CIMMYT Economics Program Working Paper 88/01

Fertilizer in Les Cayes, Haiti: Addressing Market Imperfections with Farm-based Policy Analysis

Michael Yates*
Juan Carlos Martínez*
Gustavo Sain*

1988

* CIMMYT Economics Program.

The authors wish to thank Robert Tripp, Derek Byerlee, Donald Winkelmann, and other colleagues at CIMMYT for their helpful comments, and Maria Luisa Rodriguez and Beatriz Rojón for their patience in typing many drafts of this paper.

Views expressed in this paper are not necessarily those of CIMMYT. CIMMYT's resident program in Haiti has been financed by the Rockefeller Foundation (1981-82) and by the Canadian International Development Agency (CIDA) (from 1983 to the present). Staff in Haiti have been supported by CIMMYT's Regional Program for Central America and the Caribbean, funded by a grant from the Swiss Development Corporation (SDC).

Preface

CIMMYT's methods for on-farm research (OFR) are now being implemented by many national programs, helping them to identify improved and appropriate technologies for target groups of farmers. These experiences have contributed to a growing awareness that policy-induced constraints can limit gains associated with potential or actual technological change. CIMMYT's Economics Program has recognized that efforts to analyze this policy context and effectively communicate information derived from the analysis to policymakers could improve the basis for formulating or implementing policy. This area of research is called farm-based policy analysis (FPA).

The case of market imperfections in fertilizer provision in Haiti discussed in this working paper illustrates the close links between OFR and FPA. However, although traditional OFR assumes that socioeconomic circumstances--including the policy environment--are a given, FPA sees policy as a *variable*, and builds a case for modifying policy constraints by applying microeconomic tools to farm-level data obtained through OFR programs.

As this study demonstrates, that approach helped encourage important changes in fertilizer policy in Les Cayes, Haiti, which suggests that the market imperfections identified through the analysis were due at least in part to a lack of appropriate technical information among the relevant decision makers. It is apparent that FPA analysis using data generated from OFR programs has much potential to help correct such deficiencies and make farmers' policy environment more conducive to technological change.

Derek Byerlee
Director, CIMMYT Economics Program

Contents

iii Tables and Figures

1 Introduction

3 The OFR Program and Its Results

5 Identification of Policy-induced Constraints

15 Targeting Audiences and Communicating the Findings

16 Changing Patterns of Fertilizer Distribution and Use in Les Cayes

18 Conclusions

20 References

21 Appendix: The Derived Demand for Nitrogen

Tables

Table 1. Average annual field prices of maize and nitrogen, Les Cayes, Haiti, 1981-85 8

Table 2. Yield gains and nitrogen demand associated with alternative pricing scenarios 9

Table 3. Fertilizers sold in the Cayes Plain, 1981 12

Table 4. Urea sales by the private sector, Les Cayes, 1983-85 17

Table A. Potential regional demand for nitrogen in maize production, Les Cayes 22

Figures

Figure 1. Hypothetical response curve and derived demand for nitrogen 7

Figure 2. Regional market demand for nitrogen by land tenure system 7

Figure 3. Estimated response to nitrogen and per-hectare derived demand, Les Cayes, Haiti 10

Figure 4. Conceptual structure of the regional supply and demand for nitrogen, Les Cayes, Haiti, 1981-82 13

Introduction

The environment in which farmers make production decisions is generally complex. Both natural circumstances (e.g., rainfall, soil type) and economic ones (e.g., product and input markets) condition farmers' behavior and choice of technology. The economic environment is shaped by many factors, including agricultural policy decisions. Such decisions significantly affect the introduction and diffusion of improved technologies.

CIMMYT has formulated a set of cost-effective research methods for developing improved, appropriate agricultural technologies through on-farm research (OFR).[1] These methods are being implemented in many areas of the world, increasing the capabilities of national research programs to generate and transfer appropriate technologies for target groups of farmers.

The experience of many OFR programs has indicated that policy-induced constraints can limit gains associated with potential or actual technological change. CIMMYT's Economics Program recognizes that methods for analyzing the policy context could greatly benefit many national research programs. The methods would provide guidelines to identify, where appropriate, policy constraints or opportunities related to the use of new technologies, and to effectively communicate that information to relevant policymakers to improve the basis for formulating or implementing policy. This area of research is what we call farm-based policy analysis (FPA).[2]

As this case study illustrates, OFR and FPA are closely linked. An essential characteristic of both approaches is a "bottom up" perspective that takes as a point of departure the microlevel data obtained through field research with target groups of farmers. Thus FPA and OFR tend to be "case-specific." Another link between the two approaches is the concept of "recommendation domain"[3] used in OFR. In FPA, that concept is an appropriate framework to measure the impact of policy on target groups of farmers, for policy issues cannot be assessed effectively at the level of the individual farm.

1 See Byerlee, Collinson et al. (1980).

2 A tentative conceptual framework for FPA is described in greater detail in Martinez et al. (1986).

3 A recommendation domain may be defined as a group of farmers sharing agronomic and socioeconomic circumstances similar enough for the same recommendation to be appropriate for all. See Harrington and Tripp (1984) for more details.

But there are important differences between OFR and FPA. Traditional OFR assumes that socioeconomic circumstances, including the current policy environment, are given, and tries to identify technologies within that context. In FPA, policy is seen as a variable, and *where appropriate* an analysis of the wealth of farm-level data that can be supplied by OFR programs is used to build a case for modifying policy constraints.

Although CIMMYT is only just beginning to develop an approach for FPA, initial work suggests that the following sequence of steps can be helpful:

1) Identify the policy-induced constraint(s).

2) Understand the rationale behind the policy in question, and how the policy affects relevant sectors of society.

3) Identify the decision makers most directly associated with the policy to better target results of the analysis.

4) Identify solutions or policy options, including performance measures that can satisfy decision makers, again taking into account the potential impact of those options on relevant sectors of society.

As this paper will illustrate, microlevel data from OFR can be used effectively to generate both appropriate technologies and valuable information that policymakers can employ to make the policy environment more conducive to technological change. First, some background information on the OFR program and its results is presented. Next follows a discussion of inconsistencies between local policies and conditions that might accelerate adoption of the recommendations of the OFR program. The third section of the paper describes the process of targeting audiences and communicating information to them. The fourth section reviews actions taken by institutions and policymakers that encouraged changes in fertilizer distribution in Les Cayes. The role of both the FPA analysis and the Les Cayes OFR program in supporting these positive changes is also discussed. Finally, some general conclusions underline the impact that farm-based policy analysis can have on increasing the productivity and incomes of target groups of farmers.

