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TWO CORN PRODUCTION SYSTEMS IN THE CAQUEZA PROJECT[1]

by

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I INTRODUCTION

Production research for small farmers in Latin America is now generally recognized to require a different approach, design and interpretation from traditional crop production research methods as used in Europe and North America. The changes designed to better meet the small farmers situation have so far focused primarily on three additional requirements. Firstly, the need to realize research on new practices or materials within the region for which the application is intended. Secondly, the need to consider various levels of financial inputs, in order to structure recommendations to the farmers' ability to pay for them and his preparedness to accept the risks involved. Thirdly, the need to infuse new methodologies on materials into existing production methods, in this way avoiding the recommendation of entirely new production systems in an extremely risk sensitive society (ALADER, 1972 pp. 56,57; Turrent, 1973).

Although the need for these changes is now recognized, there remains a considerable lack of unanimity about the role of production research, its methodology and performance criteria for its results, in the process of rural development. Such results, which are generally expressed as production recommendations have, in the majority of cases, achieved a very limited acceptance by the small farmer. This lack of adoption has been widely discussed and used as an argument both to justify the employment of and to criticize the performance of communication specialists assigned to "extend" research results to the farmer.

In this study, some of the results of the production research in the Cáqueza Project and some of the experiences acquired from studying farmers' adoption behaviour related to production recommendations, will be employed to further define the role of production research in rural development. In addition, methods for the interpretation of research results will be discussed that may lead to action programs better adjusted to the operational restraints existing in the small farmers community.

II TWO CORN PRODUCTION SYSTEMS IN THE CAQUEZA PROJECT

A. The Farmers Methods

Farmers in the project region generally make a plowing contract with a member of the community who owns oxen and a wooden plow. Corn is then seeded in hills, spaced 1 m. by 1.20 m. Seeding rates are three to four plants per hill and the resulting stand is not thinned. The field is weeded twice and hilled up once, at the time of the second weeding. No fertilizer is applied. The family harvests corn with the cobs covered and stores the cobs with half the covering leaf still on the cob (Gonzâlez and Zandstra, 1973).

A survey of 188 farmers' fields (Narváez, 1974) provides a more precise analyses of this production system (Table 1) and shows the low production costs, low yields and the precariously low returns provided to the farmer using 1972 (10 ct/kg) and 1974 (16 ct/kg) corn prices.

B. The Projects Recommendations

Because of the obvious potentials for production increases indicated in Table 1 and the dominance of the corn crop in the region, the Cáqueza Project has devoted considerable research effort towards the definition of an improved corn production method in the project area. Initial research concentrated on the selection of adapted hybrids and varieties from the assortment of ICA-produced certified materials that were already available (Gonzâlez and Zandstra op. cit.). Major emphasis was, however, given to experiments on farmers' fields formulated to define adapted recommendations for planting densities, fertilizer application and pest control (Cobos and Zandstra, 1973).

Two- or three-replicate trials were carried out over a period of three years at 27 different sites, in order to arrive at suitable recommendations. Yield analyses from these trials, combined with yield figures from 23 commercial farmers fields in which recommended fertilizer levels were applied, permitted an estimation to be made of the benefits to be derived from following the projects recommendations (Table 2). To derive the yield estimate presented in Table 2, experimental yields were deflated by an average of 20% (for the highest yields the deflation factor was approximately 40% in order to adjust for bias in experimental control and site selection, Zandstra and Villamizar, 1974).

C. The Project's Experience with Farmer's Adoption of its Recommendations

Since the early project work in 1971 suggested that it was possible to increase production and net income by over 200%, the project began to make preliminary recommendations in the extension program for 1972. In 1972 and 1973, it also studied the response to farmers to a six-factor package of recommendations. In 1972, farmers who received credit and were urged to follow the recommendations showed considerable resistance to the application of some of the components of the recommendation. Only 22% of the recommended fertilizer was applied, even though fertilization was a well recognized part of the trials on farmer fields (Escobar, 1972). Most farmers (86%) did, however, adopt a higher planting density, although during the experimental phase, this measure was unpopular with many farmers.

