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IMPROVING THE SMALL FARM PRODUCTION SYSTEMS IN CENTRAL AMERICA

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The purpose of this paper is to provide selected results of an applied research process being implemented by the Tropical Agricultural Research and Training Center (CATIE)[2] to develop and test improved crop and animal production systems for low income farmers in specific areas representing the typical ecological zones of Central America.

THE CENTRAL AMERICAN SETTING

Central America includes Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panamá. In 1979 these countries had a population of 22 million of which 52% was rural. In the same year, the estimates of yearly per capita income were $872 for all sectors and $401 for the agricultural sector. Crops, pastures, forestry-woodland, and other areas including non-utilized, occupied 12.5, 22.3, 47 and 18.2%, respectively, of the total land area of 486570 square km (FAO,BID).

The region can be divided into three ecological environments (Table 1). Population density and the intensity of agriculture are relatively greater in WDT areas, lower in LHT areas. However, all three ecological zones are of considerable importance in terms of these characteristics.

Table 1. Distribution of land, human population and farms in Central America according to ecological zones.

Ecology	Land	Population		Farms	
	%	%	per Km^2	%	per Km^2
Semi-Arid Tropics (SAT)	23	28	44	77	3.5
Wet-Dry Tropics (WDT)	37	50	47	53	6.6
Lowland Humid Tropics (LHT)	40	22	19	20	1.9

Source: CATIE[a]

The climatic conditions of these ecological zones are presented in Figure 1. Farming systems in SAT areas, reflect the availability of soil water which is the most limiting factor. Rainfed systems, by far the most common, favor the production of drought resistant varieties of maize and sorghum and other crops and the management of small stocks of animals which are fed partially from crop residues, particularly during the dry season. Rainfall patterns severely limit cropping alternatives and intensify agricultural activities during certain periods of the year, thereby exacerbating labor shortages.

The WDT zone provides the most favorable environment for both human settlement and agricultural production. Most large cities are located here, implying a high food demand, pressure on land, and need for appropriate technologies. Farming systems in this zone are highly diversified to include annual (maize, beans, cassava and vegetables) and perennial crops (coffee, sugar cane and banana) as well as livestock (cattle, swine and chickens).

Farming systems in the LHT are the least intensive and tend to favor perennial crops (banana, cacao and African oil palm) and beef cattle. Year-round abundant rainfall, temperature and radiation permit immense biomass production but there is also a very fragile ecological and soil environment. Thus research priorities in technology development include proper soil management, weed control and

