TROPICAL AGRICULTURAL RESEARCH AND TRAINING CENTER

(CATIE)

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TESTING OF TECHNOLOGY WITH SMALL FARMERS IN JINOTEGA, NICARAGUA

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1. Introduction

Development and diffusion of new technology runs usually through a series of stages, like problem identification, controlled experiments, on-farm trials, pilot production programs, and finally large scale diffusion (2,7,11). The on-farm trials play an important role in this process, because there it must be proved whether the technology packages are adapted to the prevailing conditions of the target group.

Two packages with maize and beans in association and maize as a sole crop (where humidity was too high for beans) were tested in collaboration with small farmers in the highlands of Jinotega, Nicaragua. The purpose of this paper is to report on the approach used and the results achieved during the first cropping cycle.

2. Characteristics of working areas and farms

Within the Department of Jinotega, three working areas were selected which differ greatly in climate and altitude (see Table 1). Farming systems are highly diversified and adapted to their ecological environments. Maize, beans, and to some degree, sorghum are the principal stable crops and are produced mainly for subsistence. Coffee and vegetables have gained in importance during the last decades and are the predominant cash crops of the small farmers in the study areas. Yields of grains and coffee are rather low compared to other areas of Central America or to experimental results within the Jinotega region. Low yields and drastic price increases for agricultural inputs during the last years resulted in low net farm incomes (see Table 1).

3. Approach and technical packages tested

The testing phase was preceded by an area description with emphasis on the physico-biological and socio-economic conditions. This information and results from experiments from the working area or similar areas were used to elaborate the technical packages to be tested. They were then discussed in meetings with the collaborating farmers and adapted when necessary. These discussions had a stimulating effect and motivated the farmers to collaborate actively throughout

the cropping cycle.

The participating farmers were members of the group selected for the which was conducted simultaneously with the on-farm trials. Consequently, a direct comparison between traditional and recommended technology was possible.

Field assistants helped in the establishment of the plots (1000 m^2 each for improved and traditional technology) and visited the fields weekly together with the farmers. All activities, however, were carried out by the farmers themselves. The recommended technologies tested included a maize-beans (en Suni) and a maize package (in Sisle and Los Robles) with improved varieties, increased plant densities, application of fertilizer, and insect control.

Table 1: Characteristics of farms and their environments in three areas of Jinotega, Nicaragua

	AREAS		
	SUNI	LOS ROBLES	SISLE
Annual precipitation (mm)	850	1.500	1.800
Altitude (m)	700-1000	1000-1150	1000-1300
Farm sizes (ha)	5.1	5.4	8.4
Thereof: annual crops	2.2	0.9	2.2
perennial crops	-	1.6	0.7
pasture + fallow	2.9	2.9	5.5
Total value of production[2)]	31.500	37.000	31.500
Thereof: grains	11.000	3 000	7.000
vegetables	15.000	1.500	9.500
coffee + fruit trees	-	27.500	6.000
livestock	5.500	5.000	9.000
Net farm income	24.500	22.500	21.000

1) Only farms with less than 50 ha were included.
2) Cordoba (C$) = US $0.033 in the unofficial market.

SOURCE: (10)

4. Comparison between traditional and recommended technology

4.1 Agronomic aspects

4.1.1 Maize-beans-yields

An analysis of yields reveals that with the recommended technology, mean production for maize and beans is 1659 and 869 kg/ha respectively. These performances are 300% (maize) and 50% (beans) greater than those obtained using the traditional technology.

In Figure 1, the distribution of gross returns for the maize-bean association can be observed. With the farmers' technology, approximately 54% of them realize less than C$5000/ha; this is in contrast to 18% earning that amount under the recommended technology. When the major production groups are compared for mean value, only 42% of those using the farmers' technology attain that value in contrast to 72% for those employing the recommended technology.

4.1.2 Maize yields

In Sisle, with the recommended technology, 1975 kg/ha was obtained which represents 781 kg/ha more than with the traditional technology However, in Los Robles, the resulting yield of the two technologies are similar given that with the recommended variety (NB-3) approximately 20-30% of grain was lost in the field as a result of fungi and insects.

