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By

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ABSTRACT

FARMER ASSESSMENT OF MAIZE RECOMMENDATIONS IN NORTHERN VERACRUZ STATE, MEXICO

By

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This study develops procedures for farmer assessment of new technology and applies these procedures to assess maize recommendations for three defined groups of farmers in Northern Veracruz State, Mexico.

Farmer assessment goes beyond conventional economic analysis of agronomic data, in which researchers assume that they are familiar with the important costs and benefits associated with new technology. In farmer assessment, those farmers with sufficient experience with the new technology (such that they have made a decision for or against its use) explain how they employ it (positive information), list its advantages and disadvantages (normative information), and describe why they decided in favor of or against its use in commercial production (prescriptive information). This information may be used to suggest changes in priorities and procedures regarding agricultural research, extension or policy.

Steps for the practical implementation of farmer assessment are developed. The step of dividing farmers into users, ex-users and non-users is found to be especially useful. Alternative data collection techniques such as purposive surveys, random surveys and farmer trials are examined for usefulness in farmer assessment and conditions are established underwhich each is preferred. Finally, it is found that farmer assessment is likely to be most

useful: 1) when farmers have had little previous experience with components of the new technology, 2) when a knowledge of the recommended technology is needed to focus questions on farmers' experiences, 3) when the farming system is complex and therefore costly to accurately represent in a formal model, 4) when _ex-ante_ survey work was not well conducted.

Maize recommendations are developed for the study area for fertilizer levels, weed control practices, variety, planted density, and insect control practices. These recommendations are developed from experimental data obtained from on-farm agronomic trials conducted by CIMMYT's Maize Training Program. Analytical techniques used in developing recommendations include partial budgets, simple risk analysis, and production function analysis.

Fertilizer recommendations are found to be generally acceptable to farmers. Farmers experience yield increases similar to those observed in experiments, for the recommended treatment. Problems of fertilizer availability led to suggestions for a change in fertilizer distribution policy on the part of the local government bank and extension service. Weed control recommendations involving herbicides are found by farmers to be useful but formal recommendation of them is subject to further analysis going beyond private benefits and costs that correspond to a single maize cycle. Variety and density recommendations are rejected by farmers. The recommended variety demonstrates unexpected problems of storability which, in the farmers' viewpoint, outweight the advantages of that variety of earliness and resistance to lodging. A recommendation of increased planted density is complementary to variety choice, so an increase in density is likewise rejected. Insect control recommendations are found to be unrelated to farmer problems and circumstances because recommended inputs are not locally available. Specific suggestions are made for changes in research or policy to remedy this situation.

In summary, farmer assessment of recommended technology is found to be a useful step in the context of more general procedures for on-farm agro-economic research.

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CHAPTER 1

BACKGROUND AND OBJECTIVES

The purpose of this study was to develop and test procedures for farmer assessment of new agricultural technology, as part of a more general set of procedures for selecting agricultural technologies useful to farmers. Before proceeding with a more formal presentation of specific study objectives, it is appropriate that the background of the study, including these more general procedures for technology selection, be described and the pertinent literature reviewed. Then the methodological and problem solving objectives of the study will be stated.

1.1 Background Regarding Methodology

There has been an increasing insistence on the part of international agricultural research centers and national research programs that agricultural research and extension lead to the rapid development of technologies usable by farmers. This is consistent with a similar call by economists for increased multidisciplinary collaboration between biological scientists and social scientists in work directed towards this same objective. Norman, for example, advocates agricultural research that is multidisciplinary, centered on farmers' circumstances and proceeds by building on current farmer practice (Norman, 1978). Dillon, in a recent article, favors research that uses knowledge of current technology (and how it relates to the farmer's culture and needs) to identify innovations whose adoption is feasible; this suggests that research emphasis be "tailored toward technology that matches the farmer's resource, financial and climatic environment..." (Dillon, 1979).

Among national programs, that of Guatemala has made rapid progress in the implementation of the kind of agricultural research orientation proposed above. The institution in question, ICTA (Instituto de Ciencia y Tecnologia Agricola), is nationally responsible for the development of agricultural technology. Four steps are defined in the ICTA approach

> (1) description and analysis of the traditional farmer with an orientation toward an understanding of the factors which have prevented his benefiting from modern technology, (2) adaptive research to generate new technology appropriate to him, (3) farm testing (and promotion) to assure, early in the process, that the technology being developed is satisfactory from the target group farmer's point of view, and (4) evaluation of the technology generated (Hildebrand, 1976).

The development of procedures for developing technologies usable by farmers has received a strong emphasis in the IARCs (International Agricultural Research Centers). The very mandate of some of the Centers, e.g., IITA (International Institute for Tropical Agriculture) and CIAT (Centro Internacional de Agricultura Tropical), is in terms of the development of cropping systems or farming systems suitable for defined regions, using improved varieties of specific crops.[1] Furthermore, the CGIAR (Consultive Group on International Agricultural Research), in a recent report on farming systems research in the IARCs, strongly advocated

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[1]The CGIAR/TAC, 1978, describe a farming system as a purposive, multi-goal, open, stochastic, dynamic system. This system is composed of such subsystems as social (labor, family), biological (soils, plants, animals), technical (tools, machines, inputs) and managerial (knowledge, decision-making) which overlap and interact. A crop system comprises all components required for the production and use of a particular crop and the interrelationships between them and the environment.

agricultural research that meets the following objectives: (1) understand the physical and socioeconomic environment in which research takes place, (2) evaluate existing farming systems and improve understanding of the farmer, (3) improve problem identification in existing farming systems, to better focus research activities, (4) conduct research on improved practices in the context of the whole farm, (5) evaluate new practices through on-farm studies and measurement of farmer reaction to new technology, and (6) assess the impact of new technology on various affected groups (CGIAR/TAC, 1978, pp. 21-22).