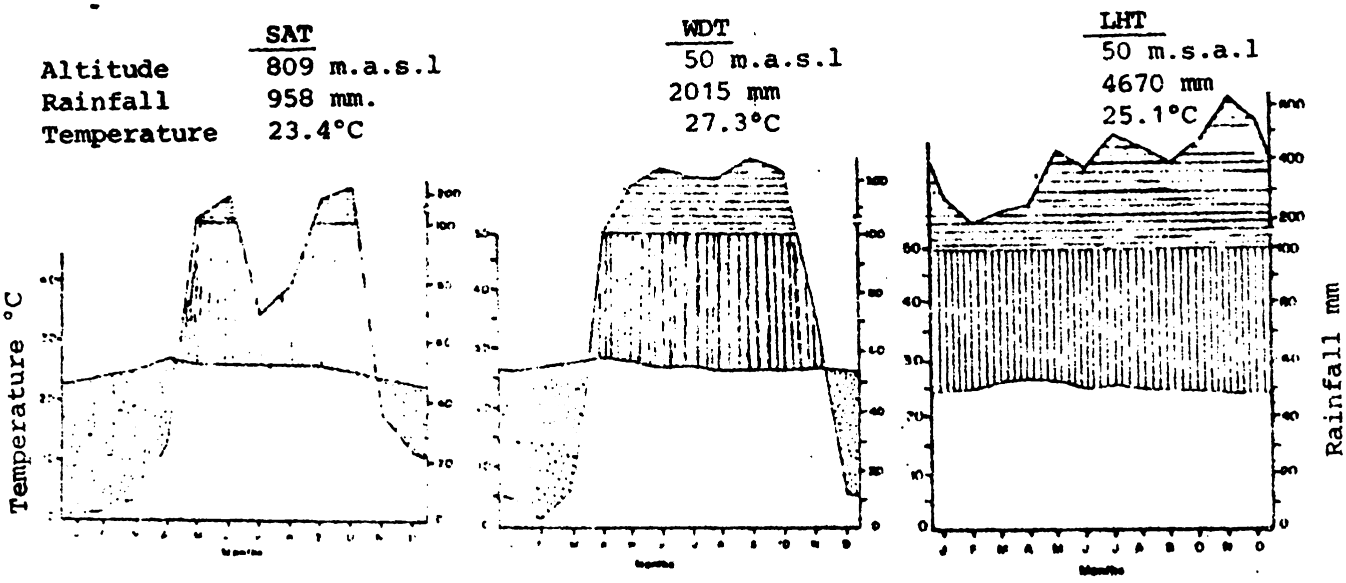

Fig. 1. Temperature and rainfall distribution according to typical ecologies in Central America: minimum of 10 years of data.

increased labor productivity.

Identified as a major sector in all the ecological zones described, the small farm sector, grossly defined as farms less than 35 ha, controls approximately 25% of the total farm land and accounts for less than 20% of the total farm input expenditures, while per capita income is less than $100 per year (CATIE 1981a). These farmers provide two-thirds of the active rural labor force and produce 80% of the total food, excluding rice, for the region. Their participation in rice, perennial crops, and livestock production, which the region exports, amounts to 36, 29, and 21% of the total production value. Given the present forecasts for population growth, economic expansion, and energy costs for the region during the next 20 years, small farmers will continue to be one of the most important social and economic sectors in Central America.

Therefore, if the economic development of the region is to progress further, particularly in terms of income generation and equitable distribution, there is a need to mobilize the resources of this sector. In this respect, this paper is well attuned to the theme of this Conference.

THE OVERALL RESEARCH STRATEGY

Three main features distinguish the strategy of CATIE. The focus on small farmers in an effort to raise food production and income levels in the agricultural sector. The interdisciplinary approach is used to develop technology for improved farming systems. There is a strong determination to support national institutions by working together with their staff on country-related problems and by providing graduate and short-term training programs (CATIE 1978).

CATIE, together with local institutions, conducts research to develop *in situ* production technologies suitable to the various target areas with the active participation of farmers in all phases of the methodology. A production system must be studied and understood before it can be modified or improved. Thus the process of applied research follows logical steps: area selection and description, analysis of predominant production systems, development of innovations, testing under farmer conditions, and diffusion of improved systems (CATIE 1978, Navarro, Lagemann).

The role of the social scientist in the research process is to collaborate in assessing farmers' resources and productivity, designing appropriate technology or systems, evaluating the probable impacts of these alternatives and training national professionals in applied socio-economics (Avila and Navarro).

SELECTED RESULTS IN TYPICAL AREAS

Although CATIE has been carrying out farm-level research in crop and animal production in all countries of the Region, reference to only four areas in different countries will be used to illustrate research methodology and progress[3].

Technology development in food crops in the Semi-Arid area of Tejutla, El Salvador

Tejutla, located 64 km north of San Salvador, is a small community with 11500 ha and 10155 inhabitants. The rainy season is short, extending from May to December. Both the onset and end of rains are erratic, and furthermore, there is a severe "canicular" period, a dry spell lasting as long as 30 days, during the June-July weeks. The lack of soil water is complicated by the mountainous configuration of the terrain and the edafic conditions of the shallow Lithosols and Grumosols that predominate in the area (CENTA). Under these ecological conditions and the low development of the public infrastructure and markets, the farming systems tend to be very traditional. In a survey of 56 farms, 1 to 18 ha in size, 63% maintained small herds of cattle less than 10 head, and 75% had some supplementary small animal enterprises, 1 to 10 chickens and 1 to 2 pigs. Perennial crops and forestry activities include a few fruit trees and other drought resistant species, some for fuel.