The OFR Program and Its Results

The Ministry of Agriculture (Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rurale--MARNDR) of the Republic of Haiti faces important challenges. Small farms of less than one hectare per household, characterized by low productivity and little use of improved technologies, are common. Rising population pressure--an estimated 470 persons per square kilometer of cultivated land in this largely mountainous country--is placing increasing demands on resources and has encouraged agriculture to expand onto Haiti's most marginal lands. The resulting increase in soil erosion is alarming and has now received national attention. This situation sharply demonstrates the need to identify and encourage the use of improved and appropriate technologies to raise farmers' productivity.

The most important cereal in Haiti is maize, which covers approximately 30% of all cultivated land. Annual production is estimated at almost 300,000 t. Though the grain is still a crucial dietary staple, in recent years maize production per capita has declined and yields have remained relatively stagnant at approximately 1 t/ha. In that context, MARNDR decided to explore the potential contribution of OFR methodologies to developing appropriate technologies for Haiti's small-scale farmers. An area-specific OFR program was defined for the Les Cayes Plain in southwestern Haiti and carried out by the Ministry with technical assistance from the International Maize and Wheat Improvement Center (CIMMYT).

The Les Cayes District embraces some 32,000 ha of arable land and its population exceeds 200,000. As maize is the most important crop in the area (total production for the District is estimated at 14,000 t), it was selected as the target crop for the OFR program. Each year, farmers in Les Cayes plant an average of half a hectare of maize, often spread over two or more parcels of land. The principal maize season extends from February/March to June/July; relatively little maize is grown at other times.

Following CIMMYT's sequential strategy for OFR,[4] the team in Les Cayes did an exploratory survey of farmers' circumstances to identify and assign priority to production constraints. At that time most farmers were not fertilizing their maize, though they generally cropped their fields continuously. That practice implied a steady depletion of plant nutrients, which was confirmed by agronomic field observations that identified important nitrogen deficiencies and suggested possible phosphorus deficiencies. Secondary data (Virginia Polytechnic Institute/USAID 1979)

4 See CIMMYT (1980).

suggested that local maize varieties had low genetic yield potential, so both plant fertilization (N and P) and variety were subsequently identified as high-priority research topics.

The experiments implemented to test hypotheses on fertilizer and variety revealed that nitrogen fertilization (80kg N/ha) had a highly consistent, positive effect on yield across sites and cycles, with yield increases averaging 850 kg/ha.[5] Response to phosphorous fertilization (50 kg P/ha) was significant in only 3 of 12 locations (with no significant interactions), and it was apparent that phosphorus levels were not a major production constraint in most of the area.

Variety gave more promising results. An improved maize variety yielded better than the local material in 16 of 21 locations, with yield increases averaging 520 kg/ha. The interaction between nitrogen and variety was not statistically significant.

A combined economic analysis of three years of on-farm trials indicated that two factors strongly conditioned returns to nitrogen fertilization by limiting farmers' ability to obtain the technology's full potential benefits: 1) land tenure arrangements and 2) the type of fertilizer available.

Approximately half of the maize farmers interviewed were sharecropping. Sharecroppers were typically compelled to give half of the harvest to the landowner, though fertilizer costs were generally not shared. Under those arrangements, tenant farmers received only half of the benefits of using fertilizer while paying all of the costs. Thus the economic returns to nitrogen fertilization were dramatically different for landowners and sharecroppers.

Aside from land tenure, the other factor affecting the economic feasibility of nitrogen fertilization was the type of fertilizer available. Rates of return to investment capital were computed for two nitrogen pricing scenarios: 1) urea sold in the free market and 2) the more widely available compound fertilizer (18-8-20 NPK) supplied and subsidized by MARNDR. With urea, returns across locations *for landowners only* were well above the opportunity costs of capital. With MARNDR's fertilizer blend, returns were below acceptable levels. The OFR program therefore identified an important inconsistency between the Ministry's fertilizer policies and the real needs (and potential demand) of Les Cayes maize farmers.

5 For full details of the Les Cayes OFR program and experimental results, see Yates and Martinez (1984).

The researchers assumed that this economic constraint was an integral part of farmers' decision-making environment, and so decided to inform the relevant policymakers of the situation. Their subsequent actions, based partly on the information mentioned above, helped remove the constraints to using the recommended technology. The next sections of this paper will consider those developments in greater detail, presenting the methodological framework that was used in the Les Cayes study and which may be used to analyze similar cases elsewhere.

Identification of Policy-induced Constraints

Local Demand for Nitrogen

Results from three experimental cycles (1981, 1982, and 1983) showed a consistent maize yield response across sites and years to nitrogen application. That physical response may be represented by the following function:

$$Y = f(N/X, Z) \tag{1}$$

where:

- Y = maize yield;
- N = units of applied nitrogen;
- X = units of other factors influencing the nitrogen/maize yield relationship but considered fixed (typical components of vector X will be levels of other inputs, such as other nutrients or variety); and
- Z = a vector of farmers' circumstances conditioning the choice of techniques (e.g., soil type).

Consider a single response curve, $Y = f(N/X_0, Z_0)$. Given a set of maize and nitrogen prices, it is possible to derive a demand function for nitrogen. The demand function reflects a farmer's willingness to pay for successive units of nitrogen. That is,

$$N^* = g(r), \tag{2}$$

where:

- N^* = per-hectare amount of nitrogen demanded by a representative farmer in the recommendation domain; and
- r = price ratio P_n/P_m, where P_n is the field price of nitrogen and P_m the field price of maize.

Figure 1 illustrates a hypothetical response curve (panel a) and a hypothetical derived demand (panel b) for nitrogen [6] For any given price ratio, and with perfect information, the farmer will choose a level of nitrogen that maximizes profits. The derived demand function would then reflect these amounts for different price ratios. In Figure 1 (panel b) at r_0, the optimal nitrogen use level is N_0 (point A), whereas if the price ratio drops to r_1, it is economically appropriate for a farmer to increase the use of nitrogen to N_1 (point B).

Note that the derived demand curve of panel b can also be interpreted as illustrating the maximum amount that a farmer will be willing to pay for successive units of nitrogen. Furthermore, note that at price ratios above r_2 the farmer will choose not to use any nitrogen.

To this point we have developed the response function $y = f(.)$ and its associated derived demand curve for nitrogen $N^* = g(.)$ for a representative farmer. The per-hectare amount of N the farmer will apply would be N_0, given r_0 and the physical response curve. However, to derive the demand curve for the market we need to aggregate horizontally the demand curves of all farmers belonging to the recommendation domain--that is, those whose response curve for N can be fairly represented by the same response function, $Y = f(N/X_0, Z_0)$. In this case, although N_0 in panel a or b could represent, for example, 30 kg of N per hectare, N_0 in aggregate might be 120 t of nitrogen,[7] reflecting the aggregated demand of the regional market at the price ratio r_0.