The project team's reaction to the low adoption of the fertilizer recommendation was two-fold. Firstly, they recognized the desireability of simplifying the fertilizer recommendation from a triple application to one in which all fertilizers was applied early in the season (when the farmer still had cash from the credit program), if possible in a single application. This led to a new research program with ten on-farm experiments carried out over a period of two years. This program will terminate next month and is designed to compare the performance of the simplified fertilizer application methods to that of the split application, taking into account adoption experiences, income and risks. The second reaction to low adoption of their recommendations was to criticize the extension methodology used (a traditional reaction by technicians to a lack of adoption of their recommendations).

In 1973 considerably more pressure was applied and more supervision was given by the project to recipients of corn production credits. The fertilizer recommendation was reduced from a three-fold application to a two-time application method. Preliminary results of the 1973 adoption study (which, unlike the 1972 study, also includes yield measurements) indicate that there was a substantial increase in adoption rates and a marked improvement in corn yields. The staff did, however, sense a lack of enthusiasm by farmers for the corn production credits in comparison to credits for horticultural crops or potatoes. This lack of enthusiasm existed even though the price of corn in the field had increased from 10ct/kg in 1972 to approximately 13 ct/kg in 1973, but may relate to the fact that average per ha net incomes from vegetables and potatoes are much higher than those from corn.

III AN ANALYSIS OF THE CONSTRAINTS ON ADOPTION

Through regular meetings with farmers and a research project designed to establish the "real cost" of credit in the region (M.S. thesis of V. Villamil directed by K. G. Swanberg, in preparation), the project team began to suspect the existance of some constraints, of which they were not fully aware, that were limiting the adoption of what appeared to them to be sound recommendations. This led to a more complete comparison of the two production systems, with particular emphasis being given to comparative risks, returns to inputs and cash and labour requirements. The production method recommended by the project showed advantages over the existing production method, except for cash and labour requirements, returns to cash invested and both measures of risk (Table 3). Each of these disadvantages will be discussed separately:

Cash requirements were increased by 575% in the recommended method. This changed the production system from one that was land and labour intensive (75% of total investment for the actual method) to one that is cash intensive (62% of total investment for the recommended method).

To appreciate what this change may mean to the Cáqueza farmer, one needs to compare these figures to the average income for the region, the approximate cash turnover and the available cash on a per ha basis. The project benchmark study (Escobar, 1973) indicated a per ha income of $235,3/ of which approximately $150 was received in cash and the rest as farm produce for consumption on the farm. The average income from agricultural production was $190 /ha ($85 consumed and $105 sold) and

3/ Adjusted for inflation at 25% per year and differences in peso exchange rates, assuming an average farm size of 3.2 ha and a family size of 7.5 members.

$45 /ha was received off-farm sources of income. A separate study of food consumption data of 259 families in 1974 allowed these figures to be cross checked against actual consumption data. On a per ha basis using the same assumptions, per family food costs were $222. Although this estimate of cash available after food costs ($13 /ha) can be substantially varied by slight changes in inflation rates, it is most indicative of the limited cash available to the farmer for investment in crop production. Where he originally needed to invest $21 in cash, to follow the project's recommendation, he will need $142 or nearly six times as much. His low cash availability suggests that, to do so, he will need to seek credit from the agrarian bank or from his community. He will therefore incur an interest charge of $21 (Table 2) which is nearly equal to the total cash requirement of his original production method.

Labour requirements were 18 man days /ha higher with additional labour demands evenly distributed throughout the season. Depending on the availability of labour (under study), this factor may reduce adoption rates. However, returns to labour under the recommended method increased substantially and may therefore be competitive to other employment possibilities.

Returns to cash dropped in the change from actual to recommended practices. This production input was receiving the highest returns per dollar in the actual production system, which could be considered an expression of the value the farmer attaches to cash input. The combination of reduced returns to cash with its limited availability may well be sufficient reason to qualify the recommended method as an inadmissable strategy in the decision-making space of the farmer. The reduction in the productivity of cash inputs may also explain the farmers' preference for credits for horticultural crops.

The farmer's risk was calculated as the expected value of the loss.[4/] Two different loss functions were calculated using (a) the total cost of production, including land, labour and cash, and (b) using cash outlays alone. The second alternative was considered important as the farmer appeared to be more sensitive to a loss of cash than to reduced productivities of land and labour. Indeed the work of Duncan and Swanberg suggest that farmers did not regard land as an input and that many disregard labour also. In their low cash economy, cash was the primary, if not the sole, item in any consideration of inputs.