Figure 2 demonstrates the variation in the distribution of yield within the two technologies. Thus, for the recommended technology, only 38% have values greater than the average (1975 kg/ha) and for the traditional, 24% are above their respective average (1194 kg/ha). Figure 3 demonstrates that in Los Robles, for both technologies, the higher frequencies correspond to groups 2 (1000-1499 kg/ha) and 4 (2000-2500 kg/ha). In addition, it can be noted that with traditional technology, the number of farmers obtaining a yield higher than the average (1840 kg/ha) is greater (50%).

The low yield of the recommended technology is probably due to the variety of maize (NB-3) used, since it does not perform well in areas of high precipitation.

4.1.3 Factors influencing yield

In order to compare the technologies, different factors in the regression models have been included in an attempt to explain observed differences in yield.

FIGURE 1: DISTRIBUTION OF GROSS RETURNS OF A MAIZE-BEAN PACKAGE IN SUNI.

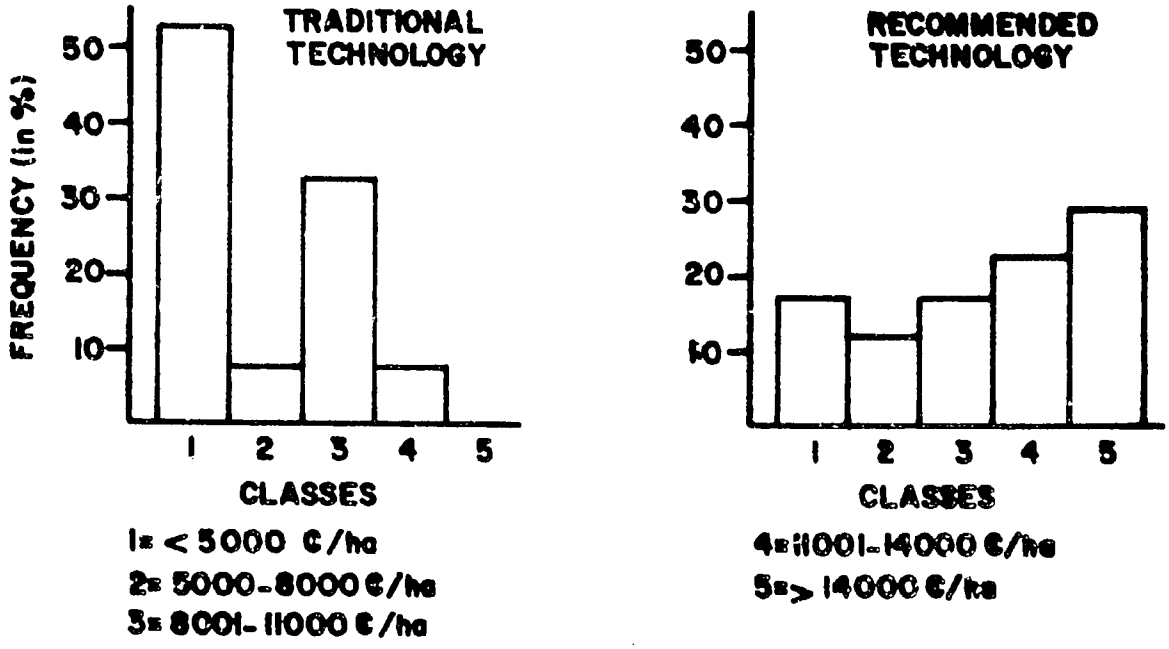


FIGURE 2: DISTRIBUTION OF MAIZE YIELDS IN SISLE.