The OFR program in Les Cayes identified a potential demand for nitrogen fertilizer from maize growers in the local market. The demand had two distinct segments: 1) farmers who owned their maize plots and 2) those who sharecropped maize. The cost-sharing arrangements related to land tenure implied a different profit function for owners and sharecroppers despite identical response curves: hence the derived demands of the two groups also diverged (see Appendix). The local market demand curve shown in Figure 2 has two segments: between P_0 and P_s the curve reflects only the demand from owners, whereas for prices below P_s the curve represents the demand from both owners and sharecroppers.

6 Called "derived" because it is dependent on the response curve of panel a.

7 For example, if for a certain price ratio per hectare demand were 80 kg N and in the recommendation domain there were 3,000 farmers with an average maize holding of 0.5 ha, then total demand would be 3,000 x 0.5 x 80 = 120 t N.

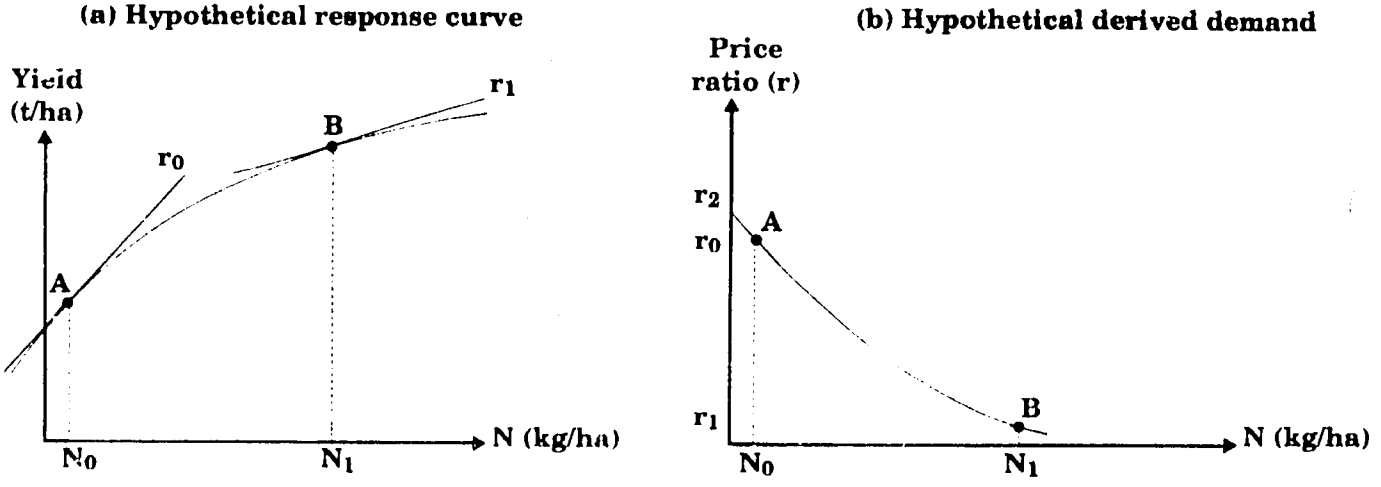


Figure 1. Hypothetical response curve and derived demand for nitrogen.

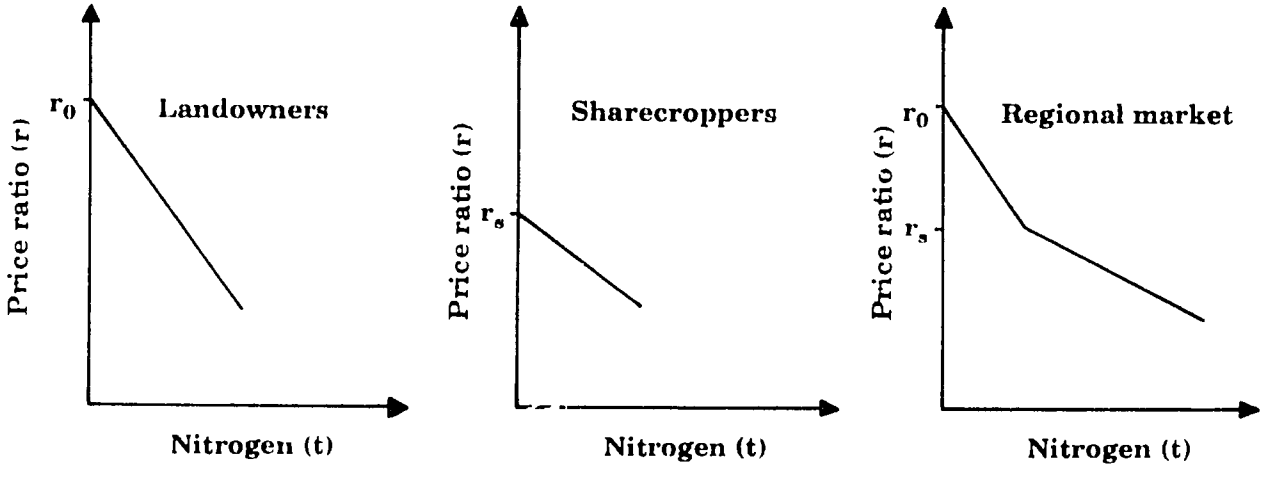


Figure 2. Regional market demand for nitrogen by land tenure system.

The response curve to nitrogen was estimated using data obtained from experiments in farmers' fields over 1981, 1982, and 1983 (see Appendix). Calculations for the corresponding derived demand were made for the relevant range of average annual field prices for maize and nitrogen (urea). Table 1 provides the information used in those calculations. For comparison, the corresponding values associated with blends as a source of N are also included.