Calculated risks on total investment more than doubled and risks associated with cash inputs increased 15 times (Table 3). As the farmers needs to borrow money for the recommended production method, this means that he acquires a risk liability to his community of at least $53, a sum that represents 23% of his per ha annual income. This risk may be excessive for the farmer, particularly if weighed against the low returns on cash inputs that he obtains from the recommended system. If the farmer does not change his actual production system, his risk equivalent is only $3.25 (Table 3, last line), which would not be vis-a-vis the community, as he is probably able to raise the $21 cash requirement without borrowing.

The above analysis suggests that resistance to acceptance of the recommended production methods lies in the high initial cash requirement, the low returns to cash invested and the high risks related to the change. The possibility exists that the additional labour required for the change and the necessity to market a larger crop will

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4/ The expected value of the loss was calculated employing a loss function that took values between zero and the cost considered (total or cash). No negative loss values (gains) were considered so that the risks are related to the probability mass associated with losses larger than zero and the size of these losses (Appendix 1).

also constitute limiting factors. These matters are currently under study (See K. G. Swanberg's presentation).

Acceptable recommendations must apparently satisfy a set of requirements that are defined by the producers' community. The lack of knowledge of researchers and planners of action programs about these conditions and their relation to the rural community, has probably been the overriding reason for the failure of new production technologies in the small farmers' community.

A telling indication of how little thought these matters have been given lies in the fact that no clear understanding exists of which conditions a production recommendation must satisfy to really constitute a better alternative for the producer. Most researchers will employ production figures or net gains as their criteria for comparison.

Through continued research closely associated with rural development action programs, the project staff hopes to narrow down more and more specific criteria for the admissability of alternative production strategies. In addition, a clearer understanding is sought of optimization criteria that include limits on returns to inputs (or their availability) and on risk, as dictated by the criteria for admissability.

At this time, the project staff is considering the following tentative conditions for admissability of alternative production strategies:[5]

1) A necessary condition is that average returns to total inputs are higher for the alternative than for the actual method;

5/ These conditions employ average returns, as marginal returns require a knowledge of the production function and an analytical capacity rarely available in field situations.

2) A necessary condition is that the risks associated with the alternative methods not be substantially higher than those associated with the actual methods;

3) A necessary condition is that returns on limited input factors (cash, land and maybe labour in the Cáqueza case) be increased by the alternative production strategy; and

4) A sufficient condition for production alternative acceptable in economic terms, appears to be that the average returns to each production factor are higher than for the actual production method, and that risks are lower.

As stated, these conditions are far from complete, e.g., the project is still attempting to define what the tolerance relation is between increased risks and increased net returns. There also exist non-economic constraints on adoption that should be considered. Moreover, this document confines the discussion to the introduction of an alternative production method for the same crop. The conclusions of this study need to be made applicable to the introduction of alternative crops and, more generally, alternative economic activities.

IV FORMULATION OF THE PROJECTS CORN PRODUCTION PLAN

To reduce farmers' resistance to adoption of the recommended production practices, one could consider reducing cash inputs for fertilizer. This would result in lower cash requirements and lower risks. However, the project does not consider this an acceptable alternative because benefits of the recommendation are closely linked to fertilizer inputs. The formulation of recommendations for different levels of richness would, therefore, lead to low incomes for poor farmers and higher incomes for richer farmers, which hardly leads to improvements in income distribution.

For this reason, the project team designed an experimental credit/risk-sharing scheme that sought to reduce the farmers' cash requirements for production to near his actual cash input level. This scheme was structured so that the participating farmers shared the risks associated with the adoption of the recommended investments in fertilizers and insecticides (Zandstra and Villamizar, 1974).

The plan operates as follows: Interested farmers specify the area to be seeded and provide information on the soil type, topography and history of the field. They pay an entrance fee of $10 /ha (Table 4). The project staff visits the farm and in consultation with the farmer formulates recommendations with respect to variety to be seeded and fertilizers and insecticides to be applied. The farmer is given a note authorizing the project cooperative to supply him with the seed, fertilizer and insecticide required at seeding time and at the time of top dressing. The farmer signs a contract, which specifies that he will share in equal parts with the plan all production exceeding 800 Kg. grain/ha and that he will be liable to a fine of $10 /ha in addition to the costs of inputs he received from the plan, if he breaks the contract.