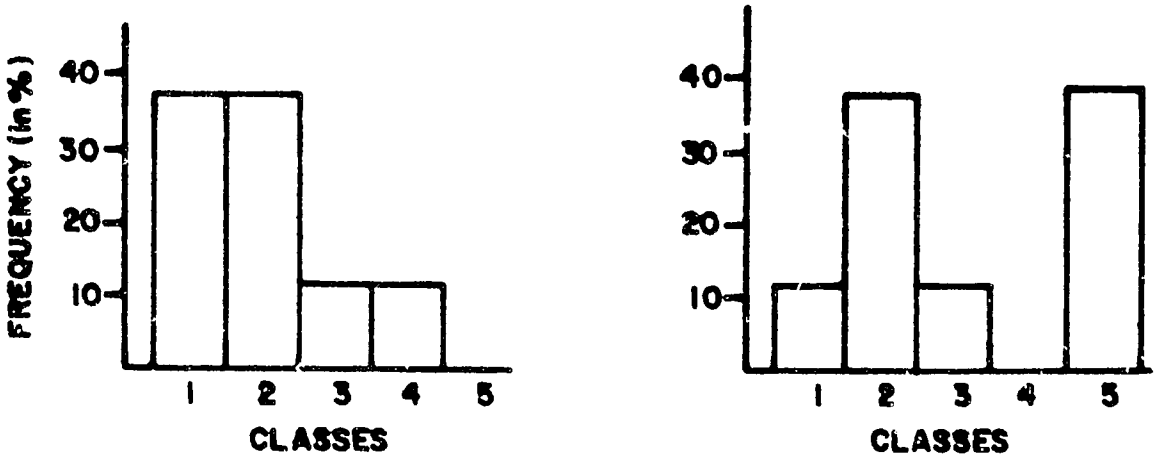
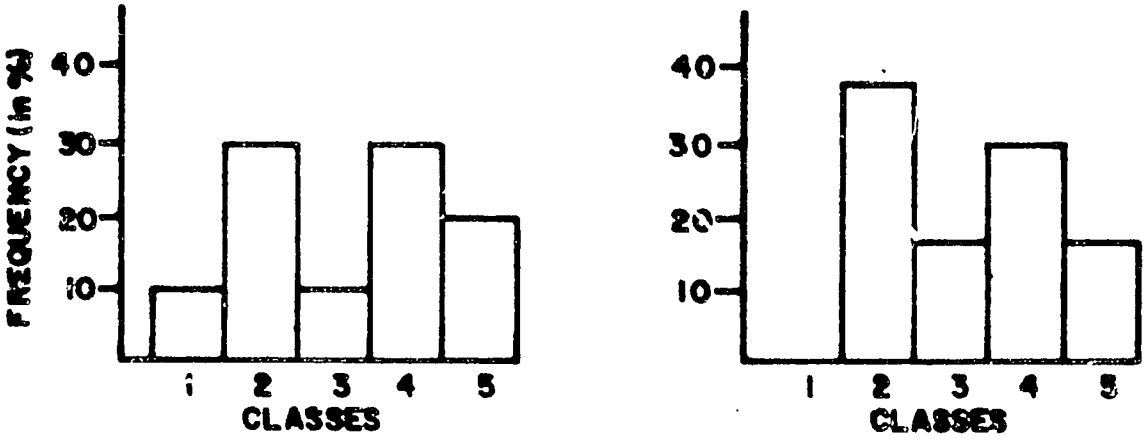


FIGURE 3: DISTRIBUTION OF MAIZE YIELDS IN LOS ROBLES.



Farmers' technology

In the first analyses, the following variables were included to explain the yield: planting date, time between first planting and first weeding, phosphorus as the most limiting soil element, density of population, and labour cost in man-days/ha. The first variables mentioned do not sufficiently explain the variation in the observed yield, and moreover, none of the regression coefficients are significant. Population density and labour utilization explain, for the Los Robles area, 94% of the variation of yield (within the observed range).

The Cobb-Douglas function best explains the relationship between the different variables. The partial regression coefficients (see below) demonstrate that an increase of 1% in population density raises the yield by 1.43%, and an increase of 1% in workdays raises it by 0.44% (maintaining constant the other factor of the model)[1].

The t values (in parenthesis) indicate that the coefficients are both significant.

$$Y = -9.41\, X_1^{1.43}\, X_2^{0.44} \qquad R^2 = 0.94$$

$$(7.18)^{**} \qquad (2.94)^{*}$$

Where:
- Y = maize yield in kg/ha
- X_1 = population density in plants/ha (at harvest)
- X_2 = labour costs in man-days/ha
- * = significant with 5% probability
- ** = significant with 1% probability

Recommended Technology

As with the farmers' technology, different regression models have been employed for the recommended technology[2]. The chemical elements of the soil, the planting date, and the time between planting and first weeding do not explain the variation in yield.

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1) It must be noted that this model is valid only for the ranges of observation, for example: population density: 27.000-50.000 plants/ha, and labour: 39 - 124 man-days/ha.
2) Factors outside of the farmers' control such as temperature, precipitation, and winds have not been taken into account.