Table 1. Average annual field prices of maize and nitrogen, Les Cayes, Haiti, 1981-85

Year	Field price of maize[a] (US $/kg)	Field price of nitrogen[b] Urea (US $/kg)	Field price of nitrogen[b] Blends (US $/kg)	Price ratio (r)[c] Urea	Price ratio (r)[c] Blends
1981	0.18	0.48	1.32	5.1	12.5
1982	0.13	0.93[d]	1.37[e]	12.7	18.1
1983	0.21	0.86	1.61	7.5	13.3
1984	0.17	0.77	1.61	8.4	16.6
1985	0.31	0.72	1.52	4.2	8.4

Source: Unpublished field data

a Average postharvest (peak sales period) field price of maize. Field price subtracts from market prices all costs proportional to yield that are paid by farmers.

b Average field prices at planting time. Field price includes transportation costs.

c The values of r were calculated as $r = (1 + C)(P_n + L)/P_m$, where C is the cost of capital; L the cost of labor for applying nitrogen; P_n is the field price of nitrogen, and P_m the field price of maize (see Appendix).

d No urea was available locally for the 1982 planting season. This estimate, based on the retail price for urea in Port au Prince, 200 km from Les Cayes, is adjusted by the cost of transportation to Les Cayes.

e Only limited supplies of subsidized fertilizer were available from MARNDR.

The results of calculations for landowners and sharecroppers are presented in Table 2 and Figure 3. Note that the derived demand functions are drawn on a per-hectare basis for "representative farmers" and not for the market.

The distribution of maize and urea prices between 1981 and 1985 (Table 1) gives an average price ratio (r) of 7.5 for that period, with a standard

Table 2. Yield gains and nitrogen demand associated with alternative pricing scenarios

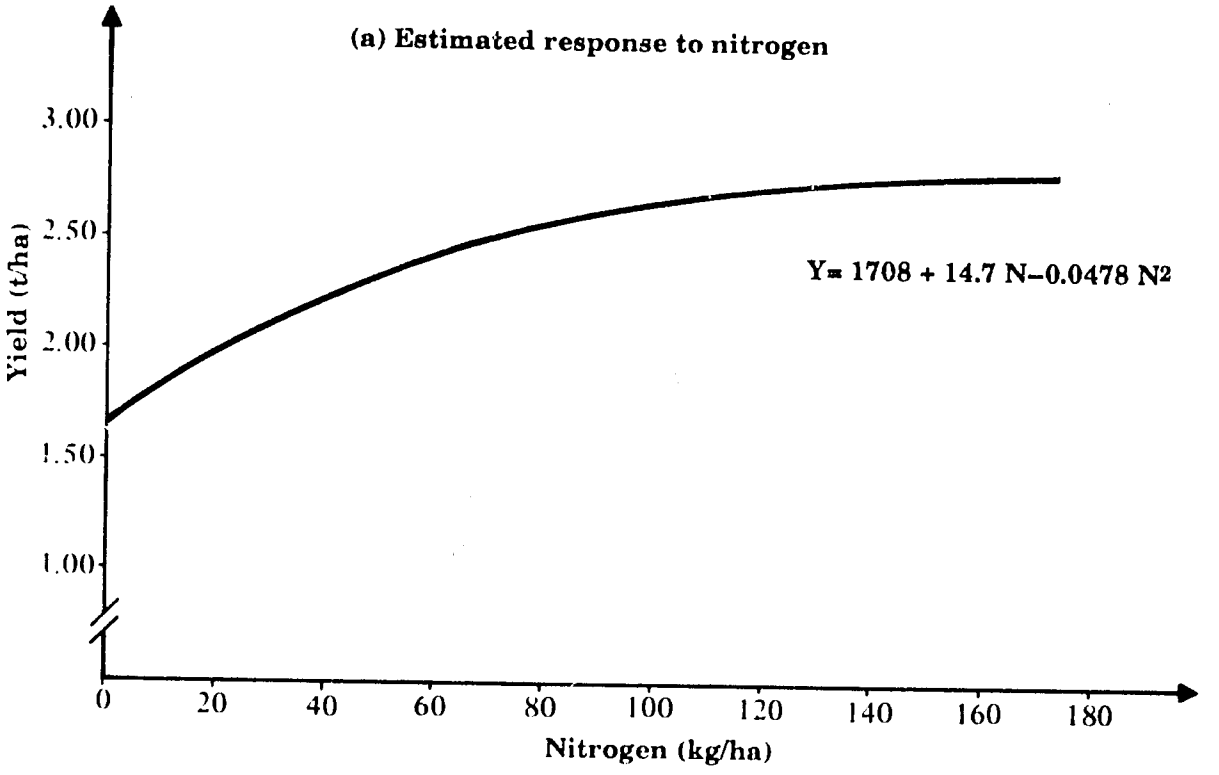
	Landowners			Sharecroppers		
Price ratio[a]	Nitrogen demand (kg/ha)[b]	Expected yield (t/ha)[c]	Yield increase over farmers' practice (t/ha)[d]	Nitrogen demand (kg/ha)[b]	Expected yield (t/ha)[c]	Yield increase over farmers' practice (t/ha)[d]
4	112	2.75	1.07	70	2.50	.82
5	101	2.71	1.03	49	2.31	.63
6	91	2.65	.97	28	2.08	.40
7	80	2.59	.91	7	1.81	.13
7.5	76	2.55	.87	0	1.68	0
8	70	2.50	.82	0	1.68	0
9	60	2.42	.74	0	1.68	0
10	49	2.31	.63	0	1.68	0
11	39	2.21	.53	0	1.68	0

a The relevant range of price ratios was estimated as the average across years of the ratio for urea plus or minus one standard deviation. The calculated average was $r = 7.5$ and the standard deviation $\sigma r = 3.3$.

b Calculations are based on the derived demand equations: $N = 154 - 10.46r$ for landowners and $N = 154 - 20.92r$ for sharecroppers (see Appendix).

c Calculations made using the values of N in the previous column with the response function: $Y = 1.708 + 14.7\ N - 0.0478\ N^2$.

d The average yield obtained by farmers with no nitrogen application was estimated to be 1.68 t/ha.