Even centers with a commodity mandate rather than a farming systems mandate have emphasized the development of procedures to formulate recommendations for the mandate crop in the context of the cropping system. For example, IRRI (International Rice Research Institute) maintains a Cropping Systems Program, which currently claims 20 percent of the Institute's budget.

In recent years, scientists at CIMMYT (the International Center for the Improvement of Maize and Wheat) have become increasingly interested in developing procedures for the rapid formulation of maize and wheat technologies usable by target farmers. Lessons have been drawn from CIMMYT's experience with the Puebla Project, as well as from studies of the adoption by farmers of new technology in various countries (CIMMYT, 1974 and Winklemann, 1976). These lessons have been combined with the experiences of other International Agricultural Research Centers (IARCs) and of national programs, to derive a set of suitable research procedures.

Somewhat incomplete descriptions of these procedures have recently appeared (Byerlee, et al., 1979, and Byerlee, et al., forthcoming).[2]

The research process proposed by CIMMYT is, in fact, an adaptive (iterative and interactive) system of information flow. It may, nonetheless, be presented, albeit simplistically, in terms of several discrete steps. These steps are as follows: (1) Experiment planning (using information on farmers' practices and problems to help plan on-farm agronomic experiments), (2) Experimentation (carrying out on-farm experiments and analyzing the results to make recommendations aimed at solving farmers' problems), (3) Promotion (insuring that target farmers are sufficiently familiar with the recommendations that they may make an adoption decision in favor of or against the continued use of these recommendations), and (4) Monitoring (determining farmer experience with the new technology).

The planning step in this model (1) has received considerable attention recently. It is largely on this step that proponents of collaboration between social scientists and biological scientists, at least insofar as on-farm research is concerned, have focused. The experimentation step (2) has likewise been the subject of considerable recent attention. Both IRRI and CIMMYT have developed relatively standardized procedures for on-farm experimentation, using simple experimental designs (De Datta, 1978, and CIMMYT, 1978). Time tested procedures, using simple budgeting and risk analysis, are available to transform the resulting agronomic data into recommendations for farmers (Perrin, et al., 1976). Finally, the promotion step (3) enjoys the attentions of a large cadre of extensionists and has long been stressed.

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[2]The case of CIMMYT is of special interest because CIMMYT supported the research herein reported and the research itself made use of CIMMYT data.

It is step (4), that of monitoring farmers' experiences with the new technology, that has received relatively little attention. Although it is occasionally mentioned as a necessary part of the process of developing technologies, detail is seldom presented on the various functions associated with this step or the efficiency of alternative survey procedures that may be used in carrying out these functions. Scientists at CIMMYT, for example, have recently focused on the *ex ante* step of on-farm research but have done little "monitoring" of farmers' experiences with recommendations. Researchers at IRRI use a systems approach in developing and testing new cropping systems but do not appear to conduct much direct "monitoring" of farmer reaction to new technology (Gomez, 1977). Yet, it is this "monitoring" step that allows on-farm research to become iterative and dynamic. These are the major reasons why this step is the subject of the present study. To distinguish this step from the "monitoring" of an action program, it has been re-named "farmer assessment." The step of "farmer assessment" will be useful insofar as it leads to improvements in the recommended technology, through suggestions for changes in agricultural research, or to improvements in the policy environment which farmers must face.

In summary, procedures for the formulation of agricultural technology usable by farmers, as proposed or practiced by some national research programs or IARCs, have much in common. These general procedures are problem-solving in nature and therefore require collaboration among various disciplines, especially between economics and agronomy. They also require the participation of the farmers. In the research process, the farmer is called upon to provide *ex ante* information on problems and practices so that experiments may be planned, to provide experimental locations, and to assess the usefulness of resulting recommendations when implemented in his own complex environment of multiple goals and limited resources. Finally, these procedures are required to be sufficiently simple and inexpensive that national research programs with limited resources can implement them, even when small farmers comprise the target group.

1.2 A Statement of the Methodological Objective

The methodological objective of the study was to develop useful procedures for "farmer assessment of new technology." These procedures should be consistent with the more general procedures, noted above, for formulation of new technologies usable by farmers. Clearly, such consistency requires that the procedures for farmer assessment of technology share the characteristics of the more general procedures. That is, they should be oriented towards problem-solving and should be cheap and simple enough for practical use by national programs.

The methodological objective includes several sub-objectives. Farmer assessment of technology must be defined. The place of farmer assessment in the more general research procedures must be explored. The practical uses for information obtained through farmer assessment must be listed and explained and the limitations of this information must be noted. The practical steps needed to implement farmer assessment must be listed and explained. Finally, the conceptual and methodological issues that surround the idea of "farmer assessment" must be dealt with. These issues include the theoretical context of farmer assessment and the choice of techniques for data collection.

1.3 Background Regarding the Use of the Methodology in a Case Study for Problem-Solving

Farmer assessment methodology was tested in Northern Veracruz, Mexico, an area of interest to CIMMYT. CIMMYT has engaged in on-farm agronomic research on maize in Northern Veracruz since 1973. Over the years, CIMMYT researchers have conducted numerous experiments in each crop cycle (two crop cycles per year) on a wide variety of agronomic questions related to maize cultivation. Five to seven experimental sites have been planted each year and several (one to seven) experiments were planted per site. The sites have been changed after one or two cycles of experimentation.

CIMMYT's agronomic research in Northern Veracruz has been carried out largely for training purposes. The study area has served as a classroom in which agronomists from developing countries may be trained, by CIMMYT agronomists and economists, in the on-farm research procedures proposed by CIMMYT (CIMMYT, 1978). Indeed, CIMMYT staff have consciously refrained from engaging in formal extension, the prerogative of a national program. Nonetheless, the on-farm experiments in the area were conducted using those procedures that, it is asserted, should be used for the purpose of developing improved technologies.

