Toward farm-based policy analysis: concepts applied in Haiti

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ABSTRACT

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Many policies – on the delivery of inputs or on marketing systems, credit, or extension – influence the potential utilization of new technologies. Through 'farm-based policy analysis' it is possible to use data generated in on-farm research (OFR) to identify policy constraints to the use of new technologies, and to effectively communicate that information to policy makers. This paper describes a tentative framework for farm-based policy analysis and suggests a sequence of five steps for the analysis: (1) identify the policy-induced constraints; (2) determine the rationale behind the policy; (3) identify the decision makers to whom the results should be communicated; (4) identify solutions or policy options; and (5) communicate results to decision makers.

A case of farm-based policy analysis from Haiti illustrates the concepts and methods described in the first part of the paper. On-farm experiments in Les Cayes, Haiti, confirmed a response to nitrogen in maize, but adoption of the recommended practice and consequent gains in productivity and income were constrained by the scarcity of urea in the local market. An analysis of local supply and potential local demand for urea and the potential benefits of urea application was conducted, and results communicated to two target groups of decision makers: representatives of the Ministry of Agriculture responsible for fertilizer distribution policy, and representatives of private fertilizer enterprises. These groups responded by making larger supplies of urea available to local farmers. Adoption of the fertilizer recommendation and urea sales increased. The case demonstrates the potential value of farm-based policy analysis building upon data from OFR.

INTRODUCTION

Cost-effective methods of on-farm research (OFR) have been devised to develop improved, appropriate agricultural technologies for target groups of farmers (Byerlee et al., 1980). Traditionally OFR regards the policy environment as fixed and seeks to develop technologies within that context. However, the experience of many OFR programs has indicated that policy-induced constraints limit potential gains associated with technological change. Local policy constraints often result from a lack of appropriate technical information among decision makers. Many national programs could benefit from methods using farm-level data to identify, where appropriate, policy constraints or opportunities related to the use of new technologies by target groups of farmers, and to effectively communicate that information to relevant decision makers to improve the basis for formulating or implementing local policy. This area of research has been called 'farm-based policy analysis'. [1] The concepts and stages of farm-based policy analysis as we currently see them, illustrated with a successful case study from Haiti, are presented in the sections that follow.

CONCEPTS OF FARM-BASED POLICY ANALYSIS

Farm-based policy analysis uses a 'bottom-up approach' that takes as its point of departure the farm-level data obtained through OFR with target groups of farmers. Another link between OFR and farm-based policy analysis is the concept of 'recommendation domain', which may be defined as a group of farmers sharing agronomic and socioeconomic circumstances similar enough for the same technological recommendation to be appropriate for all (Harrington and Tripp, 1984). The recommendation domain concept is also useful for measuring the impact of local policy on target groups of farmers.

We can establish a tentative framework for most cases of farm-based policy analysis as follows. Let Y represent output, X a vector of factors (inputs and services) over which the manager exercises discretionary control, and Z a vector of agronomic and socioeconomic circumstances, outside farmers' control, that characterize the farming system. A technique is described by the production function $Y = f(X/Z)$. The available technology (T) is represented by a collection of all possible techniques $T = [f_i(X/Z)]$, and implemented technology is IT $\in T$ (that is, a subset of T).

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[1] A tentative conceptual framework for farm-based policy analysis is described in greater detail in Martinez et al. (1986).

Depending on his or her resources and circumstances, each farmer chooses to implement certain techniques from the set of available technologies. The implemented technology is by definition 'appropriate' to the farmer's circumstances. [2] Thus, at any given time within a region, many ways of producing a crop are implemented simultaneously. The set of implemented technologies will not spread uniformly but will be clustered in recommendation domains. Each recommendation domain encompasses farmers whose Z vectors are similar enough that they will choose almost the same technique for growing a given crop. Differences within a recommendation domain are small enough that a single production function can be associated with the whole group: $Y = f(X, Z)$.