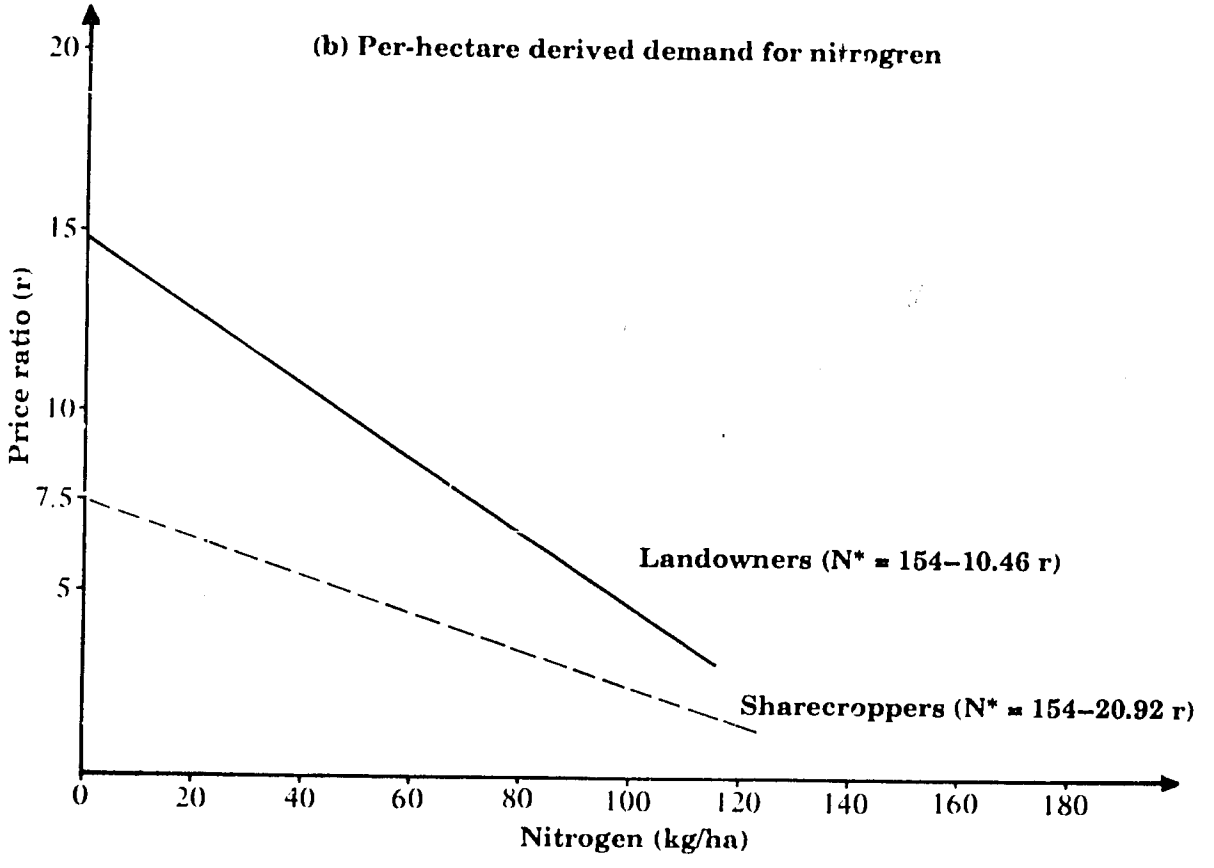


Figure 3. Estimated response to nitrogen and per-hectare derived demand, Les Cayes, Haiti.

deviation (σ) of 3.3. A conservative price ratio $r = r + \sigma$ was used to project both per-hectare demand for N (i.e., recommended dosis) and the potential aggregate demand from landowners and sharecroppers. With this ratio (approximately $r = 11$) the recommended optimum dosis of N is 39 kg/ha for landowners, whereas no nitrogen should be recommended to sharecroppers (Table 2).

These results are highly consistent with those derived earlier by the OFR team. Taking a similar price ratio based on information available at that time, and using discrete analysis,[3] the team developed a recommendation *for landowning farmers only* of 40 kg N/ha (using urea) (Yates and Martinez 1984). That recommendation is virtually identical to the optimum derived from continuous analysis using the response curve and underscores the accuracy of the research process that lead to the recommendation.

With regard to the aggregate regional demand for nitrogen, the conservative pricing scenario presented above implies a potential total demand of approximately 350 t urea for local maize production (see Appendix Table A).

In summary, results of the analysis indicated that for the relevant range of price ratios (using urea as a source of N) there should be a consistent demand for nitrogen from landowners. For sharecroppers the results are quite different, showing that nitrogen use in maize will be profitable to them only during years when price ratios are quite favorable. However, despite the clearly assessed profitability of nitrogen fertilization in maize, the OFR team found that farmers generally did not apply nitrogen to maize, although they used fertilizers with other crops. So, in addition to trying to confirm the nitrogen response with on-farm experiments and further refine a potential farmer recommendation, researchers took one more step. Because the recommendation was associated with the availability of urea in the area, the team decided to conduct a detailed supply-side analysis of the local fertilizer market (FPA).

Initial Fertilizer Market Conditions

In 1981 there were five sources of fertilizer in the area (Table 3). By far the most important was the Ministry of Agriculture office in Les Cayes, which in that year sold a total of 690 t (61% of the regional supply) of various fertilizers, especially NPK blends. The second largest supplier was the Institut de Développement Agricole et Industriel (IDAI), which dispersed approximately 205 t (18% of the market). Three private concerns provided

8 Following the methodology set forth in CIMMYT (1988).

smaller amounts exclusively to their clients, who were tobacco, sugarcane, and tomato growers.

Table 3. Fertilizers sold in the Cayes Plain, 1981

Source	NPK blends (t)	Ammonium sulfate (t)	Urea (t)	Total (t)
MARNDR	583	71	36	690
IDAI[a]	135	13	56	204
Comme Il Faut (tobacco)	15	--	--	150
Centrale Dessalines (sugar)	73	--	--	73
Facolef (tomatoes)	22	--	--	22
Total volume sold	963	84	92	1,139

a Data from Sept. 1980 to Sept. 1981.

Even though urea was the cheapest source of nitrogen (Table 1), it represented just 5% of the total fertilizer provided by the MARNDR to Les Cayes. One other source of urea was IDAI, but that agency assigned almost all urea to rice production. At that time, no private sector fertilizer distributors operated in Les Cayes, and if maize farmers wanted to obtain urea, they had access to only minimal supplies from the Ministry. All Ministry fertilizer was sold at a subsidized price (US$ 10.00/100-lb bag, regardless of fertilizer type), resulting in different field prices for nitrogen depending on the source used ($0.48/kg for urea and $1.32/kg for blends) (Table 1). In 1982 the market situation was even more restricted. No urea was available from the public sector, and supplies of blends were down sharply.

