period of low prices (November to April) the farmer receives ₡ 10.00 for 100 oranges, but could gain ₡ 30.00 for the same quantity in the principal market in San José. In this latter market, up to ₡ 1.00 per orange is paid during the periods when oranges are not generally being harvested.

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For other fruit such as bananas and pejibaye, detailed information was not obtained due to the low quantity of sales for these products. On the average a bunch of bananas or plantains brings ₡ 15.00; the sales are made exclusively in the same area. Pejibaye receives an average of ₡ 3.65 per kg.

Cattle are priced according to their physical condition. A calf of a few months is worth up to ₡ 1,500; at six months ₡ 3,000. The best prices are paid for adult beef cattle which bring between ₡ 8,000 and ₡ 10,000 per head.

4.8 CASH FLOW THROUGHOUT THE YEAR

With the analysis of cash flow comes an analysis of actual monetary inflows and outflows which occur on the farms. One can estimate, therefore, if there is sufficient cash available for incremental investments.

Table 42 presents the respective numbers on the average of the Acosta and Puriscal farms. Although it is not known exactly when payment will be received for coffee, the cash receipts can be estimated according to the experience of past years[46]/.

Thus, it can be seen that:

- In the months of high income from coffee and tobacco (Acosta: June, July, November until January; Puriscal: June, July, November until March) the positive balance is high.
- In other months, the balance is very low and even on the negative side.
- The renumeration system of coffee has the advantage of spreading the income at least over two peaks per year, thus avoiding a long period of very low cash incomes.
- There is a positive balance for the year in both Acosta and Puriscal with average values of ₡ 33,500 and ₡ 75,000 respectively.

The good resulting average of all the farms, however, gives no information about each one of the farms and their cash flow. Table 43 shows the results of the analysis of the farms in Acosta and Puriscal with a positive and a negative balance. The calculation was made for the entire year. A sum of ₡ 10,000/year was calculated as household expenses and deducted from the balance obtained from the calculation in Table 42.

46/ Paid in three installments, around 50% during the harvest, 25% at mid-year and the rest one year after harvest.

CONCEPT	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
ACOSTA:													
Inflows													
Basic grains	35	–	–	–	–	13	–	–	–	–	53	–	101
Fruit	179	270	244	131	252	298	129	187	101	236	436	309	2,772
Brown sugar	20	40	154	215	155	280	210	234	242	272	722	417	2.961
Coffee	–	–	–	4,091	4,091	–	–	–	8,181	12,272	4,091	–	32,726
Animals	63	57	43	111	47	121	225	216	–	184	75	150	1,295
Others	–	13	34	8	–	–	–	–	–	–	–	–	55
Outflows[a)]	282	687	1,560	490	199	657	360	143	743	439	593	250	6,402
Balance	15	–307	–1,085	4,066	4,346	55	204	494	7,781	12,525	4,784	626	33,505
PURISCAL:													
Inflows													
Basic grains	–	11	–	36	89	527	88	–	–	133	266	–	1,195
Fruit	7	3	–	–	–	–	–	–	–	–	–	–	10
Brown sugar	–	–	–	–	–	–	–	–	40	55	38	–	133
Tobacco	17,483	–	–	–	–	–	–	–	–	–	–	17,483	34,966
Coffee	–	–	–	5,440	5,440	–	–	–	10,880	10,880	5,440	5,440	43,520
Animals	89	–	107	–	243	–	–	–	2,321	857	1,643	2,136	7,396
Others	86	332	653	377	508	170	97	113	120	1,213	565	189	4,432
Outflows[a)]	1,594	642	1,813	1,516	899	678	2,299	1,835	2,666	1,550	740	573	16,805
Balance	16,071	–296	–1,053	4,337	5,381	64	–2,114	–1,722	10,695	11,588	7,212	24,675	74,847

Table 43: Percentag

BALANCE FOR YEAR
Positive
Positive only with out
Negative

Results indicat balance is positive on Acosta only because o farm. Nevertheless, eve allow incremental inves Puriscal respectively, th sufficient ones to cover order to finance investm

Animals	89	–	107	–	243	–	–	–	2,321	857	1,643	2,136	7,396
Others	86	332	653	377	508	170	97	113	120	1,213	565	189	4,432
Outflows[a]	1,594	642	1,813	1,516	899	678	2,299	1,835	2,666	1,550	740	573	16,805
Balance	16,071	–296	–1,053	4,337	5,381	64	–2,114	–1,722	10,695	11,588	7,212	24,675	74,847

a) Monthly cash expenses on the farm.

Table 43: Percentage of farms according to positive balance

BALANCE FOR YEAR	ACOSTA	PURISCAL
Positive	72.5	85.7
Positive only with outside income	22.5	3.6
Negative	5.0	10.7

Results indicate that for Acosta as well as Puriscal, the annual balance is positive on the majority of the farms; although this is true in Acosta only because one-fourth of the farms had income from outside the farm. Nevertheless, even on these farms, it is assumed that there is capital to allow incremental investment. On 5% and 10.7% of the farms in Acosta and Puriscal respectively, there are no available funds for investments nor even sufficient ones to cover the cost of living. These farms depend on credit, in order to finance investments on the farm.

5. INTRODUCTION OF INNOVATIONS AND FARMERS' PERCEPTIONS

Rodríguez P., G.[1]/

5.1 INTRODUCTION OF INNOVATIONS AND PAST ADOPTION

In the past, numerous innovations constituting the "traditional agriculture" have been introduced little by little. Farming systems were not and are not stable and apparently are in a constant flux. In general, the farmers are open to new ideas and adopt them whenever they are in line with their objectives and with what is possible[2]/. After basic grains, cash crops such as tobacco in Puriscal and coffee in the entire area were introduced. The small and medium farmers especially adopted these new crops because they permit a better utilization of manual labor and drastically increase the income to the families.

Another stimulus to the production and productivity of the farm was the introduction of new coffee varieties (caturra, principally) about 10 years ago, and the introduction of chemical fertilizers which were applied during the early years mainly on tobacco and coffee. During the last few years, the farmers have begun using fertilizer also on the grains.

An increase in the costs of labor has favored the introduction of herbicides which are applied mostly on coffee. Only a few farmers have replaced traditional pasture grasses with improved one *(Cydodon plectotachyus, Brachiaria ruzziziensis);* this innovation is still new, and the advantages are not widely known in the region.

1/ Agronomy Engineer of the CATIE-GTZ Project: "Farming Systems in Central America".

2/ THRUPP, L. A. Deforestation, Agricultural Development and Cattle Expansion in Costa Rica, M.Sc. Thesis, Stanford University, 1980.

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5.2 TECHNOLOGY TESTING WITH THE SURVEYED FARMERS[3]/

One of the biggest problems are the slopes, particularly when used for annual crops. These crops, during part of the year, leaves the land exposed and subject to the influence of drought and strong rains. Another limiting factor is labor. There is competition for available labor between the different farm enterprises, between activities on the farm and outside, and between the necessity of planting for subsistence and the need for cash income.

Of the 68 surveyed farmers, 74% plant covered beans. Of the total land dedicated to annual crops in the second season, 50% is given to covered beans.

Information from the Agricultural Census of 1973 indicates that the yields from covered beans was very low with 350 kg/ha[4]/.

With the hypothesis that it is possible to increase the production and productivity of the covered beans, a technology package for this crop was designed with the cooperation of the grain specialists from the Agricultural and Livestock Ministry in Puriscal.

The package consists of improved and cured varieties, an increase in plant population density, a light application of fertilizer (150 kg/ha. N-P.K, 10-30-10), and insect control when needed.

In order to compare the farmers' technology with the recommended one, the farmer executed the recommended technology on his own farm.