Food grain production is the only farm activity for all farms under 2.1 ha and the principal farming activity for 95% of all farms. Gross incomes ranging from $600 to $1200 per year were reported by farmers with 2.1 to 4.9 ha, the largest subgroup according to the survey (CATIE 1979)4.

The cropping systems within the area show their adjustment to the two overlapping and short cropping seasons which are determined by the bimodal rainfall pattern. Since most farm activities are labor intensive, the concentration of agricultural activities during certain periods of the year produces labor problems during the cropping season and high rural unemployment during the off-season which may last up to half the year.

The most common cropping pattern, practiced by 95% of farmers in Tejutla, includes maize seeded at the beginning of the rainy season and sorghum added as a relay-intercrop a month later (maize/sorghum). This pattern demonstrates the risk-spreading strategy of the farmer since it allows a good harvest of maize in September and sorghum in December during favorable rainy seasons, or at least a good harvest of sorghum during drier years. Both the common H-3 hybrid maize and the local sorghum cultivar included in the pattern are well adapted. During grain maturity in October, and even after harvest which is often delayed to December due to labor shortage, the local cultivar of sorghum maintains a good proportion of green foliage. This adds an advantage to the maize/sorghum cropping pattern within the farming system because the field residues are used for direct animal feeding during the dry season.

The maize/sorghum based cropping system was selected for research in Tejutla because it is also widely used elsewhere in the Semi-Arid Tropics of Central America.

Tested technical recommendations are selected to improve crop yield and returns to labor and capital investment per ha and also to maintain the traditional advantages of the system. Most evaluation trials are carried out on farms with the participation of farmers to assure that the resulting technology requirement is maintained within the resource endowment and the interest of target farmers (CENTA). As shown in Table 2, the farmers' system was studied and quantified, and moderate adjustments were designed to be tested; these included vegetation management before seeding, use of fertilizer, and soil insect control. The results

Table 2. Yield, costs and economic efficiency indicators of farmers' and improved maize/sorghum cropping system, per ha

	Farmers' System	Improved System % Increase	Criteria	Farmers' System	Impr.System % Increase
Maize, kg	1750	31.9	Net Income (NI) $	254	46.6
Sorghum, kg	1100	74.8	Net Family Income, $	590	36.5
Operational costs (OP), $	336	16.4	NI/MD, $	6.16	19.5
Man-days (MD)	84	43.2	NI/OC, $	2.51	-15.9

Source: CATIE 1979

were favorable except in the case of net returns to working capital. The farmers use very low levels, if any, and thus obtain high returns. Subsequently, additional tests in 10 sites involving the substitution of the H-11 hybrid maize for the common H-3 resulted in average maize yields of 2149 kg/ha. There are other cultivars of sorghum with higher grain yields, but they lack the additional characteristics required by the farmers.

The resulting recommendations for developing the maize/sorghum cropping system are ready for evaluation under the exclusive management of a large number of farmers in Tejutla and other areas previous to its final diffusion. These evaluations, called validation within the methodology, will be implemented in 1982.

Farming systems in the Wet-Dry area of Jinotega, Nicaragua: the importance of cash crops for small farm development

The Jinotega region in Nicaragua has a high concentration of small farms in comparison to other parts of the country. Of all surveyed farms 75% own less than 10ha the average farm size is 6.4 ha[5]. Farmers cultivate their crops on hilly landscape as 60% of all fields are situated on slopes between 10 and 50%. The prevalence of stones in parts of the region prevents the introduction of mechanized cultivation methods. Average family size is 8 with 1.5 man-equivalents available for farm work.

Land use consists of annual crops (2 ha; added effective hectarage of two cropping cycles), perennial crops (0.8 ha) and pastures or fallow land (3.7 ha).

Of all smallholders 88% rear a few chickens and 72% of the farms own on average 2 pigs which are produced mainly for family consumption. Cattle production is found on only 32% of all farms, which own an average 7 head.