To be sure, a certain amount of confusion exists with respect to the extent the training function of the experimental program in Northern Veracruz has led to the use of practices and treatments that otherwise would not have appeared in a program focused on formulating technologies.

It is generally felt, however, that training considerations have not materially affected the recommendations forthcoming from the program.[3]

1.4 A Statement of the Problem-Solving Objective

The problem-solving objective of the study was to use the procedures developed for farmer assessment in solving a problem of interest to CIMMYT. This problem is as follows: Are the recommendations for maize cultivation in Northern Veracruz State, Mexico, derived from CIMMYT's program of on-farm agronomic experimentation in that region, suitable for local farmers? Even if they are suitable, have farmers modified them in the process of adoption to make them more consistent with their goals and constraints? The answers to these questions will be useful to CIMMYT in two ways. First, if recommendations are found to be unsuitable, work can proceed to correct any inconsistencies that may be found between recommendations and farmers' circumstances. After all, one purpose of the program is to demonstrate how CIMMYT's procedures can develop technologies usable by farmers. Second, research results can be subsequently used for purposes of illustration and training with respect to how farmer assessment may be implemented and how its results may help re-direct agronomic experimental priorities and provide information to policy-makers.

The problem-solving objective has several sub-objectives:

(1) Formulate maize recommendations for the study by means of economic analysis of agronomic data. The analytical technique to be used was partial budgeting, combined with simple risk analysis. Production function

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[3]CIMMYT Training Agronomists, personal communication.

analysis was also used in the case of fertilizer data. The agronomic data were obtained from CIMMYT's Maize Training Program. (2) Conduct farmer assessment of the recommendations so formulated. (3) Use the results of farmer assessment to suggest changes in the maize research program conducted by CIMMYT, and provide information to policy-makers regarding agricultural policies affecting target farmers.

1.5 An Overview of the Study

The methodological objectives noted above (define farmer assessment, place farmer assessment in the context of research procedures, list the specific uses of farmer assessment, list the steps to be followed in farmer assessment, and place farmer assessment in a theoretical context) are addressed in Chapter 2. The data collection instruments employed in the study area, and the study area itself, are described in Chapters 3 and 4, respectively. Subsequently, individual chapters deal with the use of specific inputs and practices in maize cultivation for the study area. Recommendations are formulated and subjected to farmer assessment. The results of this assessment are then used to suggest changes in agricultural research in maize, and in agricultural policy affecting local maize farmers. Weed control practices, fertilizer use, variety and density choice, and insect control practices are the subjects of Chapters 5, 6, 7 and 8 respectively. Finally, Chapter 9 contains a summary of results and a discussion of how well objectives were met.

CHAPTER 2

FARMER ASSESSMENT OF RECOMMENDED TECHNOLOGY--DEFINITION AND METHODOLOGY

Farmer assessment of recommended technology, the subject of this study, has been referred to above as a part of a more general process of the generation of technology usable by farmers. Special emphasis was placed on the CIMMYT formulation of this process in that the case study on farmer assessment that was conducted examined recommendations for maize production derived from CIMMYT on-farm training experiments.

This chapter will address the methodological objectives stated in Chapter 1: (1) define "farmer assessment;" (2) explore the place of farmer assessment in the more general procedures for agricultural research; (3) list the practical use for data obtained through farmer assessment; (4) list the steps to be used in farmer assessment; and (5) address conceptual and methodological issues that surround farmer assessment, e.g., its theoretical context and choice of data collection techniques.

2.1 Definition of "Farmer Assessment"

Farmer assessment, also referred to as "evaluation of technology" or "monitoring of farmers' experiences with technology," has been described by several authors. The Tennessee Valley Authority (TVA) began, as early as the 1930s, a series of Test-Demonstration trials which continue to this day. As McKnight (1959) notes:

> Test-Demonstration work is designed to fill the gap in the no-man's land between research and extension for the purpose of shortening the time lag between the discovery of information by the agricultural scientist and its general acceptance by farmers. Test-Demonstration farms are used to try out and demonstrate promising research findings before they are conclusive enough to be released for general use.

More recently, Dillon notes that:

> Once research is under way and results begin to come to hand, evaluation can begin. Full evaluation is not possible until farmer utilization or trials of the new technology provide real-world data. Until then, only relatively soft data will be available. But this should not deter the start of evaluation. Indeed, the early evaluation of research station and field trial data will be very important to extension design activities.
>
> Necessarily, ex post evaluation activities will duplicate much of the ex ante activity. Data on research and farmer results will need to be collected and appraised, leading in turn to further research guidance. In this sense, particularly when an ongoing program of research is under way, ex ante and ex post guideline activities meld together in a continuing cyclical process. (Dillon, 1979, p. 176).

Similarly, Anderson and Hardaker define an important role for the evaluation of technology:

> Evaluation can be thought of as an on-going process of monitoring seemingly useful changes in technology. It can and should take place in the various contexts discussed below, and it provides information for groups--most immediately to the developers and purveyors of new technology, then to the various communicators of information. (Anderson and Hardaker, 1979, p. 13).

In Guatemala, farmer assessment of new technology is included in the process of technology generation used by ICTA because,

> . . . small farmers will, and do accept change when the available resource base changes or new and appropriate technology becomes known. Otherwise, they could not be efficiently adjusted to alternatives they now have. But it is important to understand that this efficient adjustment is in terms of the farmers' own understanding and interpretation of his situation, and it is not necessarily efficient according to the perceptions of well meaning, but incompletely-informed third persons. (Hildebrand, 1978).