Policy-induced constraints and/or institutional restrictions in market structures are reflected in the components of the vector Z (farmers' circumstances). For example, an OFR program found no evidence of fertilizer response in maize. To obtain credit, however, farmers were required to use chemical fertilizer to produce maize. When the OFR results were communicated to bank officials, a simple adjustment in credit policy (vector Z) allowed farmers to decide if they wished to use fertilizer or not, leading to a considerable reduction in the use of chemical fertilizers for maize production (Martinez and Arauz, 1984).

STAGES OF FARM-BASED POLICY ANALYSIS

Although the approach to farm-based policy analysis is in the early stages of development, initial experiences suggest that the following steps can be helpful.

1. Identify the policy-induced constraint(s).   Productivity constraints (whether or not they are induced by local policies) and opportunities for reducing them with appropriate technology may be identified at several stages in OFR. It is expected that most cases of farm-based policy analysis will come from fairly advanced OFR programs that have amassed substantial survey and experimental data.

2. Determine the rationale behind the policy.   Once a problem is identified, several questions should be asked. The most critical question for successful farm-based policy analysis is: Does the policy constraint appear to arise because insufficient information has been available to policy makers? Other questions to help define the problem more precisely include: Which policy

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[2] In OFR a technology is appropriate when it is consistent with the prevailing agronomic and socioeconomic circumstances of target farmers.

objectives gave rise to the problem? Is there any divergence between the objectives of the policy and its implementation in the region (in other words, is the problem a matter of policy formulation or of implementation)? Which groups are affected by the problem, and who benefits from the status quo?

3. Identify the decision makers. After the origin of the policy constraint and the rationale behind it have been determined, the next step is to identify the institutional level at which decisions and/or corrective action pertaining to the policy can be taken (persons at that level are the target audience of information generated through farm-based policy analysis). Once the goals and objectives of the audience are understood, the level of analysis needed to convince the audience to correct the problem can be determined.

4. Identify solutions or policy options. Depending on the results of step 3, it may be necessary to choose a set of performance measures for the analysis, such as net social loss by different groups or changes in regional production, in regional productivity, in government revenue, or in foreign exchange earnings. The selection of performance measures will depend on the case. Possible solutions should be identified and researchers should determine which groups in society would benefit from change and who should pay the costs of any change that takes place. The solutions should be appropriate (that is, politically feasible) under the circumstances faced by the target decision makers.

5. Communicate results to decision makers. Recommendations based on the analysis in steps 3 and 4 should be communicated to the decision makers identified earlier.

CASE OF FERTILIZER IN LES CAYES, HAITI

The steps listed above are illustrated by a case of farm-based policy analysis in Les Cayes, Haiti, which examines the roles of OFR and farm-based policy analysis in supporting positive changes in Les Cayes agriculture. [3]

To develop appropriate technologies for Haiti's small-scale farmers, the Ministry of Agriculture (Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rurale – MARNDR) established an area-specific OFR program for the Les Cayes District in southwestern Haiti (32 000 ha of arable land and a population exceeding 200 000). The program was carried out by the Ministry with technical assistance from the International Maize

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[3] Additional information about this case is presented in Yates et al. (1988).

and Wheat Improvement Center (CIMMYT). Because maize was the most important crop in the area, it was selected as the target crop for the OFR program.

The Les Cayes research team conducted an exploratory survey of farmers to identify and assign priority to production constraints (following methods described in Byerlee et al., 1980). Each year, Les Cayes farmers planted an average of half a hectare of maize. About half of the farmers surveyed were landowners and the other half sharecroppers. The principal maize season extended from February/March to June/July; relatively little maize was grown at other times. Most farmers did not fertilize their maize, though they generally cropped their fields continuously. Agronomic field observations identified nitrogen deficiencies and suggested possible phosphorus deficiencies. Secondary data (VPI/USAID, 1979) suggested that local maize varieties had low genetic yield potential, so both plant fertilization (nitrogen and phosphorus) and variety were identified as high-priority research topics.