Regional market conditions in 1981 and 1982 are illustrated in Figure 4, where curve ABC represents the potential regional demand for nitrogen. The curve is calculated by summing all of the estimated individual nitrogen demands at each relevant price ratio over the total maize area where the

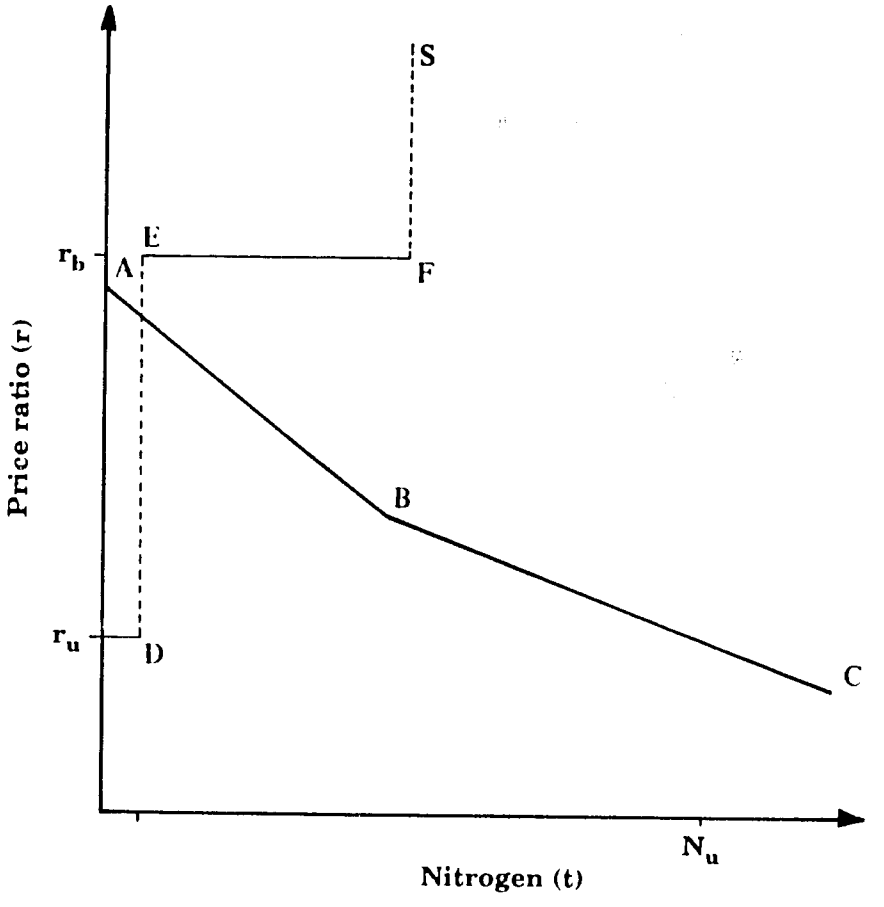


Figure 4. Conceptual structure of the regional supply and demand for nitrogen, Les Cayes, Haiti, 1981-82.

recommendation is applicable (both landowners and sharecroppers).[9] For each of the price ratios considered, the curve represents the total amount of nitrogen farmers should buy to apply to maize. It should be interpreted as a long-term demand curve, since it implies that the process of diffusion and adoption by farmers is complete.

The curve r_uDEFS, on the other hand, represents the short-term market supply of nitrogen for maize. As noted earlier, two sources of nitrogen were available in different amounts in the local market: urea and blended formulas. Urea was the cheapest source but was available only in very limited amounts (represented in Figure 4 by segment r_uD). More nitrogen was available from blended formulas (Figure 4, segment EF), though it was much more expensive. The price ratio with urea as the source of nitrogen is represented by r_u; the much higher r_b reflects the same ratio with blends. Note the difference in length of segments r_uD and EF, which represent the availability of urea and blends in the market.

It was clear to the OFR team that the implicit/explicit fertilizer distribution policy was not in the best interests of farmers growing maize in the Les Cayes Plain. Experiments in farmers' fields clearly demonstrated that a nitrogen-rich fertilizer such as urea offered by far the cheapest and most efficient means of increasing local maize yields. Therefore a strong demand for nitrogen should exist at most of the relevant price ratios, provided that the information was available to farmers. However, potential adoption by farmers and consequent gains in area productivity and income were constrained by the scarcity of urea in the local market.

Meeting the strong and unfulfilled excess demand for nitrogen implied by the analysis (Figure 4, DC) would mean potential gains for all interested parties: farmers (gains in productivity and income), MARNDR (increased agricultural production), and the private sector (increased sales in an expanding market for the appropriate fertilizer). The OFR team concluded that improving the availability of urea in the local market would be highly desirable and was possible if policymakers would take appropriate actions based on the analysis. In effect, the team assumed that local market imperfections were due in no small measure to a lack of appropriate technical information among policymakers. The next step was to identify the relevant decision makers and convey that information to them.

9 The landowners' recommendation domain comprises approximately 6,000 ha of maize. An equal area was estimated for the sharecroppers' recommendation domain. In addition, a 70% adoption ceiling was used in both cases for estimating the potential regional demand for nitrogen.

Targeting Audiences and Communicating the Findings

Once the policy constraints were identified, the OFR team determined that two audiences should receive the information they had assembled: 1) the public sector, represented in this case by MARNDR, and 2) the private sector, represented by a few firms that had recently begun selling inputs in the area.

Through personal interviews with MARNDR officials, researchers confirmed that one of the main reasons for the fertilizer distribution policy in Les Cayes was a lack of relevant technical information. Policy decisions were made at two levels within the Ministry: at the local MARNDR offices in Les Cayes and at MARNDR headquarters in the capital, Port-au-Prince. Regular reports and preliminary findings were submitted to both offices.

Another target audience for this information was the nascent private sector involved in fertilizer distribution. Although no private dealers were selling fertilizers before 1982, as soon as local merchants began to operate the OFR team established close and regular contacts with them. They were given research results and preliminary findings relevant to the fertilizer recommendation, and discussions between private sector representatives and the OFR team became a regular part of the project's activities. The OFR team perceived that the private sector was truly interested in making the appropriate fertilizers available to farmers, provided there was sufficient demand and that prices (margins) were adequate.

With these audiences in mind, the OFR team devised a set of "performance measures" to be used in making a case for changing fertilizer provision policies. For the public sector, the potential gains in farmer productivity--yield increases--were emphasized (see Table 2, column 4). For the private sector, emphasis was placed on the amounts of fertilizer that could be sold to farmers if urea were adequately available at reasonable prices (see Appendix Table A). The large difference between existing supply and derived demand was a powerful argument for changing fertilizer provision patterns.

During 1983 and 1984 the OFR team maintained close contact with both the private and public sectors. They continued to emphasize the potential gains in productivity that might be realized if the excess demand for nitrogen were satisfied with urea. In January, 1984, the OFR program made a final recommendation through the Ministry to landowning farmers. The recommendation, as noted previously, called for the application of 40 kg N/ha

of maize, regardless of variety, and specified urea as the source of nitrogen. The recommended fertilizer rate was intentionally conservative to take account of year-to-year variability in yields and prices and the associated risk involved (see Yates and Martinez 1987).