The most important factor in the work areas, as one would expect, is the population density which explains a high percentage of the observed variation (see Table 2).

Additionally, the labour input used for the production of maize seems to be a significant factor in the area of Suní. In short, population density seems to be the most important of the management factors[1].

Table 2: Factors influencing maize yield in three areas of Jinotega

AREA	FUNCTION	R^2
Suní	$Y = -760.62 + 0.045\ X_1 + 17.93\ X_2$ (2.13) (2.68)*	0.80
Sisle	$Y = -1201.20 + 0.093\ X_1$ (10.34)**	0.95
Los Robles	$Y = 42.23 + 0.054\ X_1$ (8.02)**	0.87

Y = maize yield in kg/ha

X_1 = population density in plants/ha (at harvest)

X_2 = labour cost in man-days/ha

4.2 Economic aspects

To evaluate the recommended technologies, different criteria may be used. The relevance of each depends on the economic situation in each area and on the objectives of the farmers. In the following sections, cash costs of the two technologies and the gross margin per ha and per man-day are compared.

After analyzing the risks involved in the technological packages, for the case of maize-beans in Suní, the marginal benefit-cost-ratio for replacing traditional technologies will be interpreted.

1) Plant density is not a purely exogenous or independent variable since it is influenced by soil quality, precipitation, insect population, etc.

4.2.1 Input costs

The cost of inputs for maize-beans is estimated at C$584/ha at the farmers' level compared to C$1770 kg/ha for the recommended technology (see Table 3).

Regarding maize production as the only crop, the costs with the farmers' technology are C$195.00 and for the improved package, C$1.707 as can be seen in Table 4.

The higher costs for the two recommended packages result from the use of greater quantities of fertilizer and insecticide with the new technologies.

Table 3: Input costs per ha for maize-bean association

	Farmers' Technology		Recommended Technology	
INPUT	Quantity (kg/ha)	Value (C$/ha)	Quantity (kg/ha)	Value (C$/ha)
Seed				
Maize	14	31	14	130
Beans	45	382	36	300
Fertilizer				
N-P-K (12-30-10)[1]	36	138	47	180
N-P-K (17-44-3)	-	-	82	370
Urea (46% N)	-	-	70	280
Insecticide				
Furadan	-	-	19	230
Clorahep	-	-	26	180
Interest (12%/year)	-	33		100
Total costs		584		1770

1) Only three farmers applied fertilizer.

Table 4: Input costs per ha for maize production

INPUT	Farmers' Technology Quantity (kg)	Farmers' Technology Value (C$)	Recommended Technology Quantity (kg)	Recommended Technology Value (C$)
Seed				
Corn	20	51	42	390
Fertilizer				
N-P-K (12-30-10)[1]	20	76	140	530
Urea (46% N)	-	-	70	280
Insecticide				
Furadan	-	-	19	230
Clorahep	-	-	26	180
Herbicides		57		-
Interest (12%/year)		11		97
Total costs		195		1707

1) Only four farmers applied fertilizer

4.2.2 Economic efficiency

For small farmers in the Jinotega region, the possible loss of invested capital (input costs) seems to be a major preoccupation.

As can be seen in Tables 5-7, the minimum value of gross margin/ha (value of production less cost of inputs)[1] is always positive, signifying that all farmers could recuperate their invested capital. However, a more appropriate evaluation is the comparasion of gross margin per ha and per man-day between the two technologies[2].

In the case of maize-beans (Sumí) the averages for the two criteria are higher for the recommended technology (see Table 5). The range of observation

1) The labour costs are not included; it is supposed that all work was executed by family labour and that the farmers' objectives is to maximize net income to family resources.

2) The gross margin per man-day can be a major indicator than gross margin per ha as it incorporates the labour input.

(min. - max.) is larger in the improved technology, but the variation of gross margin is higher in the case of the farmers' technology

In Sisle, the maize package produced a gross margin/ha that is 60% higher when compared to the traditional technology (see Table 6) Nevertheless, the coefficient of variation is almost double in the case of the recommended technology, indicating that the average conceals much information; 37.5% of the parcels have a gross margin/ha lower than C$500 and yet, the same percentage of parcels have given a value higher than C$5000/ha.