Results of experiments testing hypotheses on fertilizer and variety revealed that nitrogen fertilization (80 kg N/ha) had a highly consistent, positive effect on yield across 22 sites and three cycles of experimentation (1981, 1982, and 1983), with yield increases averaging 850 kg/ha. [4] Response to phosphorus fertilization (50 kg P/ha) was significant in only three of 12 locations (with no significant interaction with nitrogen), and it was apparent that phosphorus levels were not a major production constraint in most of the area.

Experiments on variety gave promising results. Two improved maize varieties yielded better than the local material in 16 of 21 locations, with yield increases averaging 520 kg/ha. However, the interaction between nitrogen and variety was not statistically significant; consequently, each component was treated independently when recommendations were formulated.

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. Sharecroppers were typically obligated to give half of their harvest to the landowner, although fertilizer costs were generally not shared. Thus the economic returns to nitrogen fertilization were dramatically different for landowners and sharecroppers, and the two groups constituted distinct recommendation domains in the study.

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

Aside from land tenure, the other factor affecting the economic feasibility of nitrogen fertilization was the type of fertilizer available. Rates of return to fertilizer use were computed for two nitrogen pricing scenarios: (1) urea sometimes sold in the 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 even for landowners. The OFR program therefore identified an inconsistency between the Ministry's fertilizer policies and the real needs (and potential demand) of Les Cayes maize farmers.

Potential demand for nitrogen

Results from three experimental cycles 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, in which P_n is the field price of nitrogen and P_m the field price of maize.

Figure 1a is a response curve estimated using data from experiments in farmers' fields, 1981–83; Fig. 1b is the derived demand for nitrogen calculated from average annual field prices for maize and urea (Table 1). For any given price ratio and with perfect information, farmers will choose a level of nitrogen that maximizes profits. The derived demand function should reflect these levels for different price ratios. In Fig. 1b at r_0, the optimal nitrogen use level is N_0 (point A). 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 at price ratios above r_2 the farmer will choose not to use any nitrogen.
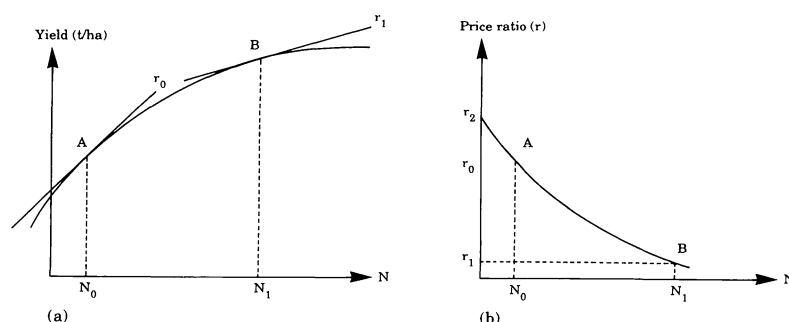
Fig. 1. Estimated response curve (a) and derived demand (b) for nitrogen.

The OFR program in Les Cayes identified a potential demand for nitrogen fertilizer from maize growers in the local market. Because of the cost-sharing arrangements related to land tenure, the derived demand had two distinct segments: (1) farmers who owned their maize plots, and (2) those who sharecropped maize. Between r_0 and r_s, the curve reflects only the demand from owners. For prices below r_s the curve represents the demand from both owners and sharecroppers (Fig. 2). The results of calculations for landowners and sharecroppers are presented in Table 2.

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 deviation (s) of 3.3. A conservative price ratio $r = r + s$ was used to project per hectare demand for nitrogen (that is, the recommended dose per