The natural yield (in grain) from the traditional fields shows an average of 561 kg/ha and from the fields using the recommended technology, 678 kg/ha.

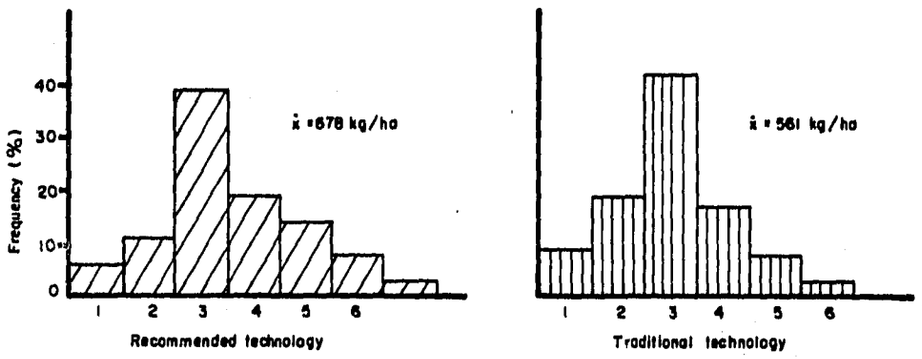
However, the difference of 117 kg/ha on the average is not statistically sure because of the great variation observed from 100 to 1,250 and 1,400 kg/ha.

Figure 23 shows the yield distribution. The two techniques have their best frequency in the classes of 500-699 kg/ha (class 3), but the recommended technology has, contrary to the traditional, the majority of its observations in the high classes.

3/ This section derives from: PLATEN, H. von and RODRIGUEZ, P. G.: La producción de frijol tapado en el área de Acosta-Puriscal, Costa Rica. CATIE, Turrialba, Costa Rica, 1982, 15 p.

4/ DIRECCION GENERAL DE ESTADISTICAS Y CENSOS: Censos Nacionales de 1973: Agropecuario, San José, 1974.

Fig.23 Yield distribution of covered beans



Class :

1 = 100 - 299
2 = 300 - 499
3 = 500 - 699
4 = 700 - 899
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6 = 1100 - 1299
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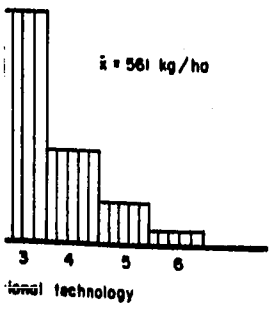
An analysis of the relation between the yield influencing factors and the yield itself indicates that plant density at the time of harvest has the greatest influence on the yield. 51% of the yields are explained by this factor in the fields employing the recommended technology.

The other measured factors (such as chemical elements in the soil, labor) do not show a significant influence alone or in combination. However, there are other factors such as climate, etc., whose influence on yields cannot be explained.

Fertilization, supposedly, has some influence, but this cannot be determined because it did not vary between fields.

The higher costs of the recommended technology are compensated by the higher yields which leave, after inputs and interest deductions, a gross margin of ₡ 1,340 more per hectare (Table 44). Nevertheless, it is not believed that this 12% increase in the gross margin/ha is sufficient to convince the farmers to change to the recommended technology, principally because the high initial cash investment (the traditional technology almost never requires a cash investment) for the production of basic grains intimidates many of the farmers.



As, or more, important than the gross margin/ha is the gross margin per man-day in those periods of the year requiring much labor. In this, the productivity per hour of invested labor is almost the same. The recommended technology pays ₡ 32.00/hour, the farmers' technology pays ₡ 33.00.

Table 44: Gross margin and components per hectare (averages in colones).

	Farmers' technology	Recommended technology
Production value	11,200	13,550
INPUTS:	720	1,700
Seed	675	875
Fertilizer	–	620
ORTHENE	–	70
ALDRIN	–	30
Interests (20% p.y., 4 months)	45	105
Gross margin/ha	10.510	11.850

The risk of a modification can be estimated with an accumulated frequency curve of the yield or of the gross margin. The gross margin gives more information because it contains the costs. Figure 24 demonstrates the frequency curve. It can be noted that the curves are almost equal to a gross margin of approximately ₵ 11,000, which corresponds to an accumulated frequency of 60%.This means, that in the two technologies a gross margin of ₵ 11,000 or less is obtained with a probability of 60% . Apart from the ₵ 11,000, th curve of the recommended technology alwa-- is to the right of the others, which signifies that the higher yields are attained with greater probability using the recommended technology rather than the traditional.

Nevertheless, the differences are small and not significant, therefore a definitive conclusion cannot be drawn.

At the end of the bean harvest, an inquiry was made of the farmers who had a "Technology Test" field.

78% of the farmers attaining an average yield of 760 kg were satisfied with the package while those reaching an average of 387 kg/ha were not. 50% of these latter believed the problem lay with unfavorable conditions (strong winds and rains), while the others thought that the seed was not well adapted to the zone.

Table 45 tabulates the reasons for a good harvest. According to the opinion of the farmers, fertilizer and seed quality generate a good harvest. A few mentioned the time of planting and the type of soil as favorable factors.

Fig.24 Accumulative distribution of covered bean

Table 45: Reasons for a good harvest according to the opinion of the farmers (multiple answer).

REASONS	Response frecuency
Fertilization	86%
Variety and quality of the seed	73%
Use of insecticides	57%
Time of planting, type of soil	3%

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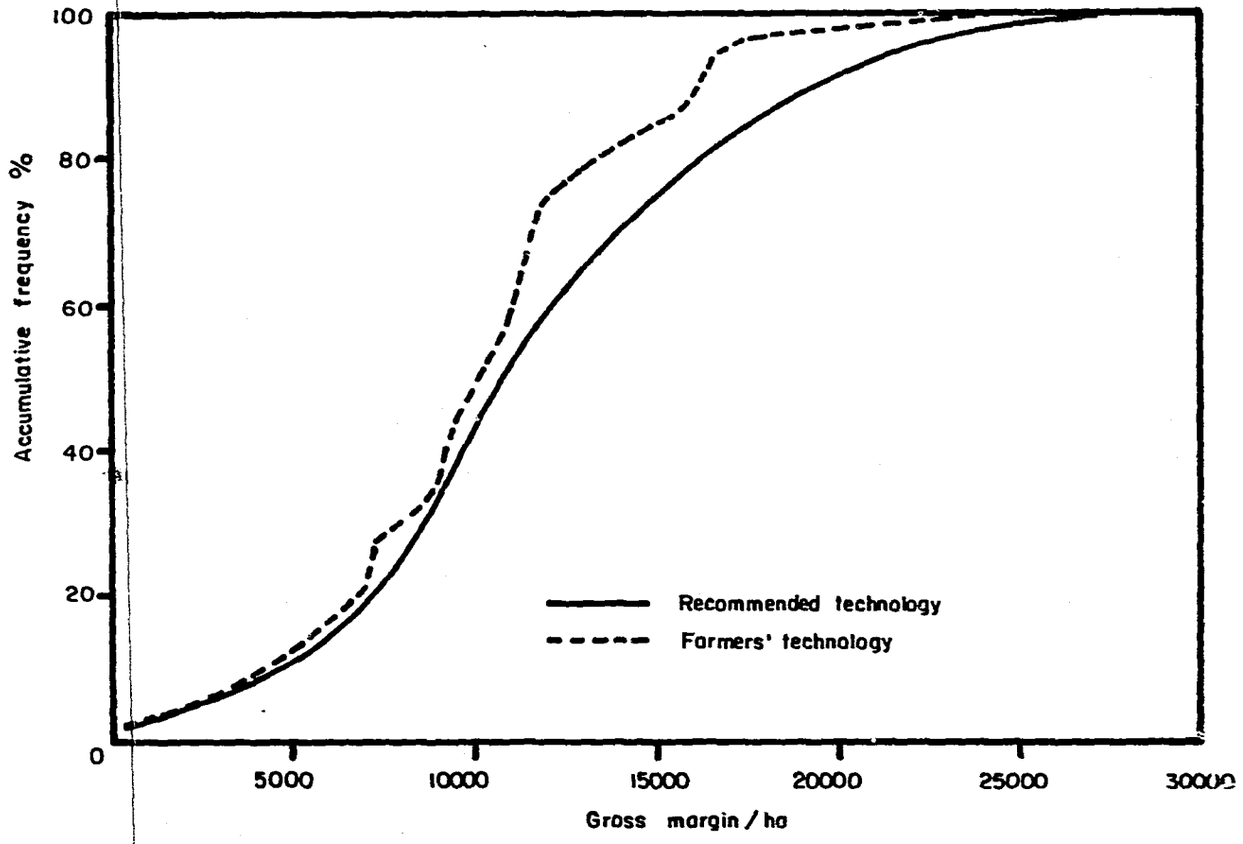
Fig.24 Accumulative distribution of covered bean