It is clear that the above authors are all referring to more or less the same concept, though the terms used vary. However, a more precise definition of "farmer assessment of recommended technology" is needed. The following is suggested: an iterative process whereby the collection and analysis of information from farmers, concerning the way in which they employ a recommended technology as well as the advantages and disadvantages they perceive in it and their decision regarding the wisdom of employing it, is used in subsequent decision-making on research and extension priorities, and on policies affecting farmers' adoption decisions.

An explanation of this definition is in order. What is it that farmers do to assess the technology in question? According to the definition, they provide three kinds of information to researchers: (1) the exact fashion in which they employ the technology, (2) the advantages and disadvantages of using the technology, and (3) their decision regarding use or non-use of the technology, given these advantages and disadvantages.

The above kinds of information correspond to the concepts of "positive information," "normative information" and "prescriptions," as discussed by Johnson and Zerby (1973). Positive information is concerned with non-normative attributes of things, conditions and situations in the world. Normative information is concerned with the goodness and badness of these things, conditions and situations. Prescriptions, or decisions on right and wrong, are formed by processing positive and normative information through a decision rule.[1]

[1]The difference between "good and bad" on the one hand, and "right and wrong" on the other was noted by C.I. Lewis (1955). The former refer to normative concepts whereas the latter refer to prescriptions.

Clearly, then, farmer assessment of recommended technology involves the communication of prescriptions, in this case the farmers' decision regarding the wisdom of employing the recommendations (or modifications) under varying conditions of weather or markets. The positive information embodied in these prescriptions includes the input/output relations obtained by the farmer when he uses the recommendations (or modifications) under his own conditions. The normative information so embodied includes information on monetary and non-monetary values. The information on monetary values will likely include such considerations as product and input prices, value of losses of yield in storage, value of yield changes in other crops, and the monetary value of other changes in the farming system due to the introduction of recommendations in the target crop. Information on non-monetary values may include consumption preferences, the utility of income, and the utility or disutility of imperfect knowledge.

The farmer takes the positive and normative information noted above and applies his decision rule to arrive at a prescription--a decision for or against adoption of the recommendations or a modification of the recommendations. In the process, he may reveal much regarding the relative importance of the noted advantages and disadvantages. In any event, he performs a valuable service by reducing the advantages and disadvantages (monetary and non-monetary) to common terms and by establishing second-order conditions, thereby allowing comparisons between technologies to be made.

Farmers and not researchers are used in assessment at this stage, because researchers are not as likely to be as aware as farmers of the presence of changes in the farming system, or the direction and amount of consequent changes in value. Indeed, the farmer himself may not be aware of the implications on other consumption and production activities of the use of recommendations until he, himself, has tried them.

One further clarification is in order. Just as farmers assess recommendations in light of their whole farming system, data collection and analysis by researchers emphasize the level of the enterprise (e.g., maize) or below (e.g., insects in maize) and interaction between these and the rest of the farming system. It should be recognized that research at higher levels of aggregation (e.g., the crop-livestock system) will at times be necessary to answer other kinds of questions than those addressed by farmer assessment. Useful taxonomies of agricultural systems and subsystems may be found in National Academy of Sciences (1974) or Hart (1979).

2.2 The Relation of Farmer Assessment to the Other Steps in the CIMMYT Procedures

The technical process of technology-generation may be thought of as "technology for the production of technological recommendations." One may then conceive of the various steps in the process as inputs used to produce the final product--recommendations usable by target farmers--whose value depends on such considerations as adoption rates and the amount of benefits and costs accruing to their users. These inputs may be substitutes or complements. *Ex ante* identification of farmer problems and circumstances and well-focused, on-farm experiments seem to be complements. Both are required to produce much of value. Such *ex ante* work and farmer assessment, however, seem to be substitutes. Excellence and comprehensiveness in *ex ante* study of farmer circumstances will usually mean that fewer inconsistencies between these circumstances and the new technology will exist to be discovered later by farmer assessment. Equally, the fact that farmer assessment is known to be in the offing allows researchers to restrict ex ante description and analysis of farmer circumstances to those variables of greater importance and/or relatively cheap to observe and measure. This is merely a reflection of the well-known conclusion that, as substitutability increases, the importance of price relatives also increases.

A further comment is in order regarding the timing of farmer assessment within the more general CIMMYT procedures. In general, feedback from farmers should be continuous and may include farmer comments on experimental treatments proposed by researchers, farmer monitoring of experiments, farmer listing of factors to take into account when making recommendations, and farmer feedback through the extension service once formal extension is underway. However, the current study emphasizes that stage in the research/extension process when recommendations (hopefully based on on-farm experiments carried out in the target area) are more or less complete, but before widespread and formal extension has been undertaken. This is when farmers are just beginning to try the technology on their own. They provide resources and management and accept the corresponding risks.

2.3 The Uses of Farmer Assessment

The purpose of farmer assessment of new technology should, by now, be clear. Specifically, this purpose is to provide feedback from farmers. The farmer provides information to researchers and policy-makers on the consistency of recommended technology with his goals and constraints, on needed improvements to be made in the technology, and/or modifications in the technology he has adopted. Researchers use this information to formulate testable hypotheses. If the information obtained from farmers is confirmed, i.e., if the hypotheses are accepted, the information may be used in six different ways, as listed below.

(1) Re-analysis of the results of past agronomic trials: if a hypothesis on the presence of a problem with the new technology is confirmed, then the results of past experiments should be subjected to a new economic analysis that includes the new problem. For example, if a hypothesis on the relative storability of varieties is confirmed, agronomic data on variety comparisons should be re-analyzed to see if yield differences compensate for storage loss. Recommendations may change as a result. Likewise, if a farmer hypothesis is confirmed relative to the seasonal scarcity of labor at a time in which the technology calls for increased labor input, economic analysis might be changed to allow for a newly estimated shadow wage for this peak period.