TABLE 1

Average annual field prices of maize and nitrogen, Les Cayes, Haiti, 1981

Year	Field price of maize [a] (US$/kg)	Field price of nitrogen [b]		Price ratio (r) [c]	
		Urea (US$/kg)	Blends (US$/kg)	Urea	Blends
1981	0.18	0.48	1.32	5.1	12.5
1982	0.13	0.93	1.37	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.
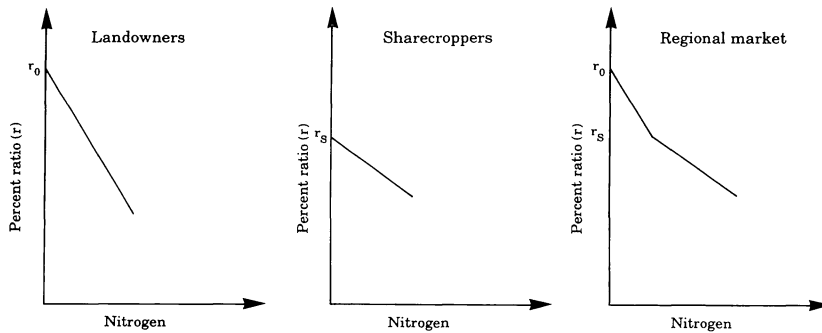
Fig. 2. Regional market demand for nitrogen by land tenure system, Les Cayes, Haiti.

hectare). With this ratio (approximately $r = 11$) the recommended optimum dose of nitrogen is 39 kg/ha for landowners. No nitrogen should be recommended to sharecroppers (Table 2).

The demand curve for the market was derived by aggregating horizontally the demand curves of all farmers belonging to the recommendation domain

TABLE 2

Yield gains and nitrogen demand associated with alternative pricing scenarios

Price ratio [a]	Landowners			Sharecroppers		
	Nitrogen demand (kg/ha) [c]	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	0.82
5	101	2.71	1.03	49	2.31	0.63
6	91	2.65	0.97	28	2.08	0.40
7	80	2.59	0.91	7	1.81	0.13
7.5	76	2.55	0.87	0	1.68	0
8	70	2.50	0.82	0	1.68	0
9	60	2.42	0.74	0	1.68	0
10	49	2.31	0.63	0	1.68	0
11	39	2.21	0.53	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 $s_r = 3.3$.

[b] Calculations are based on the derived demand equations: $N = 154 - 10.46r$ for landowners and $N = 154 - 20.92r$ for sharecroppers.

[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.

that is, those whose response curves for nitrogen can be fairly represented by the same response function, $Y = f(N/X_0, Z_0)$. [5] The conservative pricing scenario presented earlier implies a potential total demand of approximately 350 t urea for local maize production. 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. Hence the team decided to conduct a detailed supply-side analysis of the local fertilizer market (farm-based policy analysis).

Local fertilizer market

In 1981 the most important source of fertilizer in the Les Cayes area 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 distributed approximately 205 t (18% of the market).

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. The IDAI was another source of urea but 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 MARNDR. All MARNDR 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 ($0.48/kg for urea and $1.32/kg for blends) (Table 1).

Regional market conditions in 1981 and 1982 are illustrated in Fig. 3 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 recommendation is applicable (both landowners and sharecroppers). [6] 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.

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[5] For example, if for a certain price ratio per-hectare demand were 80 kg N and 3000 farmers in the recommendation domain had an average maize holding of 0.5 ha, then total demand would be $3000 \times 0.5 \times 80 = 120$ t N (t, metric tonne = 1000 kg).

[6] The landowners' recommendation domain comprises approximately 6000 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.
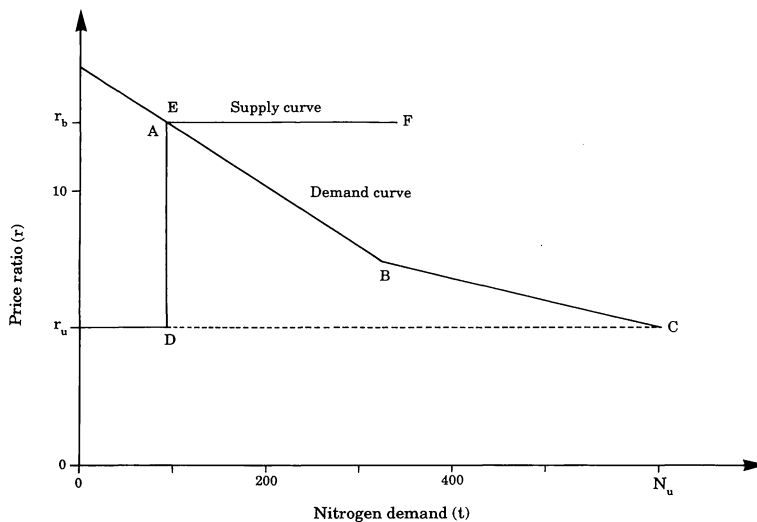
Fig. 3. Regional supply and demand for nitrogen, Les Cayes, Haiti, 1981.