The gross margin per man-day is lower in the case of the recommended technology because of its greater work-day requirements.

The gross margin for maize technology in the area of Los Robles demonstrates that the recommended technology was clearly inferior to that of the farmers' traditional methods. This conclusion relates to the two criteria: gross margin/ha and per man-day

Table 5: Comparison of gross margin between farmers' and recommended technologies in the Suni area.

	Farmers' technology (n=15)	Recommended technology (n=17)
Gross margin (C$/ha)		
Average:	5084	9075
Min - max.:	1165 - 10.296	210 - 18 370
C.V. (in %)	57	47
Gross margin/man-day		
Average	73	112
Min. - max.	13 - 178	25 - 262
C.V. (in %)	58	53

4.2.3 Estimation of risk

To estimate the risk, the concept of "stochastic dominance" was utilized; that is, the recommended technology has to demonstrate a probability of receiving

Table 6: Comparison of gross margin between the farmers' and the recommended technologies in the Sisle area.

	Farmers' technology (n=8)	Recommended technology (n=8)
Gross margin (C$/ha)		
Average	2.479	2.638
Min. - max.	443 - 4746	53 - 7093
C.V. (in %)	54.3	102.6
Gross margin/man-day		
Average	50	46
Min. - max.	6 - 135	9 - 172
C.V. (in %)	70.1	105.5

Table 7: Comparison of gross margin between the farmers' and the recommended technologies in the Los Robles area.

	Farmers' technology (n=10)	Recommended technology (n=13)
Gross margin (C$/ha)		
Average	3850	2304
Min. - max.	807 - 7526	493 - 4673
C.V. (in %)	53.7	62.5
Gross margin/man-day		
Average	51	31
Min. - max.	20 - 75	7 - 62
C.V. (in %)	41.3	61.8

FIGURE 4: CUMULATIVE DISTRIBUTION OF GROSS MARGIN IN THE SUNI AREA.