Eventhough the farmers were satisfied with the yields, 25%.of them suggested a change in plant population density (see Table 46).

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Table 46: Farmers suggestions for changing the technology.

COMPONENT	Farmers happy with the yield (n = 28) %	Farmers unhappy with the yield (n = 8) %
Density[a)]	25	50
Variety	11	63
Fertilization	0	13
ORTHENE	7	0

a) The suggestion is to reduce density.

11% suggested changing the variety (two varieties were offered to satisfy the different environmental conditions). None mentioned changing the fertilizer, and all answered "Yes" to the question of whether the higher yield compensated for the cost of using fertilizer.

The farmers who suggested not using Orthene were satisfied with the results, but stated that it was too expensive.

The different reasons given for the poor harvest, can be estimated with more security according to the suggestions for changes. One-half of the farmers mentioned that the density was too high, 63% stated that the variety was not adapted to the zone. One farmer mentioned that the fertilizer also favored the weeds which suppressed the beans. This observation was also made verbally to the authors by other farmers.

Although the recommended technology had a 21% higher yield than the traditional, the increase of the gross margin per hectare was only 12% higher due to the increase in the cost of inputs. The risk, however, of obtaining a certain gross margin is equal in the two technologies.

This increase of 12% (or 21% in natural yields) normally is not sufficient to provide incentive to the farmers to change their technology. It is estimated that this figure must be at least 30%. However, the majority of the farmers were satisfied with the yield, and more importantly, almost all of them manifested their interest in using the same techniques during the next year.

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6. RECOMMENDATIONS

J. Lagemann, J. Heuveldop, R. Borel[1]/

The description of the project region with its emphasis on the physico-biological and socio-economic environment and the analysis of the actual farming systems shed light on the existing problems in the Acosta-Puriscal region.

The identification of the greatest problems and the objectives at the farm and state levels are used as a base for elaborating recommendations.

6.1 PROBLEMS AT THE FARM AND SOCIETY LEVELS

The following restrictions appear to be the most serious at the farm level:

1. The erosion in the steeper areas is evident, particularly for land under annual crops (maize and tobacco) and in natural pastures. Consequently, each year parts of the fertile soil cap is lost, and the production base for future generations is placed in danger. Although there are no quantified data on the affected area or the volume of lost soil, the negative effect is obvious, and there has been declared an "emergency region" by the Ministry of Agriculture.
2. 74% of the coffee fields are planted with traditional varieties ("Typica" and hybrid "tico" with low yields (≈ 700 kg/ha) compared to caturra which produces an average of 1,200 kg/ha. The better fields of caturra yield in excess of 2,500 kg/ha, demonstrating the great potential of this variety.
3. 65% of the total cultivated are is under pasture, although the relative percentage on the smallest farms is lower (54%) as was seen in the multi-visit survey. The production per hectare is low, and the net income of the cattle component is estimated at ₡ 1,300/ha. Information from five surveyed farmers and from one experimental

1/ Agricultural Economist, Agro-Silviculturalist, and Agrostologist, respectively.

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2/ La Nación of Dec. 28,

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5/ SIRGA: Estadísticas S

Ministry farm in the region, demonstrates that production could be doubled with the pasture varieties *Cynodon plectostachyus* and *Brachiaria ruziziensis.*

4. Labor is a very restricting factor especially during the second cropping season. An increase in cultivated surface area does not seem possible because of the impossibility of introducing mechanization to this hilly zone.

To obtain an increased agricultural production in the area, aid or assistance from the state is necessary. An analyisis of the critical problems facing the state can indicate interest and thus, potential for aid in the future. Costa Rica is currently facing an economic crisis with various repercussions for the agricultural sector:

1. The deficit of the 1982 government budget is critical, and this situation will probably continue for the next few years. The Ministry of Agriculture and Livestock has been very affected by this situation, due to a 30% cut in its 1982 budget[2]/. This signifies that the research and extension programs cannot function at the necessary intensity.
2. Costa Rica's balance of payments was slightly deficit between 1965-1973. Since that time, it has risen form 67 million U.S. dollars to a total of 516 million dollars in 1980[3]/. This has resulted principally from the diminished prices of coffee, cocoa and sugar, as well as the drastic increase in the cost of petroleum and its derivatives. In 1981, the colon was devaluated against the dollar by 250%. Prices for imports (agro-chemicals, fertilizer, machinery and vehicles) have risen drastically. The negative effect of all this is particularly difficult for the small farms with few financial resources.
3. In the past, unemployment was not a serious problem in Costa Rica in comparison to the other Central American countries.
   These numbers rose from 6% in 1974 to 9% in 1981[4]/. It can be assumed that unemployment will continue to rise in the future years because 39% of the population is currently 15 years old or less and will be entering the labor market in a few years[5]/.

2/ La Nación of Dec. 28, 1981.

3/ Banco Central of Costa Rica: Información Estadística Mensual, Oct. 1981.

4/ Personal communication from the Information Office of the Ministry of Labor and Social Security.

5/ SIRGA: Estadísticas Sociales. San José. 1973.

6.2 OBJECTIVES OF FARMERS AND SOCIETY

The identification of the farmers' objectives was based on information given by the farmers themselves (with formal questionnaires and in discussions), and the objectives of the state were taken from the current government's program[6]/.

Farmers' objectives:

- To produce sufficient alimentation for the family
- To produce a variety of products to reduce risk, to produce diversified alimentation, and to make better use of land and labor.
- To increase the net family income from the farm.
- To conserve the land for long-term production.

Society's (state) objectives:

- To produce greater amounts of foodstuffs to replace imports.
- To produce crops for export sales and generate foreign exchange.
- To create jobs in agriculture and agro-industry
- To increase income resources (taxes) to finance the national budget
- To increase the standard of living of the small farmers.

6.3 AGRICULTURAL RESEARCH AND EXTENSION PRIORITIES

6.3.1 Identification of priority enterprises

In case of scarce financial resouces, it is necessary to establish priorities for the possible enterprises. Those innovations which can introduce the greatest benefit —according to multiple objectives— must be first on any list of priorities.

An exact quantification of the benefits is not possible, but with existing data, one can estimate the relative magnitude of an improvement in the different farm enterprises.

The focus on farming systems has as its objective an improvement of the whole farm. But this does not signify that the research or extension objective must be the production of complete farming systems. The farm

6/ PARTIDO LIBERACION NACIONAL; Volvamos a la Tierra, Programa de Gobierno, 1982-1986, San José, 1981.

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organization and management is done by the farmers themselves according to the available resources and their objectives.[7]/.