The curve r_uDEF, 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 cheaper but available in very limited amounts (represented in Fig. 3 by segment r_uD). At the cheaper price of nitrogen (r_u), the horizontal distance between supply and demand (DC) gives an idea of the latent excess demand for nitrogen. Nitrogen was available from blended formulas (Fig. 3, 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 price ratio with blends. Note the difference in length of segments r_uD and EF, which represent the relative availability of urea and blends in the market.

It was clear to the OFR team that the fertilizer distribution policy was not in the best interest 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 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 (Fig. 3, DC) would mean potential gains for all interested

parties: farmers (gains in productivity and income), MARNDR (increased agricultural production and saving of subsidy), 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 decision makers would take appropriate actions based on the analysis. The next step was to identify the relevant decision makers and convey the results of the analysis to them.

Targeting audiences and communicating 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 in the area that began selling inputs in late 1982 and early 1983 when MARNDR's stock of subsidized fertilizer was exhausted.

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 makers were not aware of the fertilizer response uncovered through OFR and had expected a response to phosphorus and potassium). Policy decisions were made at two levels within the Ministry: at the total 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 by the national program agronomist in charge of OFR operations in Les Cayes. The information presented included experimental results and the study of local fertilizer supplies.

Another target audience for this information was the nascent private sector involved in fertilizer distribution. As soon as local merchants began to sell fertilizers, 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 private sector was 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 build a case for changing the fertilizer provision policy. For the public sector, potential gains in farmer productivity – yield increase – 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 enough urea was available at reasonable prices. 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. The team 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 recommendation through MARNDR 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.

Changing patterns of fertilizer distribution and use

The provision of urea by both the public and private sectors rapidly increased in Les Cayes after the recommendation was made to decision makers. Although MARNDR provided minimal supplies of urea in Les Cayes in 1981 and offered none from 1982 to 1984, that policy changed dramatically in 1985 when MARNDR made available more than 90 t of urea, fully 60% of the total fertilizer they distributed in the region. This increase of 250% over the amounts provided to Les Cayes by MARNDR in 1981, when only 5% of total fertilizer was urea, attests to a shift, consistent with the project recommendation, in MARNDR's fertilizer provision priorities for Les Cayes. The project's positive impact on helping to change these priorities was confirmed to the OFR team by the authorities concerned.

The government's role in providing urea was complemented by positive interventions from the local private sector. The increase in private urea sales has been impressive, with an almost 10-fold jump from 11 t/year in 1983 to 105 t/year in 1984. From 1984 to 1985, urea sales rose to 289 t/year. Although sales of mixed blends also increased rapidly, the change in urea sales was far more pronounced. Urea accounted for just 9% of the total sales volume in 1983, but its market share increased to 28% in 1984 and to 36% in 1985. Rapid growth in sales was consistent with the demand hypothesized by the OFR team, as well as with the timing of the project recommendation to farmers (January 1984).

CONCLUSION

The success of the strategy followed in alerting decision makers to the advantages of providing urea to Les Cayes farmers suggests that agricultural policy can indeed be a variable in location-specific, adaptive research, and that well-oriented farm-based policy analysis can encourage policy makers to consider modifications in accordance with farmers' circumstances. Though

the approach described here is clearly in the developmental stage, we feel that the experience we have gained provides grounds for believing that we are witnessing the beginning of a promising research area. The case of Les Cayes indicates 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 et al., 1982). That first-hand understanding can have important positive implications for target groups of farmers.

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