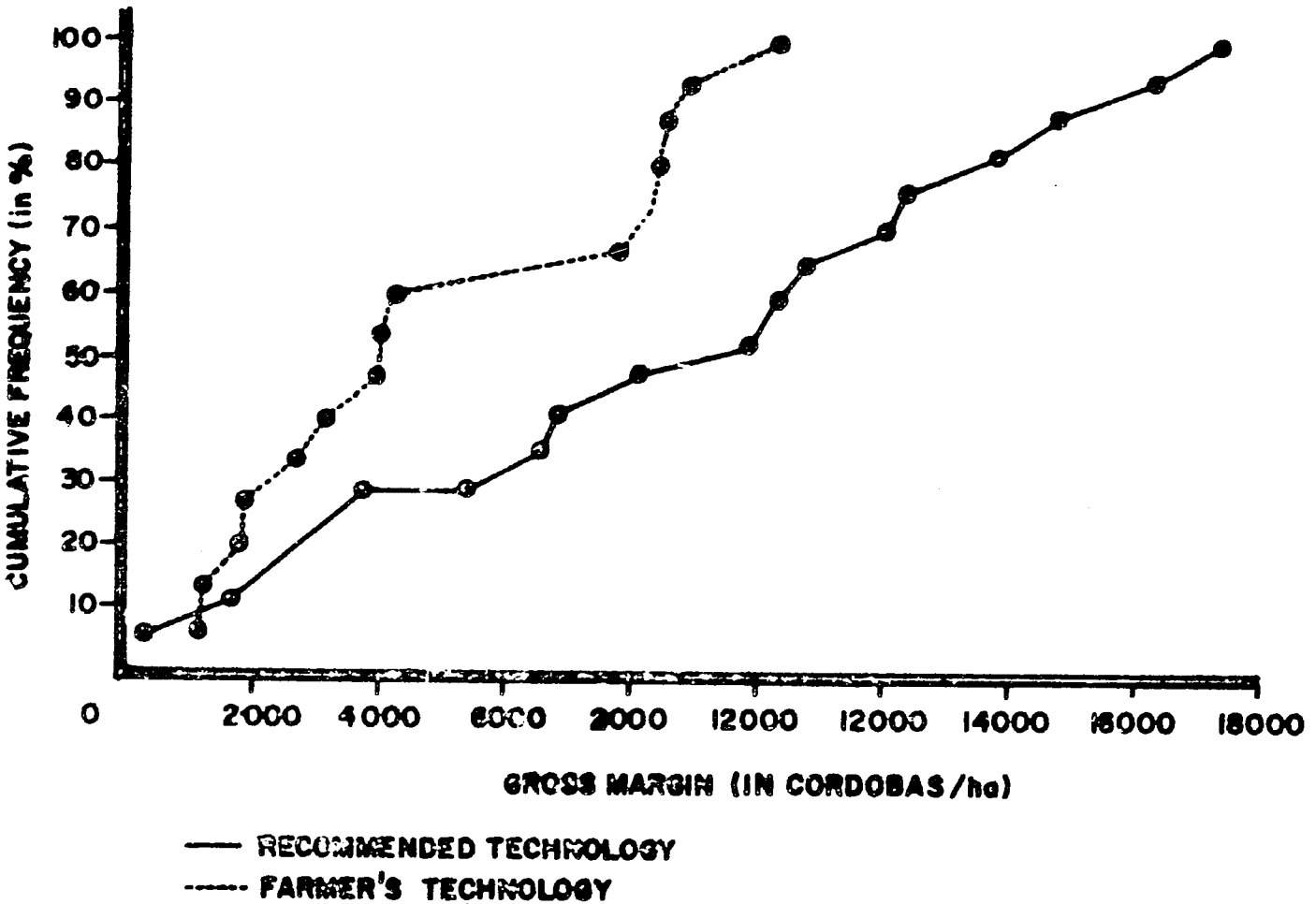
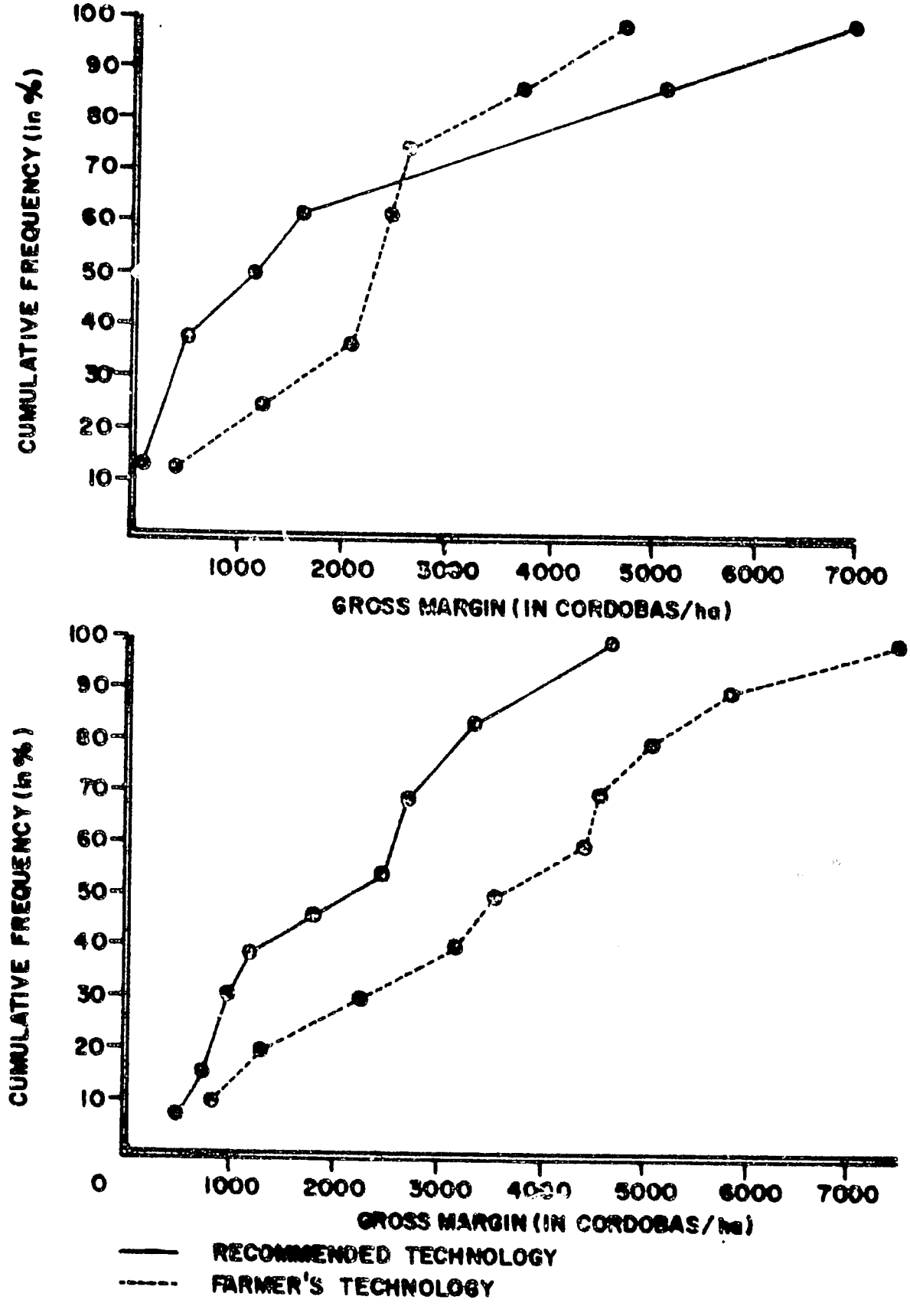