Crop production is labor intensive due to the fact that, apart from ploughing with oxen, all activities are carried out by manual labor (Table 3). Labor for crop production represents 72% of total farm demand, whereas livestock production is labor extensive. General farm activities constitute 54 man-days, and off-farm work about 70 man-days per year. Labor intensity per enterprise varies considerably with onion cultivation having the highest demand on a per ha basis.

The labor distribution shows three peaks within a year: at the beginning of each cropping cycle, in May and August, and in the coffee producing areas, during harvest period from November to January. Most of the hired labor, which amounts to 100 man-days per farm, is used during these peak labor periods.

Increase of crop production area with present cultivation methods seems unlikely due to labor bottlenecks.

Table 3. Labor use, production and productivity of small farmers in Jinotega, Nicaragua, March 1981-February 1982: N= 63 farms

LABOR USE, man-days a) Per farm	$\bar{X}$	C.V.%	Per enterprise	$\bar{X}$	C.V.%
Crop production	236	102	Maize	68	92
Animal production	40	128	Beans	75	87
General farm activities	54	97	Maize/beans	90	48
Total farm	30	88	Cabbage + lettuce	150	75
Off-farm activities	70	132	Onions	260	80
			Coffee + fruit trees	92	57

PRODUCTION AND PRODUCTIVITY Per farm	X	C.V.%	Per enterprise	Tons/ha	GM/ha	GM/MD
Value[b] of total product.	33000	110	Maize	0.9	1240	18
Thereof:			Beans	0.5	3100	41
Basic grains	7200	150	Maize + beans	0.9+0.4	4000	44
Vegetables	8100	100	Cabbage + lettuce[c]	17000	14400	96
Coffee + fruit trees	11400	247	Onions	12.0	41100	158
Livestock	6300	187	Coffee + fruit trees	0.58[d]	12100	131
Net farm income (NFI)	23900	105				
Off-farm income	2800	144				
Total family income	26700	95				
Gross margin(GM)/ha crops	7000	197				
NFI/man-equivalent	15900	140				

a) 8 hours of work of a male adult equivalent b) Córdoba (C$)=US$0.33 in the unofficial market c) Value of production d) Yield for dried coffee only

Source: TIENHOVEN, N., ICAZA, J. and LAGEMANN, J.

Maize and bean production are relatively low due to risky rainfall conditions in the region, and in comparison, maize and beans in association proved to be more stable and with higher yields.

Vegetable production, compared to grains, is very intensive and carefully managed. The value of cabbage and lettuce production amounts to C$17000/ha, and for onions to C$44400/ha. Vegetables were introduced to the region about 15 years ago and are actually, in addition to coffee, an important cash crop in the area. Average coffee production with 580 kg of dried coffee/ha is very low compared to similar areas in Central America or to experimental results in Jinotega. Livestock production is managed extensively with an average production of C$6300 per farm. Poor husbandry practices is the principal cause of low productivity of the livestock enterprise.

Gross margins per ha and man-day vary greatly between different farm enterprises. They were extremely high for onions, followed by coffee, cabbage and lettuce, and finally, by beans, maize and beans in association; maize only had the lowest returns.

The value of whole farm production averaged C$33000. The coefficient of variation is high (110%), minimum values are in the order of 3000, maximum values close to 220000. The great variation in performance results principally from differences in husbandry practices and management capacities of the farmers. The amount of cultivated land and labor use explains only a relatively small part of the total variation observed.

Value of production was highest from coffee and fruit trees, followed by vegetables, basic grains, and livestock. These results demonstrate clearly the importance of cash crops within the whole farming systems studies.

The average values on productivity are rather low compared to other areas in Central America, but the results from the better farmers indicate that significant improvements are possible.