Comparison of the production plan with the actual and recommended practices (Table 5) shows that the plan increases cash outlay by $10 because of the entry fee, but the cash costs for the farmer participating in the plan are far less than those of the farmer using the recommended package. As far as risks are concerned, the plan shows low probabilities for low yields, a risk related to total investment similar to that of farmers' actual practice, and a risk related to cash investment that is substantially below that which the farmer accepts for his actual corn production method (Table 5, last 3 lines).

The production plan was designed to reduce cash requirements and risks and to avoid that returns to cash were below those obtained by the actual system. In this case, returns to cash were increased from $3.75 to $6.03 per dollar invested. These high returns may be required to make sure that the plan can compete against high value product crops such as tomatoes and onions.

Under the plan, the farmer's per ha net gain is reduced from $205 to $168 because the plan generates a net return to itself of $48 b/. This income is required to insure continuation of the plan, to cover its operating costs (transport, handling, losses, over-application of fertilizer, etc.) and to serve as a buffer against unexpectedly low yields. It is expected that the costs of supervising the harvest will be high and ways to reduce this will be a key item in refining the plan.

In 1974, 27 farmers participated in the plan. To date, farmers seem to be pleased with the way it operates: one farmer was heard to say to a participant in the plan "You have won the lottery in corn this year". Although yields appeared to be

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b/ Total net gain from the plan ($168 + 48 = $216) exceeds net gain from the projects recommendation ($205) by the difference between the cost of credit ($21) and the entry fee ($10).

at or above the expected average, the corn had not been harvested at the time of writing (October). Furthermore, the plan is expected to present problems in terms of transport of produce, the farmers' and the extensionists' accuracy in estimating the yield and their preparedness to agree to an estimated yield figure, etc. In this sense, we regard the plan as a link designed to explore a new approach to credit, in the complex chain of activities that constitute rural development.

V CONSIDERATIONS FOR AGRICULTURAL PRODUCTION RESEARCH

The experiences discussed are in reality no more than a documented example of what often occurs when national and international research programs endeavor to introduce new production technologies on small farms. A prime reason for this may be the isolation of these "centres of excellence" from the reality of the small farmers' society to which they are supposed to direct at least part of their activities, since in general there appears to be a deep void between those responsible for biological research and those responsible for delivery systems to small farmers. Because of this a dismal picture of non-participation and non-identification is often seen all the way up the ladder. Although rural development personnel make valient attempts to sell new technology, this study indicates that it is not always saleable and probably will not be until methods have been developed to insure a realistic participation of the farmers' community in the problem definition and research of the projects (See also Ronald Duncan's presentation).

The small farmers are even less understood by central experimental station research personnel, to the extent that the majority of these researchers are hard pressed to understand and assign importance to what rural development staff tell them about the small farmer with respect to the design of new production technology. Except for a few personnel specialized in small farmers' agriculture and in agricultural development, sociology or economics, staff at most major centres for agricultural research in developing countries continue to think in biological terms only about what is in reality a problem that heavily overflows into economic, social and culturally oriented areas of knowledge.

This study clearly indicates that the proposition: "A good variety sells itself" may only be valid under a specific set of circumstances, of which the probability of occurrence in a small farmers' community is extremely small. For this reason, production research designed to benefit small farmers should incorporate into its planning and design stages the socio-economic and cultural specifications of the recipients of their results. To do this, researchers need to acquire a better understanding of the relation between the socio-economic and cultural characteristics of the farmers' community and the optimization criteria to apply in the formulation of recommended production practices. The most effective method to arrive at this is to structure realistic participation in the decision-making processes, of the farmer at the change agent level, of the change agent at the research station level and of the national research organization at the level of the "centres of excellence".

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CALCULATION OF EXPECTED LOSS

Let f_y be the probability density function of corn yields and assume:

$$f_y \sim N(\mu, \sigma^2)$$

Let f_L be a corn function in terms of costs, yields and prices so that

$$f_L = \bar{L} \text{ for yields } < x$$
$$f_L = 0 \text{ for yield } \geq x$$

where x is the break even point.

Then the expected value of the loss will be:

$$E(L) = \int_{-\infty}^{\infty} f_L \cdot f_y \, dy$$

In this sense, the loss function specified is not an actuarial loss function, as it does not take on negative values (See Halter and Dean, 1971).