The objective must focus on the search for crops or enterprises on the farm where an improvement would have a great positive impact.

In Table 47 the most important annual crops are shown, coffee and pastures with their current yields, possible yields using new techniques, and possible increases in net income per farm.

Table 47: New technology's potential to increase net income of an average farm in Acosta-Puriscal (with 1981-1982 prices).

CROPS	Current Yield kg/ha	Possible Yield[a)] kg/ha	Area efect per farm[b)] (in ha)	Increase in net income/farm (in ₡)
Covered beans	510	800	0.6	2,000
Maize	1,800	3,000	0.6	1,000
Tobacco	1,100	1,400	0.3	1,800
Coffee	970	1,500	1.4	21,500
Pasture (net income)	1,000	2,000	6.2	6,200

a) The base of the "possible yield" are the yields of the best quartile (according to the criterion: gross margin/ha) of the surveyed farmers. In the case of maize, the average of the best quartile was 2,700 kg/ha. Experiments in the area have shown that new varieties can produce between 3,200 and 4,000 kg under experimental conditions. Because of this, the possible yields under farming conditions were estimated at 3,000 kg/ha. The estimate of the possible net income of pastures was done with the results of five farmers who have improved pastures such as "estrella africana" (*Cydodon plectotachyus*) and *Brachiaria ruziziensis*.

b) The data from the affected area came from the results of the preliminary survey; large farms were excluded from the multi-visit survey.

With the data on current yields (averages of all surveyed farms) and possible yields (averages of the best quartile, excluding maize), and the following suppositions:

7/ Technological packages are, for example, frequently only partially adopted. Some components are adopted, others are changed, still others are excluded. Thus, the farmers "invent" their own technologies. See: CHAPMAN, J.: Design and analysis of appropriate technology for small farmers: Cropping Systems Research in the Philippines, Ph. D. Thesis, Michigan State University, 1981.

a) The area dedicated to each enterprise does not change
b) Labor demand requirements do not change drastically
c) Relative prices remain constant.

One can see where the key enterprises are according to the criterion "increase in net income". Coffee has the highest potential for increasing net income to the farms with ₡ 21,500/farm which is three or four times higher that the potential with pasture improvements which is ₡ 6,200/farm. Last are the basic grains and tobacco with values between ₡ 1,000–2,000/farm.

One criticism could be that the potential estimates for the basic grains are low. However, if the "possible yields" are increased by 50%, the order of priority remains the same.

Pasture improvement has a significant influence on the largest farms, and because of this, especially in Puriscal. Nevertheless, a farm with 10 hectares of pasture is considered –due to the ecological conditions of the area– to be a small farm.

As a second step in the valuation of different enterprises, one must compare the effect of improvements according to the previously mentioned objectives. The first two farmers' objectives can be assured through diversified production. This is a basic tenet for the farmers, and any suggestions made by extension personnel must take it into consideration.

With respect to the potential contribution of the different enterprises to the remaining objectives, their relative contribution is shown in Table 18.

The estimation of the possibility of reaching the multiple object. of the society (or state) provides clear results:

- The majority of the objectives can be met with coffee, and this at a higher level than the other alternatives. Soil conservation can de done in combination with trees which is a traditional system in Acosta-Puriscal.
- Second in importance is the introduction of improved pasture followed by tobacco, "covered beans" and maize. Establishing priorities of importance for the last three crops is difficult and depends on which of the objectives is considered most important.

The comparative advantage of coffee compared with the alternatives is great even if international coffee prices decrease as is the case now (1980-1981: 2.58 US$/kg compared to the 1976-77 price of 4.57 US$/kg[8]/. The great fluctuations in coffee prices during the last 30 years has not

8/ OFICINA DEL CAFE: Informe sobre la actividad cafetalera de Costa Rica, San José, febrero 1982, Costa Rica.

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9/ ARAYA P. C.: Histori
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negatively influenced coffee production or the area planted. To the contrary... "the decrease of coffee prices does not effect a rapid substitution of crops, but to the contrary, an increase in production and in the area planted"[9]/.

Regarding the possibility of the sale of an increased production, there are various factors to consider: a) the production of Costa Rica (1.96% in 1981)[10]/ on the world level is insignificant. b) the exportation sales on a world-wide basis tend to increase, due principally to the increase in Brazil's coffee production, and c) the frequency of freezes in Brazil has increased drastically in the last 20 years with intervals of one to 3 years[11]/ and represents a major insecurity in any estimation of coffee sales. Although there is a global tendency of decreasing coffee prices, it seems that the high quality of Costa Rican coffee gives it a better chance on the world market. Resulting from this situation are programs aimed at the improvement of coffee production with the objective of increasing productivity without expanding the areas under cultivation.[12]/.

The analysis on land use reveals that the primary ecological problem in the study region is erosion. From an economic point of view, this places first priority on promoting coffee production and second priority on pastures. However, it should not be deduced from this that in the future only coffee and pastures must be promoted. The production of basic foodstuffs at the farm level must be accomplished. But a logical consequence from the analysis is that beans and maize are not suitable for commercial development. The net income per farm is very much higher with coffee and pasture as can be seen in Table 48. Moreover, the intense soil treatments currently required for the production of beans[13]/ and maize add greatly to the erosion in the zone.

An increase in agricultural production within the limits of what can currently be achieved technically could augment net income from coffee more than 10 times and from pastures more than three times. This is very high compared to beans and maize; this, from an economic viewpoint, is the most interesting aspect. However, from a ecological point of view, this land use cannot be evaluated as clearly. On the slopes of the study region with a predominance of very steep hills, coffee, especially with shade trees, is a

9/ ARAYA P. C.: Historia económica de Costa Rica, Editorial Fernández-Arce, Segunda Edición, San José, 1976.

10-11-12/ OFICINA DEL CAFE: op. cit.

13/ Apart from "covered beans".

Table 48: Estimation of the possibility of reaching multiple objectives with innovation introduction in various crops plus pasture in Acosta-Puriscal.

CROPS	Soil conservation	Food production	Foreign exchange	Creation of jobs[1]/	Income sources (State)	Improved standard of living of the small farmers
Covered beans	++	+	0 (+)	0	0	(0) +
Maize	–	+	0 (+)	0	0	(0) +
Tobacco	–	0	+	+	+	(0) +
Coffee-shade trees	++	0	+++	++	+++[2]/	+++
Improved pasture and management	+	++	++	+	+	+

1/ In agriculture as well as the agro-industry sector.
2/ Added value tax on coffee production (10%).
– Added value for exportation rights on coffee production (9-28% according to coffee price).
– Tax on different exchange rates (10% in 1981). Furthermore, there are small taxes payable to the Oficina del Café and the International Coffee Organization.

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+++ great positive effect

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relatively good soil stabilizer. On the other hand, pastures are susceptible to serious damage which remains evident for two or three years. After short time periods, gulleys form which, in this region, multiply rapidly.

In any case, according to assimilated experience in the study region, this can be avoided with coffee planted on the steeper inclines. Slopes with major inclines (> 85%) particularly those with a southern orientation, are unsuitable for any agricultural crop because of the accelerated erosion. The shade of the coffee plant is limited to the first hours of the morning and the last of the afternoon. That is, insulation is extremely high throughout the year which needs a sufficient supply of nutritive elements and water which do not exist in natural form.

After identifying enterprises with the greatest potential, priorities can be elaborated for research with respect to coffee production and pastures.