Usually "testing of technology" follows the diagnostic and experimental stage. However, a "pretest" was conducted simultaneously with the diagnostic stage on the assumption that there are some innovations available from the same area or from similar areas. The technical package was identified in collaboration with national institutions and meetings with local farmers. A maize/bean intercropping package with improved varieties, increased plant densities, and fertilizer application increased maize production by 300% and bean production by 50%, Production costs were higher compared to farmers' practices, but net income per ha increased by 90% and production risks were lower. Although the package was evaluated by researchers and farmers as successful, its adoption might be limited due to a higher Marginal Benefit-Cost Ratio for onion production which is the predominant cash crop in one of the testing zones.

From the evidence presented, it can be concluded that farming systems in the highlands of Jinotega are highly diversified. Yields of grains are low, and they are principally produced for subsistence. Significant yield improvements are possible. However, given present price relations, they offer few incentives compared to other crops. Coffee and vegetables are the crops which provide the largest share of total farm revenue. These cash crops have attracted considerable attention during the last years and should be regarded as the key crops for the future development of Jinotega.

Designing and testing an improved cattle production model in the Wet-Dry area of La Nueva Concepción of Guatemala

La Nueva Concepción, located 150 kms southwest of Guatemala City, is a community formed by an agrarian reform program in 1954. There are 1415 family farms, each of 20 ha.

The rainy season averages 130 days (May-October) and the annual rainfall varies from 1619 to 2500 mm. The dry season is very severe; irrigation is possible only by digging deep wells, although a few farms are near streams.

The soils are of alluvial origin and are relatively fertile. Soil drainage conditions are favorable; the land is flat and there are no obvious soil deficiencies. Of the total population 95% are employed in agricultural activities such as cattle, maize, plantains, sesame, rice, and other minor enterprises. Since approximately 95% of all farms have cattle and there is economic and biological potential for increased production, it was identified as a key component to improving farm-level productivity. Thus an applied research program was initiated in 1979 (ICTA-CATIE,

CATIE 1981b).

From a survey of 66 farms, 97% had cattle in combination with annual or perennial crops, and 97% of the farms with cattle manage it as a dual purpose operation, that is, milking the cows once a day with the restricted suckling of the calves; the remaining 3% are specialized beef units. On pasture management: 75% of the land area is in improved grass species, and 45% have rotational grazing. As supplements, common salt is used on 86% of the farms, minerals on 10%, commercial concentrates on 18%, molasses on 37%, and crop residues on 92% of the farms. Vaccination and control for parasities are done routinely on 87% of the farms.

Estimates of biological and productive indices of the system were made: stocking rate 2.2 animal units/ha, annual calving rate 44%, milk production 505 lt/cow/year, and gross income $362/ha on a yearly basis.

The research team identified three key limiting factors to improving productivity and net income: a) poor feeding systems, particularly during the dry season when protein content of available feedstuffs is extremely low, b) inadequate health programs, and c) lack of information on the management and performance of the dual purpose system (ICTA-CATIE).

To tackle these problem areas, component and system research was begun. In this paper, only the results on system management will be reported. On the assumption that the existing levels of productivity could be substantially increased in the short run by introducing currently available technologies, a model simulating the basic features of the farmers' system was modified to include key improvements related to the restrictions described above. The physical model implemented in early 1980 under experimental conditions served to analyze and understand its performance and to demonstrate work progress to farmers. After one year of operation, the results were favorable, and thus, a similar model was established on one farmer's plot, but a few changes were made to suit his particular needs.

The improved model was tested under the management of the research staff (IMR) and of the farmer with limited assistance of the research staff (IMF). These results are compared to the typical above average farmer of the area (TAF). All three systems were monitored using farm records kept by researh field assistants.

The principal difference in the management is that in the IMR molasses and urea were used as supplements throughout the year, and feed preparation for the dry season was necessary because of the high stocking rate, whereas in the IMF he preferred not to use molasses and urea. The TAF, however, normally depends on whatever feedstuffs are available during the dry season such as crop residues, low quality pastures, and molasses.