(2) Re-design of individual on-farm agronomic experiments: farmer assessment may discover that present recommendations are not useful to farmers as a result of a defect in the recommended technology which, in turn, was caused by unrepresentative experimental conditions. In this case, it might be necessary to re-run the experiments. This pertains to the selection of controls, or "blanket treatments"--the "constant" factors or practices not subject to experimental variation. For example, consider a fertilizer trial carried out with chemical weed control as a blanket treatment. Assume that, for some reason, herbicides cannot be used by farmers (not available, damage to associated crops, etc.) and that agronomists expect different fertilizer responses to be associated with different weed control practices. In this case, then, accurate

prediction of yields, and hence profits, that farmers can expect when they use fertilizer requires fertilizer trials that use the farmer's weed control practices as a "blanket treatment."

Farmer assessment may also lead to the inclusion of new experimental treatments. If farmers indicate, for example, that the presently recommended variety is not usable by them because of insufficient drought tolerance, this criterion should be used by researchers when they select varieties for inclusion in future on-farm variety experiments.

(3) Re-design of the on-farm experimental program: CIMMYT agronomists (CIMMYT, 1978) identify several steps in the process of agronomic research, as follows: Step 1 is that of experiment-station research (e.g., development of varieties or screening of new pesticides); Step 2 is that of on-farm factorial experiments and farm surveys to identify important production limiting factors and interactions between them; Step 3 is that of determination of economic levels of inputs to overcome problems identified in Step 2; Step 4 is that of verifying that the recommendations arising from Step 3 are significantly and consistently more profitable than the farmer's technology at acceptable risk levels;[2] and Step 5 is that of seed increase and testing the new technology in commercial-sized fields. A schematic of these steps is presented in Figure 2-1.

If farmer assessment fails to identify serious inconsistencies between the new technology and farmers' circumstances, then emphasis on

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[2] Verification as used here refers to the comparison of the profitability of the farmer's technology and the recommendations, based on data obtained through small-plot experiments. It does not necessarily "verify" consistency between the new technology and the current farming system.

	Stage/Function	Test Location	Program Objectives	
1	Research Agronomy	Experimental Station	Screening new varieties based on relevant criteria at farmers level (yield, grain, end uses, etc.) Testing new agricultural chemicals.	Testing agricultural machinery. Related laboratory studies.
2	Production Research	Farmer's Fields	Identify critical management factors, their order of importance and significant interactions. Testing agricultural chemicals against pests and weeds detected as problem by farmers. Preliminary investigations of new management methods e.g. minimum tillage.	Preliminary evaluations of breeding objectives. Economic analysis to detect factors of production with a higher impact on benefits and higher probability of acceptance by farmers.
3	Production Research	Farmer's Fields	Describe quantitatively the response to each critical management factor. Further investigation of significant interactions. Trials of promising varieties. Comparative trials of promising pesticide rates. Evaluation of breeding materials under different input levels.	Formulation of technological alternatives (packages) with different benefit levels and related risk. Demonstration to extension agents on formulation of technological alternatives and how to carry out stage IV. Partial budget analysis of agronomic data and range of relevant economic factors to be considered in future trials.
4	Verification and Diffusion	Farmers' Fields	Verification trials of technological production packages. Assessing farmers reaction to new inputs and breeding materials. Observation of new factors limiting production.	Economic analysis of possible modification of production packages due to changes in relative prices.
5	Experimental Production Plot	Farmers' Fields	Verification of experimental results in production size plot (1 hectare or more). Experience with production size plot on farmers' fields. Assessing farmers' reaction to technological alternatives.	Increase of open pollinated variety seed for potential release in the area. Supervision and maintenance of varietal purity. Large scale economic study of the technological alternatives used.

Figure 2-1 Model of the Strategy Used by CIMMYT for Maize Training in Production Research

Steps 4 and 5 is probably in order. If, however, grave problems or unexpected opportunities are identified, a shift in emphasis back to stages 2 and 3 would probably be wise.

For example, if a new technology being verified and grown in commercial-sized plots (Stages 4 and 5) uses as a key input a variety found by farmers to be objectionable, then a change of emphasis to earlier stages is in order. This would allow the re-construction of a technology that uses a more acceptable variety. The identification of such deficiencies is, of course, the purpose of farmer assessment.

(4) Feedback to experiment station research: if farmers agree, during the assessment process, that a variety suffers from some defect, this information should be forwarded to breeders for inclusion as they see fit in setting breeding priorities.

(5) Allocation of funds to research versus extension: insofar as investment in these two activities is fungible, decisions made with respect to investment in one or the other could be aided by farmer assessment of the new technology to be extended. If farmer assessment is favorable, large investments in related extension may be made with more confidence.

(6) Information for analysis of agricultural policy: farmer assessment of new technology may identify constraints to widespread adoption of that technology influenced by policy, e.g., input availability, performance of credit institutions, market performance, price structures, etc. If it proves possible to estimate production foregone due to unfavorable policies, the costs of maintaining the present policy stance would thereby be available to policy-makers for consideration in future examination of the policies in question. It should be made clear,

however, that the role of farmer assessment is not to set agricultural policy, but rather to identify fruitful areas for future policy analysis.

2.4 Steps in Farmer Assessment

If it is accepted that something along the lines of "farmer assessment of new technology," for the purposes noted above, is a useful component of a more general process of on-farm research, then discussion is in order regarding the practical steps to be followed in implementing such farmer assessment.

A review of available literature, however, reveals only two studies that aid in the identification of these steps. One deals with the Guatemala experience. The other prescribes a form of farmer assessment consistent with IRRI's Cropping Systems Program.