6.3.2 Coffee production recommendations

6.3.2.1 Research recommendations

Past experience has shown that improvement of varieties is a factor of great importance (if not the most important) in agricultural development[14]/. Nevertheless, variety improvement for coffee and grasses is not CATIE's task. The recommendations concentrate, therefore, on applied research with the objective of producing innovations which are ecologically stable and economically better in comparison to the current situation. This means that under the topographical conditions of the area in question, concentration must be focused on coffee production in combination with shade trees, fruit tress, or timber producing trees. This recommendation is based on results obtained from the multi-visit survey which confirm that although coffee production with caturra was 14% lower in combination with fruit trees and shade trees, the net income of the total production was almost equal with the "coffee-shade trees" system but without fruit trees (the t-value shows no significant differences[15]/. The value of timber-producing trees was not included in these figures.

14/ RUTHENBERG, H.: Landwirtschaftliche Entwicklungspolitik. Materialsammlung Heft 20, DLG-Verlag, Frankfurt.

15/ Similar results were obtained in Colombia with a combination of coffee (caturra) and Pinus oocarpa. Source: BUSTOS, G. T.: Prácticas agroforestales en Colombia, CONIF, Bogotá, 1982.

Coffee Organization.

-	negative effect
0	neutral effect
+	small positive effect
++	medium positive effect
+++	great positive effect

A comparison of production and productivity of coffee without trees was not possible because there exist only three fields of this type. But if one calculates the eventual decrease in the harvest when 100 shade trees per ha are included in the coffee fields, there results (without considering level of productivity) a harvest lower by 3% with 3,000 coffee plants/ha and 2% with 5,000 plants/ha. With 200 trees there is a decreased value by 6% and 4% respectively.

Although one can thus demonstrate a lowering in the coffee production, the advantages such a combination with trees present must be considered:

1. The ecological stability of a system increases with diversification.
2. Diversification in the supply of products reduces the production risk (risk reduction is a fundamental consideration for small farmers).
3. Complex plant systems give, with exceptions in extreme cases, a high total production and over a long-term.

Ecological stability has been emphasized as a fundamental factor since the steep slopes of the zone run serious danger of eroding, and increased erosion destroys the water balance regime. The construction of vegetational structures of a "multi-story" type covers the soil, penetrates more efficiently the soil horizons, thereby contributing to soil stability.

The product supply, especially in the wood sector is relatively low, since in the study region there has been extensive cutting of the forests for decades, leaving a current 10% of previously forested land with trees. One compensation in the face of the lessening coffee harvest might be offered by means of wood product sales in a growing and assured market.

The reciprocal influence between shade tree and coffee plant depends on the species combination and on the form of management. In this regard, little is known. Nevertheless, coffee with *Erythrina* spp., makes one assume (given its effect in increasing production) that by adding other productive wood species or by using woody legumes, which would provide firewood or high quality woods, it would be possible to increase net income per unit area.

If there is agreement about the focus of a "coffee-trees" system as the most relevant according to the ecological conditions of the area and the objectives of the target group "small farmers", one must then identify the priority components for applied research:

1. Testing rust-resistent varieties with high potential for a moist-dry climate and under shade conditions. The "Mundo Novo" variety is

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19/ GLOVER, N.: Coff
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well adapted to dryer zones[16]/ but has not been tested in the study region.

2. Testing legumes as shade trees which augment soil fertility and possibly could reduce the application of chemical fertilizers. The farmers who apply fertilizer in Acosta-Puriscal spend an average of ₡ 3,500/ha for this product[17]/. This represent 93% of the total cost of inputs, or 56% of the variable costs. A partial substitution of the chemical fertilizers[18]/ could, therefore, improve the farmers' net incomes and save foreign exchange for the country.

3. Testing of arboreal species adequate for the zone, with a quality timber product having a productive duration of 3-4 rotations of the new varieties of coffee, that is, 30 to 40 years. This recommendation was deduced from the results obtained in the CATIE-UNU Project in La Suiza which showed that, using the species *Cordia alliodora.* the total gross income was increased approximately 27%[19]/.

6.3.2.2 Recommendations for agricultural extension

As in the case of research recommendations, these too are concentrated on the coffee enterprise.

Table 49 shows the value of production and the net income from coffee production with trees under five different techniques. The results indicate the great potential of the caturra variety with the application of fertilizers. The net income is three times higher in comparison with traditional varieties without fertilizers, and almost two times higher than the

16/ OPSA: Programa de mejoramiento de la producción de café en Costa Rica, Doc. No. 33, San José, 1979.

17/ An increase in the use of chemicals increases also the absorption of these elements into the harvest, which is then exported. Apart from this, the great quantities of fertilizers and pesticides are washed and eliminated by the strong rains in varying quantities but always at high levels.

18/ The pruned material from a tree which is trimmed twice a year provides a 100 kg of biomass annually, or 100 trees/ha provide 10 tons annually of mulch. It is certain that nutritive elments are reabsorbed from the soil by the same tree. Nevertheless, it is deduced that the tree obtains them from lower strata than those required by coffee; also being a legume it synthesizes nitrogen and the branches that fall and cover the soil decrease evaporation and soil loss resulting from the rains.

19/ GLOVER, N.: Coffee Yields in a Plantation of Coffee *Arabica* Var. Caturra Shaded by *Erythrina Poeppigiana* with and Without *Cordia Alliodora*, CATIE, Serie Técnica No. 17, Turrialba, 1981.

most common technique which consists of traditional varieties with fertilizer.

Coffee production diminishes 14% with the introduction of oranges and bananas (apart from shade trees) into the coffee fields. However, the fruit trees partially compensate for the lower coffee production. Moreover, the costs, principally for fertilizer and herbicides are minor in the combination of coffee-fruit/shade trees. Consequently, the net income is equal between these two forms of production (t value = 0.04).

Table 49: Comparison of gross and net income of coffee plots with shade trees and/or fruit trees under five different techniques.

	TECHNIQUES				
	1	2	3	4	5
Number of fields	23	38	12	15	12
Coffee varieties	tradit.	tradit.	tradit.	caturra	caturra
Shade trees	Yes	Yes	Yes	Yes	Yes
Orange + bananas	Yes	Yes	no	Yes	no
Fertilizer	no	Yes	Yes	Yes	Yes
Value of total production (₡/ha)	16.914	32.860	39.924	52.820	58.820
Net income (₡/ha)	15.312	26.772	31.676	46.960	47.670

These results and a regression analysis for the caturra fields form the base for the following recommendations:

1. Caturra can be proposed as an alternative for the traditional varieties.
2. The incorporation of shade trees and fruit trees does not, apparently, lower net income and can, therefore, improve it.
3. Fertilizer application can be suggested as an important component but with existing data, an optimal level cannot de identified.
4. Pruning is the most important husbandry factor, followed by weeding. Any recommendations for coffee production must focus on these two factors.

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6.3.3 Recommendations for pasture production

6.3.3.1 Research recommendations

Cattle is apparently a secondary enterprise of the farming system. It has been observed that the proportion of pastures increases with the size of the farm which indicates that crops cannot be extended further than labor availability and the farmer's capital will allow, and thus cattle occupy the remainder of land. This is probably due to the little labor input necessary and the high return per day of work. The principal goals of the farmer with regard to cattle seem to be:

- To have milk for the house.
- To have a capital reserve for contingencies or special items.

The breed of cattle is native with a strong line of Cebú to permit this cross to produce calves of good quality which bring better prices than those of the milk-producers.

It is noted that in the flatter locations or those with greater natural soil fertility, the pasture "estrella" (*Cynodon plectostachyus*) has a greater production than native grasses, but cannot be maintained on the steeper slopes.

It is typical of "estrella" as a grass requiring high soil fertility for satisfactory production to behave in this way. Moreover, various farmers feel that their stolons make movement difficult in the pastures and are also dangerous on the steep slopes.