Considerable improvements were achieved with the improved models compared to the TAF, in terms of birth rate, calf mortality, and calving intervals (Table 4). The IMF, though, did not perform as well as the IMR in all these aspects. In the dual purpose system the milk-beef production ratio is subject to modification within certain limits. For example, the IMF farmer was relatively more interested in selling milk than in feeding the calves well, and thereby he effectively reduced weight gains. In the case of TAF the same option is possible, but his productivity levels in both milk and beef are lower.

In terms of economic profitability, the IMF did not perform as well as the IMR, but it almost doubles the levels of net returns to labor and to total investment obtained by the TAF. In the case of the TAF, the total net income is unfavorable, and certainly, he cannot operate in the long run with such technology at current input-product price relations.

Table 4. Results of testing the improved cattle production model in La Nueva Concepción of Guatemala: January-December, 1981.

Variable	Improved Model Managed by: Research staff	Improved Model Managed by: Farmer	Typical Above-Average Farmer
Cows, head	23	18	30
Labor use, man-days/ha	70.5	67.7	64.6
Total costs/cow/year,$	335.4	373.8	366.0
Stocking rate, AU/ha	5.7	4.0	3.0
Birth rate,%	88.0	77.7	71.4
Calf mortality rate, %	0	5.9	10.0
Calving interval, mo.	13.5+2.0	13.5+1.8	15.6+2.4
Milk prod./ha/year,lt	3739.0	2223.9	1449.6
Milk prod./cow/year,lt	849.4	1111.9	623.3
Weight gain/calf/day,gr	374	279	255
Gross margin/ha/year,$	806.3	386.3	357.4
Total net income/year,$	779.5	-151.9	-1000.6
Net return to labor,$/man-day	5.13	2.27	1.23
Net return to total investment,%	9.63	5.26	3.26

Source: ICTA-CATIE

In conclusion, it is possible, using available technologies to improve the present productivity level of the farmers' system in this area. However, it is necessary to explore additional technological alternatives while simultaneously testing integrated models for a longer period and on more farms. Of course an increase in product prices to the farmers would certainly stimulate interest in better technologies and thus increase productivity, otherwise the cattle system may disappear.

Transfering dairy production technology in the Lowland Humid area of Río Frío in Costa Rica

Specialized dairy production under tropical conditions is a challenge for professionals since the transfer of such technology, developed in temperate zones, encounters ecological, biological, and management barriers.

For many years CATIE has been experimenting with this system and has designed and tested a small-scale prototype. It has an area of 3.7 ha of African stargrass (*Cynodon nlemfuensis*). The 20 cows and 8 young stock represent the product of a crossbreeding program involving Criollo, Jersey and Ayrshire breeds.[6] Their milk production potential is comparable to that of the specialized European breeds, with the added advantage that they are highly resistant to tropical diseases and parasities (Avila et al.).

The basic feeding source is grazed forage. Pasture management consists of 2 days of grazing and 21 days of rest for each of the 24 paddocks and the application of 250 kg of nitrogen/ha. A high stocking rate is maintained and a minimal supplementation of 3 kg of molasses with 3% urea is fed daily to each cow. Calves receive some concentrates and 200 lt of milk during their first two months.

Investment in infrastructure is minimal: a milking parlor, elastic fences on the perifery and lanes, a faeces depot and electric fences for rotational grazing. The system is designed as a one-man operation. High productivity levels result from well kept records and a simple health program.

Some efficiency indices estimated during the 1979 year were the following: stocking rate 6 AU/ha, birth rate 89%, calf mortality 5%, total costs/ha ₡23750, variable costs/ha ₡8702, milk production/cow 2918 lt, milk production/ ha 16673 lt, net income/ha ₡9454 and net family income/man-day ₡124. These indices have been fairly stable over 5 years.

Based on this experience, CATIE was asked to transfer this model to agrarian reform colonists in Rio Frio as a means of providing a viable production alternative to farmers and satisfying the local demand for milk.

Rio Frio is located in the northeast part of the country, covering an area of 27000 ha at an altitude of 130 meters above sea level. The soils have a clay texture, and low fertility severely limits cropping activities. However, the high temperature and rainfall levels throughout the year favor forage production.