In Guatemala, the Instituto de Ciencia y Tecnologia Agricola (ICTA) urges the standardized use of a "farmer's trial" of a complete new technology, whereby the farmer himself plants a small field using the new technology. The farmer incurs all expenses and faces the corresponding risks alone, but receives free technical assistance from researchers. Follow-up surveys are then conducted to determine adoption rates among collaborating farmers, the area on which the new technology is being used and the specific reasons for adoption or non-adoption of specific inputs and practices included in the technology (Hildebrand, 1976, p. 10).

In the 1976 Cropping Systems Symposium sponsored by IRRI, Norman and Palmer-Jones, proposed "monitoring through extension," as follows:

> Initially, extension should operate on a small scale (in farmers' trials, for instance) and, if necessary, encourage high feedback. The basic purpose of monitoring should be to update documentation of the cropping system. Initial documentation based on the cookbook would include detailed description of the physical prerequisites, inputs used (including sources and prices), husbandry operations,

> labor and power inputs, yield expectations, extension methods and support requirements. Some variants of the basic system can be given. The extension monitoring service should, on the basis of experience, update the initial documentation and, where deviation from the blueprint, or unexpected outcomes or other problems occur, should refer to the research system for instance. While for a successful innovation this can be carried out by the extension system, the study of major problems would be a matter for researchers, since it implies a research failure in either the study of the existing situation, the agronomic trials, or the management trials (Norman and Palmer-Jones, 1977, p. 257).

Both of the above emphasize the monitoring of early "users" of a new technology, with provisions for feedback of information from farmers to researchers on any problems encountered. Both place reliance on farmer trials. Neither, however, give detailed guidance on how to practically implement farmer assessment through the suggested farmer trials. Furthermore, complete reliance on farmer trials may not be necessary, as will be shown below (Section 2.5.4).

In light of this deficiency, the following steps for farmer assessment have been developed; the place of each step in the overall scheme of information flow may be seen in Figure 2-2.

(1) Explicitly identify the recommendations to be assessed. As a part of this step, identify substitutes and complements among the inputs and practices contained in the recommended technology. It is useful to know which inputs are strong complements, as rejection of one complement causes rejection of the entire set. Awareness of substitutes may be useful in overcoming problems that arise in the use of one of the substituting inputs.

(2) Stratify target farmers by "use class" for each input or practice in question. Target farmers can be divided into several categories, according to their history of using each input or practice contained in the recommendations. These are "users" (farmers who use the