The pasture ruzi (*Brachiaria ruziziensis*), although less widespread, is better adapted to a zone including small pasturage and steep inclines. Possibly, grazing animals in a pasture with ruzi could run as high as two or three animals per hectare.

Due to the serious erosion problem on the slopes covered with natural pasture, it is logical to propose that they be planted with wood-producing trees, forage shrubs or combinations of the two. This could only be done if the productive capacity of the other areas was increased. Current experience with ruzi indicates that such an increase is practicable, but it is very probable that there are species better adapted or which possess better nutritive quality. For this reason, it is suggested that priority be given to an evaluation of ecotypes for acidic soils collected by CIAT, with the purpose of identifying productive species for the present conditions with a minimum of inputs.

If one thinks of maintaining the productivity of the region on a long-term basis, it is probable that pasture is not the type of vegetation most

appropriate for Acosta-Puriscal. Furthermore, a proportion of farms do not have pastures, but do express interest in having some livestock enterprise (milkcows, goats, etc.). For this reason, emphasis must be placed on an evaluation of trees and shrubs with forage characteristics, as much for pasture systems in combination with trees as for interspacing with annual crops or existing perennials.

Research in this situation must have the objective of identifying species of high potential production. An optimal use of these species is not dependent on location, and in conjunction with this approach, there is currently work in progress in other areas which in due time can be transferred easily enough to Acosta-Puriscal.

Presently, the problems related to sanitation and management of animals are relatively unimportant, and their solution is dependent on the application of known principles which do not require specific research.

6.3.3.2 Recommendations for agricultural extension

Results obtained from farmers with improved grasses and impressions gained from field trips in the study region permit the following recommendations:

1. Cattle must be prohibited from areas with very steep slopes.
2. The grass *Brachiaria ruziziensis* should be promoted as the grass best suited to the zone.
3. Convince the farmers not to overgraze the pastures.

6.4. CONCLUSIONS

The results of Section 6 demonstrate that there do exist innovations with great potential. Research has the principal task of finding tree and coffee varieties adapted for agro-forestry production systems which are suitable to the physico-biological conditions of the region. With respect to pasture and forages, the area of greatest priority in the Acosta-Puriscal region is the evaluation of varieties adapted to acidic soils and of trees and shrubs for their forage characteristics.

To facilitate the adoption of innovations, the technical assistance must be improved and inputs and credit made available. (With limited resources, this implies a concentration on the more important enterprises).

Furthermore, for these actions at the regional level, the state must stimulate investment and production at the farm level with instruments of price policy and with laws which not only encourage the planting of trees, but also their harvest.

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GLOSSARY

Agricultural enterprise:	The different agricultural enterprises relevant to this study are: maize, beans, maize/beans, sorghum, onions, other vegetables, coffee variety caturra, coffee other varieties, animals (large and small livestock).
Area:	Refers always to one of the observed areas: Acosta-Puriscal.
Basket (cajuela):	Equivalent 2,3 dried coffee.
Capital depreciation (estimation of its present value):	**Tools and machinery:** purchase price (valued with prices of 1981) depreciated to beginning of study. In the case of machinery (vehicles, pumps, etc.), depreciation during the observed year was included in the general costs. Calculation was done with linear depreciation. **Fences:** Values of enclosures. A depreciation during the year was not done due the inclusion of these costs as replacement investments. **Perennial crops:** Valued as was machinery. **Animals:** Value was estimated by the farmer and verified from other sources at the beginning of the survey.
Colón (₡):	One (₡) is equivalent to approximately ₡ 25.00 in the beginning and ₡ 45.00 at the end of the multi-visit survey (free market).
Cultivated land:	Land planted with annual and/or perennial crops. The planted surface of annuals for the first and second growing cycles are considered separately, although the planting is done usually on the same land surface.
Fanega:	Cubic measurement for coffee equivalent to 20 cajuelas or 46 kg dried coffee.
Managed land:	All land available to the farmer including rented land and sharecropped land.
Man-days (MD):	One man-day (MD) = 8 hours of work by one man-equivalent (ME). Individuals between 15-60 years have 1 ME value; youth between 10-14 years and the elderly over 60 years are valued at 0.5 ME.
Man-equivalents (ME) for estimating availability of family labor:	Male family members between 15 and 60 years who work principally on the farm, including the farmers, less workdays spent outside the farm. The basis of the calculation is 250 available workdays per person per year for work on the farm.

Net family income from the farm:	Includes all net family income obtained from the farm (excluding off-farm income).
Region:	Refers to the combined study areas: Acosta-Puriscal.
Total net family income:	In addition to net family income from the farm, this includes income from off-farm work.

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ANNEX

Table 1: Characterization of maize production (first season).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	32		13		–
Plant density (100 m^2)	228	25	376	22	–
Plot size (ha)	0.37	110	0.84	83	2.3
LABOR INPUT					
MAN-DAYS/HA					
Land preparation	26	101	7	106	–
Ploughing	0.1	566	8	237	–
Planting	11	73	7	89	–
Weeding	23	71	14	81	–
Fertilizing	4	121	4	186	–
Earthing up	6	230	,4	238	–
Harvest	11	65	15	78	–
TOTAL[a)]	89	51	66	48	1.7*
Yield (kg/ha)	1,700	47	2,062	21	–
VARIABLE COSTS					
Seed (kg/ha)	20.3	75	21.0	50	–
Seed (value)	126	229	90	70	–
N-P-K (kg/ha)	81	112	168	103	–
N-P-K (value)	363	109	590	103	–
N (kg/ha)	10	400	77	220	–
N (value)	41	393	237	221	–
Agro-chemicals	12.3	551	179	93	–
Hired labor					
Man-days	8	222	11	136	–
Value	361	222	567	152	–
Hired oxen	5.6	566	–	–	–
TOTAL[b)]	909	111	1,664	76	1.9**
Value of production (₡/ha)	7,641	47	9,277	21	1.9*
Gross margin (₡/ha)	6,732	48	7,613	34	0.9
Production costs/100 kg	54	106	87	80	–
Gross margin/MD	111	94	153	53	–

a) Inclusive of other activities.
b) Inclusive of other costs.

Table 2: Characteristics of maize/beans, planted beans and tobacco production.

SUBJECT	PURISCAL					
	MAIZE/BEANS		PLANTED BEANS		TOBACCO	
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%
Number of plots	26		10		19	
Plant density/100 m^2	305/1,375	27/99	1,260	23	166	34
Plot size (ha)	0.79	85	0.69	91	1.24	83
LABOR INPUT MAN–DAYS/HA						
Land preparation	16	54	9	153	3	179
Ploughing	4	152	8	140	30	87
Planting	10	63	13	81	12	72
Weeding	15	66	8	68	21	82
Fertilizing	6	126	2	120	12	53
Appl. of other agro-chemicals	1	–	2	–	3	–
Harvest	13	69	10	97	56	64
TOTAL[a)]	71	32	53	49	207[b)]	43
Yield (kg/ha)	1,629/202	45/117	1,000	54	1,144	50
VARIABLE COSTS						
Seed (kg/ha)	17.1/15.5	60/60	36.2	98	–	–
Seed (value)	69/118	48/64	510	87	293	187
N-P-K (kg/ha)	107	134	104	96	952	49
N-P-K (value)	403	136	540	99	4,990	44
N (kg/ha)	109	183	–	–	15	314
N (value)	349	189	–	–	111	349
Agro-chemicals	117	209	233	176	408	133
Hired labor						
Man-days	7	150	10	71	26	102
Value	323	166	495	70	1,388	96
Hired oxen	7	182	–	–	–	–
TOTAL[c)]	1,386	71	1,780	52	7,251	46
Value of production (₵/ha)	9,346	42	18,000	54	35,822	49
Gross margin (₵/ha)	7,960	55	16,220	56	28,570	55
Production costs/100 kg	–	–	184	27	733	50
Gross margin/MD	132	60	317	70	164	62

a) Inclusive of other activities.
b) Inclusive of processing.
c) Inclusive of other costs.