As in this document the loss function for the two production systems can be specified as:

$$L = C - yp \quad \text{for } y < C/p$$
$$L = 0 \quad \text{for } y \geq C/p$$

where y = yield; p = price of corn and C is costs (total or cash).

Then the expected value of the loss is

$$E(L) = E(C-yp) \quad \text{for } y < C/p$$

$$E(L) = -p \cdot E(y) + C \text{ for } y < C/p \text{ 1/}$$

$$E(L) = -p \cdot E(y \mid y < C/p) + C$$

So that the expected loss can be calculated from the cost of production, the price of corn and the expected value of the truncated (normal) distribution of the corn yields.

1/ As the price of corn and costs of production are independent of yield for each of the production systems compared.

Table 1: The actual corn production method in Cáqueza*

Costs /ha	1972	1974
Cash: 1) Land preparation	$ 13	$ 16
2) Seed and others	$ 5	$ 5
Land (Cost of rental)	$ 30	$ 36
Labour (26 days)	$ 23	$ 28
Total	$ 71	$ 85
Yield, kg/ha	907 (S.d. = 660)	907 (S.d. = 660)
Returns /ha		
Value Product	$ 91	$144
Net gain	$ 20	$ 59

* $ = Cdn$

Table 2: The recommended production method in Cáqueza*

Costs /ha	1972	1974
Cash: 1) Land preparation	$ 13	$ 16
2) Fertilizer and seed	$ 49	$ 97
3) Insecticides	$ 6	$ 9
4) Interests (24%/yr.)	$ 6	$ 21
Land	$ 30	$ 36
Labour	$ 41	$ 50
Total	$145	$229
Yield, kg/ha	2740 (S.d. = 1170)	2740 (S.d. = 1170)
Returns /ha		
Value product	$274	$434
Net gain	$129	$205

* $ = Cdn$

Table 3: Comparison of actual and recommended corn production methods in the Cáqueza Region, assuming the 1974 corn price of 16 ct/kg.

	Cdn$ /ha		
	Actual	Recommended	% change
Yields /ha	907 Kg.	2.740 Kg.	202
Total costs	$ 85	$ 229	170
Net gain	$ 58	$ 205	253
Cash costs	$ 21	$ 142	575
Return to land /$	$2.61	$6.69	155
Return to labour /$	$3.07	$5.10	73
Return to Cash /$	$3.75	$2.44	- 58
P [gain < 0]	0.28	0.13	- 53
P [gain < cash costs]	0.12	0.06	- 50
Risk on total input *	$ 37	$ 78	111
Risk on cash input *	$3.25	$ 53	1,530

* See Appendix 1 for the method of calculation used.

Table 4 Description of the Corn Production Plan Developed in the Cáqueza Project (1974 Prices)

	Cdn$ /ha	
Entry Fee	$ 10	
Farmers Investment	$102 (Land + Labour)	
Plan Investment	$106 (Inputs)	
Minimom Yield for Farmers	800 Kg./Ha	
Expected Farmers Yield	1770 Kg./Ha (800 + 970)	)
		) = 2740 (Table 2)
Expected Yield for Plan	970 Kg./Ha	)
Net-Return to Farmer	$168 (Cash Equivalent)	
Net-Return to Plan	$ 48 (Cash Equivalent)	

Table 5 Cash requirements, returns to inputs and risks to the farmer of the Corn production plan, and the actual and recommended production methods.

	Actual	Plan	Recommended
Farmers Cash Required /ha**	$ 21.00	$ 31.00	$ 142.00
Net Gain /ha	$ 58.00	$156.00	$ 205.00
Return to Total Input/$	$ 1.68	$ 3.42	$ 1.90
Return to Labour /$	$ 3.07	$ 4.12	$ 5.10
Return to Land /$	$ 2.61	$ 5.33	$ 6.69
Return to Cash /$	$ 3.75	$ 6.03	$ 2.44
P (Yield 800)	0.44	0.05	0.05
Risk on total input /ha *	$ 37.00	$ 39.00	$ 78.00
Risk on cash input /ha *	$ 3.25	$ 0.50	$ 53.00

* For calculation method of expected losses see Appendix 1.

** $ = Cdn$