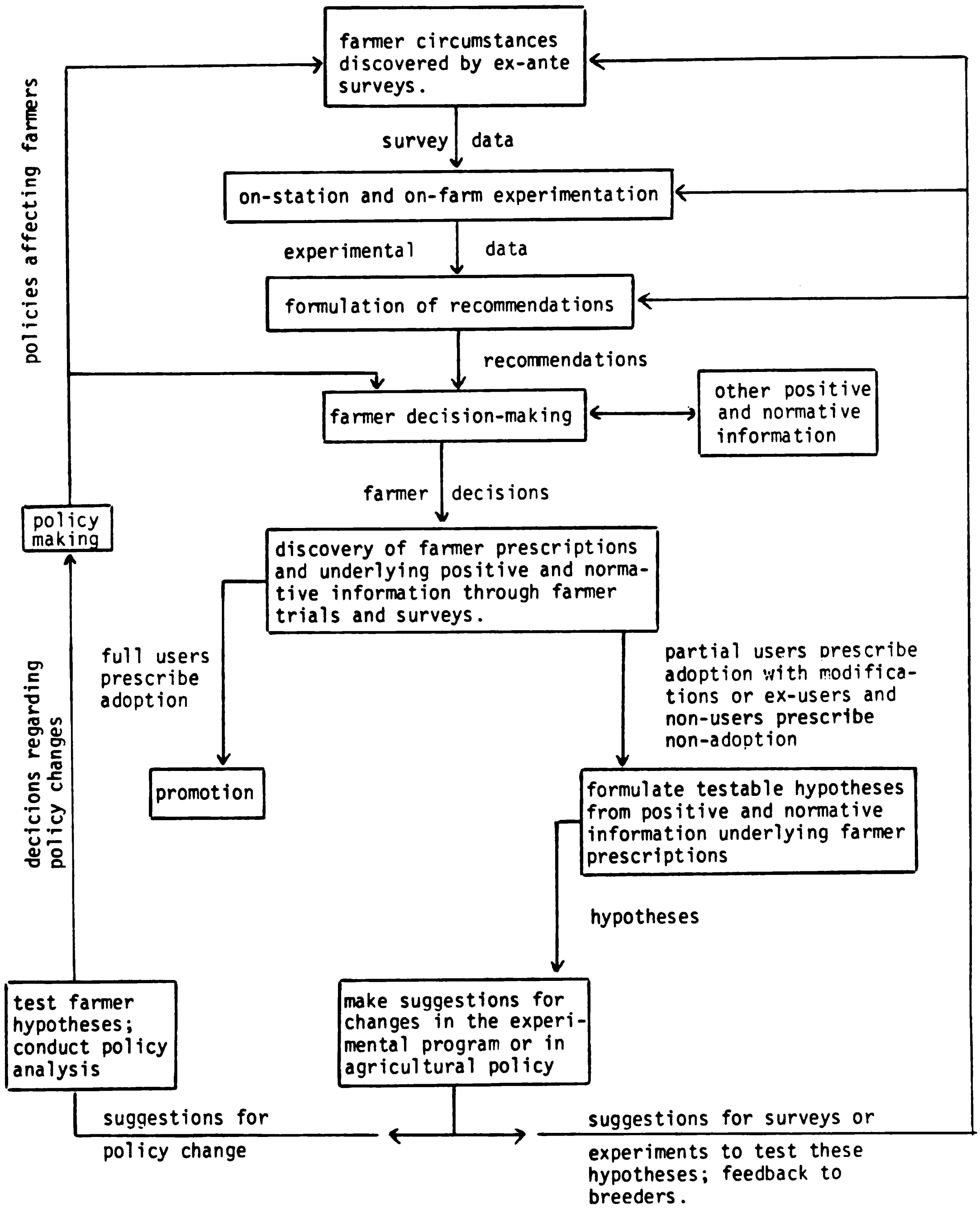

Figure 2-2 Information Flow in Farmer Assessment

input or practice in question), "ex-users" (farmers who have tried the input or practice and who have dropped it), and "non-users" (farmers who are knowledgeable about the input or practice but who have decided not to use it without trying it). In some cases (e.g., where fertilizer levels are an issue) it is useful to distinguish between those "users" that follow recommended practices to the letter and those that modify the practices in the course of adoption. These are termed "full users" and "partial users," respectively.

This classification is expected to be useful because different questions will be relevant to different use classes, though all strata will be asked to divulge positive information, normative information and prescriptions. Similarly, the relative value of the information obtained from the various use classes varies according to the use history on the part of the target population as a whole. This is illustrated in Figure 2-3.

For example, if a new variety has been tried but dropped by many farmers, information from "ex-users" is clearly of more interest than information from "non-users." Information from current "users" would be of some interest, however, to see if they have found a way to use the variety that overcomes the deficiencies noted by "ex-users."

In practice, pre-stratification of the population is usually not feasible for practical reasons. This and other issues related to implementation of the procedures are deferred to Section 2.5.4.

(3) Implementation of surveys or farmer trials: for selected use classes (as identified in Figure 2-3) and for each input or practice, identify and measure the following: current and past use practices, advantages and disadvantages, and prescriptions on technology use under

Frequency of Use:	Non-Users	Ex-Users	Users	Farmer Test
Practice commonly used	X	X	XX	0
Practice dropped	0	XX	X	0
Practice never used	XX	0	X (if any)	XX

XX = greatest emphasis

X = some emphasis

0 = little or no emphasis

Figure 2-3 Farmer Use Class to be Emphasized in Data Collection, by Frequency of Use of the Practice in the Population different conditions, together with the reasons for these prescriptions (relative weighting of advantages and disadvantages).

For example, if ex-users of fertilizers are common in the target population, positive information on the current cropping system and on the cropping system when fertilizers were being used are obtained. Farmers are asked to list the problems and advantages associated with fertilizer use (normative information). The farmer is then asked, given all of the above, if it is best to use fertilizers, or not to use them, under various realistic conditions of expected weather and markets (prescriptions), and the more salient reasons for this decision.

Issues of survey design (random versus purposive, single-visit versus multiple visit, surveys versus farmer's tests) will be deferred to Section 2.5.4.

(4) Hypothesis formulation and testing: formulate and test hypotheses stemming from information gained in the surveys. For example, if farmers reject fertilizer use largely because it is unprofitable, a profitability hypothesis can be formulated and then tested using farmer information on yield response and relative prices. Frequently, however, formal testing of hypotheses generated in this step must be left to the new experiments or surveys called for in step (5).

(5) Use of results in decision-making: use the hypotheses formulated in step (4) in one or more of the six purposes of farmer assessment that are listed above. To repeat, these are: (a) re-analysis of the results of past agronomic trials, (b) re-design of individual on-farm agronomic experiments, (c) re-design of the on-farm experimental program, (d) feedback to experiment station research, (e) allocation of funds to research versus extension, and (f) information regarding agricultural

policy. Note that for use in (a), (e) or (f) these hypotheses should have received prior confirmation. This confirmation may be obtained through special purpose surveys, or through (b), (c), or (d).

2.5 Conceptual and Methodological Issues in Farmer Assessment

A number of conceptual and methodological issues surround the notion of "farmer assessment of recommended technologies" that has been described above. Conceptual issues include the following: (1) What is the contribution of production economics to the theoretical base that underlies farmer assessment? (2) What is the difference between farmer assessment and other kinds of *ex post* studies of technology transfer, particularly adoption studies conducted by researchers in communications? (3) What reliance may be placed on information from farmers in assessing technologies? Methodological issues include: (1) How may stratification of farmers into use classes be practically conducted? (2) What criteria should be used to choose between farmer trials or farm surveys in data collection? (3) If farm surveys are to be used, should they be random or purposive, formal or informal, single-visit or multiple-visit?

2.5.1 Production Economics and Farmer Assessment

Static production economics, while useful in other steps of the general CIMMYT procedure for technology-formulation, is less useful in farmer assessment of new technology.

Procedures based on static production economics arrive at a profit-maximizing use of known inputs, given a fixed technology, fixed utility functions and institutions, and economic rationality based on perfect knowledge. This last assumption implies that all costs and benefits that are related to the use of different inputs at different levels are known in full, may be reduced to comparable terms of value, and subjected to a decision-rule of profit-maximization. A major purpose of farmer assessment, however, is to identify costs and benefits (both monetary and non-monetary) that have hitherto escaped attention. These have, as a consequence, not been included in the overall comparisons of costs and benefits leading to choices of inputs and input levels.[3]

Moreover, static production economics stresses the use of formal decision-rules of profit-maximization, where the costs and benefits to be compared may be expressed in monetary terms. In farmer assessment, however, we ask the farmer to apply his <u>own</u> decision rule (which may include one of several ways of incorporating risk, food preferences, etc.) to the complete set of costs and benefits that he perceives, including non-monetary costs and benefits and monetary costs and benefits that researchers have been unable to measure.

There is a body of concepts, however, that is useful as a theoretical base for farmer assessment. These are the concepts of dynamic production economics that are found in the Interstate Managerial Study (IMS) (Johnson, et al., 1961).