Table 3

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Table 3: Characteristics of covered beans production

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	42		11		–
Plant density/100 m^2	119	25	114	42	–
Plot size (ha)	0.57	124	0.7	83	0.9
LABOR INPUT					
MAN-DAYS/HA					
Land preparation	–	–	–	–	–
Planting	18	47	17	43	–
Weeding	–	–	–	–	–
Fertilizing	–	–	–	–	–
Harvest	20	40	14	53	–
TOTAL	38	35	31	29	1.6
Yield (kg/ha)	528	37	463	93	–
VARIABLE COSTS					
Seed (kg/ha)	40.1	40	38.3	45	–
Seed (value)	542	43	586	44	–
Agro-chemicals	–	–	–	–	–
Hired labor					
Man-days	8	150	2	230	–
Value	405	170	52	332	–
TOTAL	947	78	637	52	2.0**
Value of production (₡/ha)	9,502	37	8,337	93	0.5
Gross margin (₡/ha)	8,558	46	7,699	99	0.4
Production costs/100 kg	260	102	181	89	–
Gross margin/MD	277	62	218	96	–

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Table 4: Characteristics of sugar cane production.

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	7		5		–
Plot size (ha)	1.12	84	1,02	57	0.2
LABOR INPUT MAN-DAYS/HA					
Planting	–	–	4	224	–
Weeding	24	59	1	224	–
Fertilizing	–	–	1	224	–
Harvest	51	62	40	75	–
Processing	64	64	56	63	–
TOTAL[a)]	139	53	102	55	0.9
Yield (kg/ha)	202	85	264	62	–
VARIABLE COSTS					
N-P-K (kg/ha)	–	–	33	224	–
N-P-K (Value)	–	–	103	224	–
Hired labor					
Man-days	–	–	3	224	–
Value	–	–	106	224	–
Hired oxen	–	–	350	200	–
TOTAL[b)]	54	265	559	160	1.2
Value of production (₡/ha)	13,118,	110	11,212	78	0.3
Gross margin (₡/ha)	13,064	110	10,653	81	0.3
Production costs/100 kg	27	111	212	113	–
Gross margin/MD	92	103	104	75	–

a) Inclusive of other activities
b) Inclusive of other costs.

Table 5: Ch

SUBJECT

Number of plc
Number of co
Age of coffee
Plot size (ha)

LABOR INPU
MAN-DAYS/I

Land preparat
Planting
Weeding
Fertilizing
Appl. of othe
Pruning (coff
Harvest

TOTAL[a)]

Yield (basket

VARIABLE

Seed/plants,
N-P-K (kg/ha
N-P-K (value
N (kg/ha)
N (value)
Agro-chemic

Hired labor

Man-days
Value

TOTAL[c)]

Value of pro
Gross margir
Gross margir

a) Inclusive o
b) 1 basket =
c) Inclusive c

CAL V.C.%	Value of t
	–
57	0.2
224	–
224	–
224	–
75	–
63	–
55	0.9
62	–
224	–
224	–
224	–
224	–
200	–
160	1.2
78	0.3
81	0.3
113	–
75	–

Table 5: Chracteristics of caturra coffee production (all plots).

SUBJECT	ACOSTA X	ACOSTA V.C.%	PURISCAL X	PURISCAL V.C.%	Value of t
Number of plots	13		16		–
Number of coffee trees/ha	4,621	31	4,022	35	–
Age of coffee trees, (Yrs)	4.9	53	6.1	54	–
Plot size (ha)	0.41	94	0.76	126	1.4
LABOR INPUT MAN-DAYS/HA					
Land preparation	4	–	2	313	–
Planting	9	151	17	129	–
Weeding	39	60	47	39	–
Fertilizing	13	95	10	46	–
Appl. of other agro-chemicals	11	–	7	–	–
Pruning (coffee)	9	133	17	94	–
Harvest	93	65	115	44	–
TOTAL[a)]	182	57	221	29	1.2
Yield (baskets/ha[b)]	477	84	764	74	–
VARIABLE COSTS					
Seed/plants, value	384	151	1,284	170	–
N-P-K (kg/ha)	880	58	509	76	–
N-P-K (value)	3,453	61	2,229	80	1.7*
N (kg/ha)	122	198	439	75	–
N (value)	458	196	1,695	79	–
Agro-chemicals	578	91	672	137	0.3
Hired labor					
Man-days	26	170	30	109	–
Value	903,	189	1,432	110	–
TOTAL[c)]	5,931	69	7,604	52	1.1
Value of production (₡/ha)	39,592	79	65,332	71	1.6
Gross margin (₡/ha)	33,662	90	54,728	80	1.5
Gross margin/MD	167	58	240	64	–

a) Inclusive of other activities.
b) 1 basket = 2.3 kg of dried coffe
c) Inclusive of other costs.

Table 6: Characteristics of caturra coffee production (without fruit trees).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	5		8		–
Number of coffee trees/ha	4,818	28	3,999	30	–
Plot size (ha)	0.29	73	0.57	66	1.5
LABOR INPUT MAN-DAYS/HA					
Land preparation	8	224	8	283	–
Planting	12	143	7	105	–
Weeding	42	54	41	42	–
Fertilizing	8	72	9	44	–
Appl. of other agro-chemicals	19	–	9	–	–
Pruning (coffee)	12	113	14	120	–
Pruning (shade trees)	3	155	2	160	–
Harvest	95	71	127	45	–
TOTAL[a)]	194	61	213	26	0.3
Yield (baskets/ha)	425	78	846	75	–
VARIABLE COSTS					
Seed/plants, value	706	224	2,273	121	–
N-P-K (kg/ha)	976	74	495	73	–
N-P-K (value)	3,908	77	2,210	81	1.3
N (kg/ha)	108	224	516	55	–
N (value)	409	224	,2,263	63	–
Agro-chemicals	772	65	710	163	0.1
Hired labor					
Man-days	42	141	42	103	–
Value	1,868	137	1,911	105	–
TOTAL[b)]	8,064	70	9,767	39	0.6
Value of production	34,125	78	67,653	75	1.3
Gross margin (₡/ha)	26,061	81	57,886	87	1.3

a) Inclusive of other activities.
b) Inclusive of other costs.

Table 7:

SUBJECT

Number o
Number o
Plot size (

LABOR I
MAN-DAY

Land prep
Planting
Weeding
Fertilizing
Appl. of ot
Pruning (c
Harvest

TOTAL[a)]

Yield (bask

VARIABL

Seed/plants
N-P-K (kg/
N-P-K (valu
N (kg/ha)
N (value)
Agro-chemi

Hired labor

Man-days
Value

TOTAL[b)]

Value of pr
Gross margi

a) Inclusive o
b) Inclusive o

trees).

Table 7: Characteristics of caturra coffee production (with fruit trees).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	8		8		–
Number of coffee trees/ha	4,498	35	4,045	41	–
Plot size (ha)	0.48	95	0.95	139	1.0
LABOR INPUT MAN-DAYS/HA					
Land preparation	4	–	3	283	–
Planting	,8	168	27	103	–
Weeding	37	69	54	35	–
Fertilizing	16	91	10	50	–
Appl. of other agro-chemicals	6	124	4	168	–
Pruning (coffee)	7	160	21	79	–
Harvest	91	66	103	42	–
TOTAL[a)]	175	57	228	32	1.2
Yield (baskets/ha)	509	90	683	75	–
VARIABLE COSTS					
Seed/plants, value	183	283	295	185	–
N-P-K (kg/ha)	820	44	523	84	–
N-P-K (value)	3,117	49	2,247	85	1.0
N (kg/ha)	131	197	362	102	–
N (value)	488	194	1,127	93	–
Agro-chemicals	457	117	634	108	0.6
Hired labor					
Man-days	15	200	19	82	–
Value	300	149	952	88	–
TOTAL[b)]	4,545	49	5,441	52	0.7
Value of production (₡/ha)	43,009	82	57,011	70	0.7
Gross margin (₡/ha)	38,464	92	51,571	76	0.7

a) Inclusive of other activities.
b) Inclusive of other costs.