FIGURE 5: CUMULATIVE DISTRIBUTION OF GROSS MARGIN/ha IN THE SISLE AREA.



a higher gross margin at all levels (1,4). The estimation of risk is based on only one year. Consequently, the results are very limited because the climatic risk, one of the most important, can not be evaluated in one year.

The probability estimate of receiving a gross margin at a specified level can be seen directly in Figures 4-6 For the maize-bean association in the area of Suní (Figure 4), the recommended technology has fewer risks when compared to that of the farmer (the "Recommended Technology" curve is to the right of the other, except for one very low observation).

The probability of receiving a gross margin less than C$6000/ha is estimates at 32% for the recommended technology and at 63% for that of the farmers.

The situation with the maize package in other areas is quite different. In Sisle the two curves cross; in other words, the recommended technology holds greater risks (high probability of a low gross margin) but also offers greater opportunities of receiving a high gross margin

In Los Robles, the obtained results are completely opposite to those of Suni. Here the curve of the farmers' technology is always to the right of the other, indicating that the farmers' traditional technology carries less risk

4.2.4 Marginal benefit-cost ratio

From the previous economic evaluation, it can be concluded that the maize-bean technology tested in Suní has good chances of being adopted, especially if credit for the purchase of inputs is available[1]. However, it is necessary to take into consideration that maize and beans are not the only crops available to the farmers Besides these, farmers principally plant sorghum for home consumption and onions as a marketable crop. To better estimate the possible adoption of the maize-bean package, the marginal benefit-cost-ratio (MBCR) of the tested package was calculated along with the onion production which could possibly replace the farmers' technology (see Table 8).

The MBCR for the recommended package was estimated at 3.5, which testifies to its attractiveness to the farmers. However, the MBCR for onions is clearly higher (9.7) and appears to be a favorable alternative to farmers. With this information, it appears probable that the farmers will adopt the recommended technology for maize-beans only at the level of home-consumption.

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1) The availability of credit was investigated during the second phase of the project "Area description".

Table 8: Calculation of the marginal benefit-cost-ratio (MBCR)

Crop	Gross income	VARIABLE COSTS			net income	marginal costs	Marginal income	MBCR to replace (A)
		cash	labour	total				
	(1)			(2)	(1-2)	(4)	(5)	(5/4)
A. Maize-bean (Farmers' technology)	5668	584	1960[1)]	2544	3124	-	-	-
B. Maize-bean (Recommended techn.)	10.845	1770	2268[2)]	4038	6807	1494	5177	3 5
C. Onions Famers' technology)	54.600[5)]	3602[3)]	4004[4)]	7606	46.994	5062	48 932	9.7

1) 70 man-days at 28 Cordobas

2) 81 man-days at 28 Cordobas

3) including 76 man-days at 28 Cordobas for contracted labour

4) 143 man-days at 28 Cordobas

5) Yield: 18.6 t/ha, price: 325 C$/100 kg.