Changing Patterns of Fertilizer Distribution and Use in Les Cayes

The OFR program in Les Cayes had developed a sound recommendation for farmers, and long-term maize (Borsdorf and Foster 1985) and urea price trends augured well for increasing adoption. In addition, a potentially important recommendation was generated for policymakers in the capital, emphasizing the need to assure adequate supplies of urea for the farmers of the target recommendation domain. Those results attest to the effectiveness of the research methodology, apart from the actual policy response. In the case of Les Cayes, the provision of urea did increase after the recommendation was made to policymakers, and the response from the public sector was greatly augmented by positive interventions from the local private sector.

As noted above, MARNDR provided only minimal supplies of urea in 1981 and offered none in 1982, 1983, or 1984. That policy changed dramatically in 1985 when MARNDR made more than 90 t of urea available in Les Cayes, fully 60% of the total fertilizer they distributed in the region.[10] There is therefore some evidence of a shift, consistent with the project recommendation, in MARNDR's fertilizer provision priorities for Les Cayes.[11] The government's role in providing urea was overshadowed however, by positive interventions from the local private sector.

The increasing importance of the private sector in supplying fertilizer has been a strong force for change. One store in Les Cayes began selling small quantities of fertilizer in late 1982. The amount sold, especially of urea, has risen dramatically from year to year. Rapid growth in sales is consistent with the demand hypothesized by the OFR team, as well as with the timing of the project recommendation (January 1984).

10 This represents an increase of 250% over the amounts provided to Les Cayes by MARNDR in 1981, when only 5% of total fertilizer was urea.

11 The project's positive impact on helping to change these priorities was confirmed to the OFR team by the authorities concerned (personal communication).

The increase in urea sales has been nothing short of explosive, with an almost ten-fold jump from 1983 to 1984 (Table 4). From 1984 to 1985, sales continued to grow at a very impressive rate of 174%, and though sales of mixed blends have also increased rapidly, the change in urea sales has been far more pronounced. Note that although urea accounted for just 9% of the total sales volume in 1983, its market share increased to 28% in 1984 and to 36% in 1985.[12] The private sector is optimistic that this progress will continue, and two new distributors have begun to operate in Les Cayes since 1985.[13]

Table 4. Urea sales by the private sector, Les Cayes, 1983-85

	1983	1984	1985
Sales (t/yr)	11	105	289
Market share to urea (percentage of total fertilizer sold)	9	28	36

Note: Data for 1983 and 1984 from Agri-Supply, Port-au-Prince; data for 1985 from ASSA, Port-au-Prince.

Direct government intervention in fertilizer distribution now appears unnecessary. In fact, one could argue that government intervention, particularly in the form of fertilizer subsidies, might impede real, sustained development of local agriculture by discouraging investment by the private sector.[14] The greatest promise for a long-term solution to the problem of

12 Sales of mixed blends totalled 112 t in 1983, 270 t in 1984, and 521 t in 1985. During that period, sales of mixed blends as a percentage of total fertilizer sales declined from 91% to 64%.

13 Although we are not yet certain what proportion of the urea was applied to maize rather than to other crops in the target recommendation domain, both the private sector in Les Cayes and the OFR team have estimated that at least 50% went to maize. That estimate is based on an analysis of where urea purchasers came from (i.e., from the rice- or maize-growing areas of the Les Cayes Plain) and on the time of sale (the period of peak urea sales appears to suggest maize fertilization).

14 It is interesting to note that the private sector distributor in Les Cayes began operating just when MARNDR's stock of subsidized fertilizer was exhausted.

providing fertilizer and perhaps other inputs in Les Cayes seems to be offered by the private sector itself, and the record to date is encouraging. In fact, the most appropriate policy intervention on the part of the government to encourage more widespread adoption of the nitrogen recommendation might be to facilitate the work of private sector producers and suppliers. One might ask whether the results from the OFR program could not have been used by the government to *encourage* private sector investment in fertilizer distribution, had there been no independent initiatives from private investors.

Conclusions

Hypotheses concerning maize production constraints and research opportunities were developed by the OFR program in Les Cayes. Some of them, especially nitrogen fertilization with urea, were confirmed through three cycles of experiments in farmers' fields under farmers' production conditions and potential benefits to area farmers were shown to be substantial. Long-term price trends for both maize and urea also indicated good prospects for the increasing adoption of the recommended technology.

A follow-up analysis of the local fertilizer market from the supply point of view, however, showed that the unavailability of urea was a critical constraint to realizing those potential benefits. This information was communicated to MARNDR officials and representatives of the private sector in Les Cayes and Port-au-Prince. Both sectors responded in ways that greatly improved the availability of urea in Les Cayes. As their actions were based to some extent on information provided by the OFR project, it may be inferred that the market imperfections identified in Les Cayes were at least partly caused by a lack of appropriate technical information among decision makers.

Thus data generated from the area-specific OFR program were used to supply administrators with information that enabled them to make better decisions on an important policy. Those results underscore the effectiveness of the FPA methodology. Note too that, though the results of the OFR program apparently exerted an important influence on regional demand for urea, the FPA analysis helped encourage modifications in regional supply. This is one more example of the close and positive links between OFR and FPA.

In the case of the MARNDR, for example, the amount of urea sent to Les Cayes increased from 36 to 90 t from 1981 to 1985, with urea representing fully 60% of the total fertilizer shipped that final year. Changes in the private

sector were consistent with, if more dramatic than, those in the public sector. Private sector urea sales increased from just 11 t in 1983 to 289 t in 1985. This phenomenon suggests that agricultural policy can indeed be a variable and that well-oriented FPA analysis can encourage positive modifications in farmers' socioeconomic circumstances.

It is certain that "on-farm researchers with a first-hand understanding of farming systems and knowledge of biological responses to alternative practices under farmer conditions are in a unique position to identify policy constraints and promote changes in the policy environment to complement technological change" (Byerlee, Harrington, and Winkelmann 1982). As this case from Les Cayes illustrates, that first-hand understanding can have important positive implications both for target groups of farmers and for the nation as a whole.

References

Borsdorf, R., and K. Foster. 1985. *A Compilation of Market Price Data for Cereals and Beans, Haiti.* United States Agency for International Development Technical Assistance Report No. 103A. Manhattan, Kansas: Food and Feed Grain Institute, Kansas State University.

Byerlee, D. 1980. Continuous versus discrete economic analysis of experimental data. Economics Training Note, CIMMYT Economics Program.

Byerlee, D., L. Harrington, and D. Winkelmann. 1982. Farming systems research: Issues in research strategy and technology design. *American Journal of Agricultural Economics* 64:897-904.

CIMMYT. 1980. *Planning Technologies Appropriate to Farmers: Concepts and Procedures.* Mexico: CIMMYT.