Table 8: Characteristics of coffee production (other varieties with fertilizer).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	39		11		–
Number of coffee trees/ha	3,936	30	3,181	31	–
Age of coffee trees (years)	13.3	39	10.0	49	–
Plot size (ha)	0.76	80	0.98	85	1.0
LABOR INPUT MAN-DAYS/HA					
Land preparation	6	–	0.4	–	–
Planting	15	172	3	176	–
Weeding	36	61	21	84	–
Fertilizing	9	106	11	68	–
Appl. of other agro-chemicals	3	–	1	–	–
Pruning (coffee trees)	15	107	13	108	–
Pruning (shade trees)	5	165	–	–	–
Harvest	115	67	83	63	–
TOTAL[a)]	206	51	135	54	2.1**
Yield (baskets/ha)	383	61	441	87	–
VARIABLE COSTS					
Seed/plants, value	377	304	904	172	–
N-P-K (kg/ha)	586	68	313	134	–
N-P-K (value)	2,508	75	1,349	141	1.8*
N (kg/ha)	174	165	449	85	–
N (value)	672	169	1,351	96	–
Agro-chemicals	273	150	249	205	1.6
Hired labor					
Man-days	60	151	20	97	–
Value	2,319	170	1,009	98	–
TOTAL[b)]	6,175	80	5,065	60	0.9
Value of production (₡/ha)	34,252	61	35,635	86	1.4
Gross margin (₡/ha)	28,077	63	30,570	91	0.3
Gross margin/MD	154	106	208	59	–

a) Inclusive of other activities.
b) Inclusive of other costs.

ilizer).

Table 9: Characteristics of coffee production (other varieties, without fertilizer).

Value of t		ACOSTA[a] $\bar{X}$	ACOSTA[a] V.C.%
–			
–			
–	Number of plot	19	
1.0	Number of coffee trees/ha	3,825	64
	Age of coffee trees (Yrs)	14.4	35
	Plot size (ha)	0.76	35
–	LABOR INPUT		
–	MAN–DAYS/HA		
–	Land preparation	2	–
–	Planting	8	230
–	Weeding	25	72
–	Appl. of other agro-chemicals	1	436
–	Pruning (coffee)	8	98
2.1**	Pruning (shade tree)	5	181
–	Harvest	66	88
	TOTAL[b]	112	60
–	Yield (baskets/ha)	184	89
–			
1.8*	VARIABLE COSTS		
–	Seed/plants, value	416	242
–	Agro-chemicals	64	436
1.6	Hired labor		
	Man-days	14	244
–	Value	311	210
–			
0.9	TOTAL[c]	921	168
1.4	Value of production (₡/ha)	18,408	74
0.3	Gross margin (₡/ha)	17,488	80
–	Gross margin/MD	203	116

a) Puriscal is excluded for having only two observations
b) Inclusive of other activities
c) Inclusive of other costs.

Table 10: Characteristics of the production of coffee (other varieties, without fruit trees).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	6		9		–
Number of coffee trees/ha	5,213	77	3,169	35	–
Plot size (ha)	0.43	64	0.88	66	1.8*
LABOR INPUT MAN-DAYS/HA					
Land preparation	5	–	0.4	300	–
Planting	2	123	4	155	–
Weeding	36	84	31	95	–
Fertilizing	17	134	8	90	–
Appl. of other agro-chemicals	0.4	245	1	–	–
Pruning (coffee)	11	92	15	93	–
Pruning (shade trees)	5	205	–	–	–
Harvest	133	98	75	73	–
TOTAL[a)]	212	82	139	52	1.0
Yield (baskets/ha)	375	103	444	94	–
VARIABLE COSTS					
Seed/plants value	–	–	1,104	151	–
N-P-K (kg/ha)	337	179	297	143	–
N-P-K (value)	1,639	180	1,427	144	0.2
N (kg/ha)	147	245	378	88	–
N (value)	487	245	1,007	81	–
Agro-chemicals	37	245	170	260	0.9
Hired labor					
Man-days	142	123	22	93	–
Value	5,741	136	1,138	92	–
TOTAL[b)]	8,017	115	4,846	69	0.8
Value of production (₡/ha)	30,011	103	35,507	94	0.3
Gross margin (₡/ha)	21,994	99	30,661	100	0.6

a) Inclusive of other activities.

b) Inclusive of other costs.

Table 11: Characteristics of the production of coffee (other varieties, with fruit-trees).

SUBJECT	ACOSTA		PURISCAL		Value of t
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%	
Number of plots	52		4		–
Number of coffee trees	3,748	30	3,039	17	–
Plot size (ha)	0.80	97	1.01	121	0.5
LABOR INPUT MAN–DAYS/HA					
Land preparation	4	–	–	–	–
Planting	14	178	–	–	–
Weeding	32	64	18	68	–
Fertilizing	5	107	13	80	–
Appl. of other agro-chemicals	2	216	4	115	–
Pruning (coffee)	13	114	7	105	–
Pruning (shade trees)	5	168	–	–	–
Harvest	94	70	76	72	–
TOTAL[a)]	171	56	122	54	1.0
Yield (basket/ha)	311	69	301	72	–
VARIABLE COSTS					
Seed/plants, value	435	264	–	–	–
N-P-K (kg/ha)	414	174	192	200	–
N-P-K (value)	1,740	104	500	200	1.3
N (kg/ha)	114	209	383	145	–
N (value)	448	216	1,450	150	–
Agro-chemicals	224	178	303	200	0.4
Hired labor					
Man-days	34	159	11	96	–
Value	1,191	179	474	96	–
TOTAL[b)]	4,043	98	3,285	102	0.4
Value of production (₡/ha)	28,952	65	25,816	65	0.3
Gross margin (₡/ha)	24,909	68	22,531	60	0.3

a) Inclusive of other activities.

b) Inclusive of other costs.

Table 12: Results of soil chemical analysis of plots cultivated with "covered beans" in Acosta-Puriscal (Sample depth: 25 c.m., three samples per plot).

	ACOSTA n = 40		PURISCAL n = 24	
	$\bar{X}$	V.C.%	$\bar{X}$	V.C.%
pH (H_2O)	5.6	7.5	5.5	5.9
Organic material (%)	6.34	40.5	6.68	54.3
N (%)	0.34	35.9	0.39	54.7
P (µg/ml)	7.49	103.7	7.85	105.0
K (meg/100 ml soil)	0.51	65.8	0.31	75.4
Ca (meg/100 ml soil)	19.9	53.2	15.1	61.6
Mg (meg&100 ml soil)	7.0	57.9	5.53	107.6
Ext. Acid. (meg/100 ml soil)	1.7	200.2	0.48	70.0
S (ppm)	9.16	75.7	12.53	65.0
Cu (µg/ml)	6.7	55.5	10.0	58.2
Zn (µg/ml)	2.2	105.2	3.47	80.0
Mn (µg/ml)	14.3	55.7	24.5	50.0
Fe (µg/ml)	116.2	126.7	88.6	68.2

Analysis conducted by soil Laboratory, Crop Production Department, CATIE.