Therefore, if the farmer can find capital and labour, an increase in the cultivation of onions will be probable. This tendency will change if the price of onions decreases drastically.[1)]

5. Farmers' opinions on the acceptance of the packages

At the end of the first harvest cycle, a questionnaire was completed with farmers who had a "Technology Test" parcel.

5.1 Reasons for a good or poor harvest

Even though the yields are not independent of climatic conditions *per se* they constitute a factor by which the farmers can consider the advantages of a technological package.

In the case of the two tested packages, in Suní 100% of the farmers were satisfied with the maize-bean production. This contrasts with Sisle and Los Robles where 42% and 43% respectively were satisfied with maize yield.

The factors considered important by the farmers for good production are found in the following table:

Table 9: Factors influencing high yield according to farmers' opinions

	AREAS		
FACTORS	Suni	Sisle	Los Robles
	% of farmers		
Fertilization	56		
Fertilization and good seed	25		20
Fertilization and insecticide	6		
Good seed		29	
Plant density and good germination		14	
The total package		41	60

In Los Robles and Sisle, 60% and 41% respectively attribute their good return to the total package. Other important factors, according to the farmers

1) Lacking at this time is a study of the onion market.

in these areas, are the components of seed and fertilization.

Most of the farmers in Suní (56%) consider fertilization the most influential contributor to the yield, 25% mention the combination of fertilization and seed, and only 6% consider the combined effects of fertilizer, urea, and insecticide.

Table 10 indicates the factors that the farmers believe influence a reduced yield.

Table 10: Factors influencing low yield according to farmers

FACTORS	AREAS	
	Sisle	Los Robles
	% of farmers	
Heavy rainfall	57	17
Close spacing between plants	-	8
Erratic climate and maladapted maize	-	25
High plant density	-	8

In both localities the farmers agree in expressing that rainfall was a limiting factor affecting production. However, some from Los Robles consider that rainfall was the most negative factor for the crop because there was a greater deterioration in the grain due to rot, for which reasons they do not consider the variety usable.

The reasons given as factors influencing a good or poor harvest are inconsistent with the results of the regression analysis. It seems that "uncontrolable factors" play an important role. The reported problem of "heavy rainfall" indicates the importance of evaluating this technology over several years.

5.2 Farmers considering adoption of the package

The partial or complete implementation of a package depends upon the different acceptance rates of its components, which in the farmers' judgement increase yield.

For example, in Suní 88% of the farmers are considering adoption of the maize-bean package, and, even though some suggest certain changes, those proposed

modifications could well be due to needs or preferences which the farmers have for certain crops.

Compared to the other areas, the percentage of possible adoption seems to be high; nevertheless, it cannot be said that some package components are definitive, like fertilizer rate, plant densities or spacing. We feel that these adjustments can be carried out by the farmers themselves in a trial and error basis according to the specific conditions of their fields and their personal preferences. Only 43% and 48% in Sisle and Los Robles respectively are considering putting into practice the maize package. In these areas the low implementation rates are due to, on the one hand, the lower acceptance rate for the seed component (75% want to try another variety), and on the other, the high cost of inputs.

6. Conclusions

The approach used for testing of new technology where farmers are participating in the design, execution and evaluation process can be regarded as successful. It ensured farmers collaboration throughout the whole testing phase and strengthened the dialogue between farmers, extension workers and researchers.

An analysis of the two packages indicates that the recommended technology for the maize-bean association was better when compared with the traditional technology. This result is consistent with the opinions of the farmers who participated in testing the new technology. Nevertheless, it must be taken into account that the conclusions are preliminary because the experience of one planting season is not sufficient. On the other hand, the farmers in Suní also plant onions, and consider it as their principal cash crop as it produces a marginal benefit-cost-ratio higher than the recommended package. Consequently, the adoption of the maize-bean technology could be limited by this alternative. The maize package is not yet regarded as ready for diffusion. The variety used (NB-3) is not adapted to areas of high precipitation, and the selection of varieties for these humid zones deserves greater attention during the next year.

SUMMARY

Before entering the diffusion phase of the new technology, its relevance must be evaluated by the farmers, extension personnel, and the investigators. Two technology packages serve as examples for comparison with traditional methods. The agro-economic analysis together with the opinions of farmers indicate the possibilities for an adoption of the technological packages.

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