CIMMYT. 1988. *From Agronomic Data to Farmer Recommendations: An Economics Training Manual.* Completely revised edition. Mexico: CIMMYT.

Harrington, L., and R. Tripp. 1984. *Recommendation Domains: A Framework for On-Farm Research.* Economics Program Working Paper. Mexico: CIMMYT.

Martinez, J.C., G. Sain, M. Yates, and A. Hibon. 1986. Toward farm-based policy research: Learning from experience. Paper presented at the Farming Systems Symposium, October, 1986, Kansas State University, Manhattan, KS.

Virginia Polytechnic Institute and the United States Agency for International Development. 1979. *Corn Improvement Project.* Virginia Polytechnic Institute Technical Report. Damien, Port-au-Prince: VPI/USAID.

Yates, M., and J.C. Martinez. 1984. On-farm research methodologies at work: Progress report from Les Cayes, Haiti. Unpublished draft.

Appendix

Estimating the Derived Demand for Nitrogen

To obtain the derived demand for nitrogen, a quadratic response function of the type shown below was fitted to the three years of experimental results.

$$Y = a + b\,N + cN^2; \qquad a, b > 0; c < 0 \tag{1}$$

The derived demand functions for nitrogen from landowners and sharecroppers were obtained as:

$$\text{Landowners} \qquad N^* = (b - r)/2c \tag{2}$$

$$\text{Sharecroppers} \qquad N^* = (b - 2r)/2c, \tag{3}$$

where r is the relevant price ratio, calculated as:

$$r = \frac{(1 + C)(P_n + T + L)}{R\,(P_m - H)}, \tag{4}$$

where:

- C = cost of capital;
- P_n = price of nitrogen;
- T = cost of transportation (per unit);
- L = cost of application (per unit);
- R = ratio of farmers' yields to experimental yield;
- P_m = price of maize; and
- H = costs of harvesting, shelling, and transporting maize.[1]

In this case all quoted prices are already adjusted by T, R, and H. Therefore expression (4) becomes:

$$r = \frac{(1 + C)(P_n^* + L)}{P_m^*}, \tag{5}$$

where P_n^* and P_m^* are the field prices of nitrogen and maize quoted in Table 1 (page 7).

The estimated response equation was:

1 See Byerlee (1980).

$$Y = 1{,}708 + \underset{(2.2)}{14.7\,N} - \underset{(0.80)}{0.0478\,N^2}, \qquad (6)$$

with $R^2 = 0.30$; values in parentheses are t-values.

The overall fit of the equations was reasonable, and although not all individual coefficients are significant their signs are correct.

The calculated per hectare demand equations were:

Landowners $N^* = 154 - 10.46r$ (7)

Sharecroppers $N^* = 154 - 20.92r$ (8)

In calculating r, the cost of capital was taken as 60% and application costs as $0.1/kg (Yates and Martinez 1987). Finally, the estimate of potential regional demand for nitrogen was done by summing estimates using equations (7) over landowners' recommendation domains and (8) over those of sharecroppers (each was 6,000 ha), and assuming an adoption ceiling of 70% for each case The results were then transformed to regional potential demand for *urea* (calculated assuming urea is 46% nitrogen). Results for the price ratios are presented in Table A.

Table A. Potential regional demand for nitrogen in maize production, Les Cayes

Price ratio r	Regional demand for nitrogen (t) Landowners	Sharecroppers	Total	Total demand for urea (t)[a]
11	164	0	164	357
10	206	0	206	448
9	252	0	252	548
8	294	0	294	639
7.5[b]	317	0	317	689
7	317	0	317	689
6	382	118	500	1,087
5	424	206	630	1,370
4	470	294	764	1,661

a Calculated assuming urea is 46% nitrogen.
b Average price ratio, 1981-85.

Working Papers Available from CIMMYT Economics

Byerlee, D. 1985. *Comparative Advantage and Policy Incentives for Wheat Production in Ecuador*. CIMMYT Economics Working Paper. Mexico: CIMMYT.

Byerlee, D. and J. Longmire. 1986. *Comparative Advantage and Policy Incentives for Rainfed and Irrigated Wheat in Mexico*. CIMMYT Economics Working Paper 01/86. Mexico: CIMMYT.

Fitch, J.B. 1983. *Maize Production Practices and Problems in Egypt: Results of Three Farmer Surveys*. CIMMYT Economics Working Paper. Mexico: CIMMYT.

Harrington, L.W., and R. Tripp. 1984. *Recommendation Domains: A Framework for On-Farm Research*. CIMMYT Economics Working Paper 02/84. Mexico: CIMMYT.

Martinez, J.C. 1984. *La mise au point d'une technologie adaptee au contraintes et atouts de l'agriculteur: L'Approche du CIMMYT*. CIMMYT Economics Working Paper 01/84. Mexico: CIMMYT.

Martinez, J.C., and J.R. Arauz. 1983. *Institutional Innovations in National Agricultural Research: On-Farm Research within IDIAP, Panama*. CIMMYT Economics Working Paper 02/83. Mexico: CIMMYT.

Martinez, J.C., and G. Sain. 1983. *The Economic Returns to Institutional Innovations in National Agricultural Research: On-Farm Research in IDIAP, Panama*. CIMMYT Economics Working Paper 04/83. Mexico: CIMMYT.

Moscardi, E., V.H. Cardoso, P. Espinosa, R. Soliz, and E. Zambrano. 1983. *Creating an On-Farm Research Program in Ecuador: The Case of INIAP's Production Research Program*. CIMMYT Economics Working Paper 01/83. Mexico: CIMMYT.

Rohrbach, D. 1984. *Maize Food and Feed Consumption in the Developing World*. CIMMYT Economics Working Paper 04/84. Mexico: CIMMYT.

Scobie, G.M. 1984. *Investment in Agricultural Research: Some Economic Principles*. CIMMYT Economics Working Paper. Mexico: CIMMYT.

Tripp, R. 1982. *Data Collection, Site Selection, and Farmer Participation in On-Farm Experimentation*. CIMMYT Economics Working Paper 82/1. Mexico: CIMMYT.

Tripp, R. 1982. *Including Dietary Concerns in On-Farm Research: An Example from Imbabura, Ecuador*. CIMMYT Economics Working Paper 82/2. Mexico: CIMMYT.

Yates, M., J.C. Martinez, and G. Sain. 1988. *Fertilizer Provision in Les Cayes, Haiti: Addressing Market Imperfections with Farm-based Policy Research*. CIMMYT Economics Working Paper 88/01. Mexico: CIMMYT.