A diagnosis of farmers, background, resources and production alternatives was made (Table 5). Production enterprises (maize, beans, rice, milk and swine) generated a yearly gross income of ₡2451, which the government subsidized with ₡8789 per family.

To solve the key problems,a comprehensive strategy was adopted. First, a careful selection of candidates was made to choose farmers with the most experience or interest in dairy production. Second, the project staff had to be directly involved in all aspects: planning, approval and supervision of credit, purchasing animals from similar ecological areas, model implementation,and marketing. Third, a simple training methodology was based on the demonstration of management practices and working hand-in-hand with the farmer.

Table 5. Land use and socio-economic characteristics of the colonists in Rio Frio in November, 1977

Land area, ha	10	Level of formal education:	%
Under cultivation:		1-3 yrs.of schooling	54.2
Pastures, %	40	Completed primary	35.9
Crops, %	13	Started secondary	8.8
Colonists with bank loans, %	52	Completed secondary	1.1
Average loan, ₡*	9000	Previous occupation: %	
Age of the colonist, yrs.	36	Landless laborer	80.0
No. of children	3	Non-agricultural laborer	14.6
Average age of the children,yrs.	3.5	Other	5.4

Source: CATIE 1982 * In 1979 US$ = ₡854.

The results after 4 years of operation are impressive (Table 6). At present the total milk production of the 22 farms on which the Project staff has records is some 650430 lt a year, of which 70% is transported to other areas of the country. The government has discontinued the subsidies.

In general,the achievements demonstrate that the combined efforts of both institutions were successful in forming a team to train and help the colonists

Table 6. Comparison of the milk production system before and after Project implementation in Rio Frio: average figures for 22 units

	1977	1981		1977	1981
Area in pastures,ha	4.0	9.5	Total credit ₡*	9000	135000
Grazing paddocks, no	2.3	24.8	Milk production,lt/day	6.6	81.0
Cattle, head	4.1	32.5	Gross family income	₡8789	84700
Producing cows	1.0	15.0	Farm production,%	27.9	100
Dry cows	0.3	5.0	Government subsidy,%	72.1	0
Heifers	1.8	5.3	Net income, ₡	-	23547
Calves	1.0	7.2			

Source: CATIE 1982 * In 1981 US$ = ₡30 on the unofficial market

apply appropriate technology for dairy production. The project presently is operated and manged by the national institution.

POLICY IMPLICATIONS

Research organization and progress in crop and animal production for small farmers in Central America has progressed substantially in the last few years. The experience gained thus far indicates that there are technologies that can increase productivity levels and that small farmers do respond to technological opportunities, though the sector is not favored by price policies.

There are, however, a few factors worth mentioning that will determine prospects for research to benefit the target group. First, the question of political stability has caused activities directly involving peasants to appear conspicuous. Second, support for the stability and development of personnel skilled in research and extension should be given priority by national policy makers. Third, to some international aid agencies the cause of the income problem lies with poor extension capabilities, and therefore they do not value research. Finally, national research and extension programs on crop and animal production are not integrated to focus adequately on the farmers' system.

NOTES

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2. The Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) is a non-profit institution with headquarters at Turrialba, Costa Rica.
3. The results presented in this paper are the joint product of CATIE and the following institutions: Centro Nacional de Tecnología Agraria (CENTA)of El Salvador; Dirección General de Técnicas Agropecuarias (DGTA) of Nicaragua; Instituto de Ciencia y Tecnología Agrícolas (ICTA) of Guatemala; and Instituto de Tierras y Colonización (ITCO) of Costa Rica. Financial and/or technical support for the work in El Salvador was provided by USAID-ROCAP, IDRC and EEC; in Nicaragua by GTZ; in Guatemala by IDB and USAID-ROCAP; and in Costa Rica by ITCO.
4. In this report the local currency is used only for Nicaragua and Costa Rica due to unstable exchange rates with the US dollar.
5. A few farms over 50 ha were excluded from the survey.
6. The "criollo" is a breed brought to America by the Spaniards in the 16th century.

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