The concepts taken from the IMS that are pertinent to farmer assessment include the steps in farmer decision-making, the various

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[3]Under perfect knowledge, input choice and choice of input level are the same thing. The decision not to use an input is, in fact, a decision to use that input as a "zero" level.

knowledge states and their relation to decision-making, and the differences between kinds of problems and kinds of knowledge.

The steps in farmer decision-making include problem identification, observation, analysis, decision, action and acceptance of responsibility (Johnson, _et al._, 1961; or Bradford and Johnson, 1953). The very process of formulating recommendations embodied in the CIMMYT model may be seen as an attempt to reduce the cost to the farmer of several of these steps, especially problem identification, observation and analysis. Farmer assessment, however, is concerned with those farmers who have completed the cycle of decision-making with respect to actions prescribed by researchers. Assessment is especially concerned with the re-definition of problems by farmers as a result of this iteration of decision-making. This has implications for which farmers should be asked to assess the recommendations.

The knowledge states identified by IMS authors relate closely to the above decision-making steps. The acquisition of additional knowledge related to a problem demonstrates, simultaneously, increasing marginal cost and decreasing marginal value, though cost and value may be measured subjectively.[4] Therefore, a point exists where the marginal cost and marginal returns from acquiring more information are equal. This concept of costs and returns to acquiring information leads to the following "knowledge situations:"

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[4]Bradford and Johnson, 1953, p. 34 is the original source. This argument is repeated by Johnson and Lard, 1961.

"1. Subjective certainty, a situation in which a manager considers present knowledge adequate for either:

(a) a positive or

(b) negative decision."

So that he does not try to protect himself from error.

"2. Risk action, a situation in which a manager regards present knowledge as adequate for making a decision and in which the cost of additional knowledge is exactly equal to its value. Risk actions may be either:

(a) positive, or

(b) negative.

3. Learning, a situation in which a manager considers his present knowledge inadequate for action in the sense that he is subjectively unwilling to decide and take the consequences for the errors which he might make and in which the cost of acquiring more knowledge is less than its value.

4. Inaction, a situation in which a manager regards his present knowledge as inadequate for action and in which the cost of more knowledge exceeds its value. In this situation, no action is taken and no learning occurs.

5. Forced action, a situation in which a manager's information is inadequate for him to be ready, willing and able to make a decision subject to the errors involved but in which some outside force makes it necessary for him to act. Forced action decisions are regarded as either:

(a) positive, or

(b) negative."

Again, these concepts are useful in identifying populations of interest in farmer assessment. Information from farmers in the "learning" situation or in the "forced action" situation is of relatively little use, for in neither case has the farmer made up his mind to adopt or reject technology based on what he considers adequate information. The farmers in the "subjective certainty" or the "risk action" categories are the farmers of interest for farmer assessment. These farmers have made a decision based on, for them, sufficient information. Note that these are the only farmers who will have carried out, without coercion, the six steps of decision-making noted above. Farmers in the "inaction" situation are of interest for a different reason. The presence of a large number of farmers in the "inaction" situation may be due to the complexity of the technology under consideration. This, in itself, is of interest to researchers.

Finally, the distinction between problems and kinds of information is of interest in organizing the questions to be asked in farmer assessment. The IMS identified three kinds of information (technological, institutional, and human) with two qualities (positive, normative), to which a time dimension may further be attached (Johnson, 1961). Problems typically require several kinds of information within this classification for their solution. Farmer assessment of new technology deals with the question of whether new technology has helped the farmer solve problems (situations capable of improvement) and/or whether it has caused the farmer to perceive new problems. IMS concepts guide farmer assessment by insisting that normative information (on technological, institutional and human considerations) be collected as well as positive information. It will be noticed that this conclusion was included in the definition of farmer assessment found in Section 2.1.[5]

2.5.2 Farmer Assessment versus Adoption Studies

Farmer assessment of new technology is not the only possible kind of *ex post* study of farmers' reaction to innovations. Diffusion research, as advanced by sociologists who specialize in the study of communications, contains many examples of such research. The basic purpose of such research is to "understand how new ideas spread from their sources to potential receivers and understand the factors affecting the adoption of such innovations" (Rogers and Shoemaker, 1971, p. 1). To achieve this purpose, communications specialists have engaged in such activities as modeling the innovation-decision process, listing the attributes of innovations and how they affect the rate of adoption, forming adopter categories, conducting empirical research on the role of opinion-leaders and change agents, etc. Results from communications research aid in conceptualizing farmer assessment. For example, communications research informs us that the attributes of innovations that are likely to be adopted include relative advantage, compatibility with current activities and values, simplicity, trialability (easy to try on a limited basis), and observability.

The above illustrate the nature of much of recent communications research: it is usually disciplinary or subject-matter research. It rarely has immediate real-world application towards the practical solution

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[5]Vincent has also used the concept of farmer processing of positive and normative information in management. See Vincent, 1977, p. 127.

of a known problem. Furthermore, communications research does not use the knowledge situations outlined above (Section 2.5.1) and, hence, does not make the important distinction between farmers who have made up their minds <u>not</u> to use a given input (negative risk action) and farmers who lack sufficient information upon which to base a decision, one way or the other (learning situation).

Finally, communications specialists themselves note that "generally, there is a strong pro-innovation bias in diffusion research" and that "very seldom does one find diffusion studies which analyze the technical quality, the timeliness, and the cultural and social compatibility of the recommended innovation" (Diaz Bordenave, 1976, p. 49). Even if this pro-innovation bias (or the assumption that the innovation itself lacks defects that would lead to low adoption rates) were overcome, however, communications research offers few tools to ascertain the problems with a given innovation and how they may be practically overcome.

Farmer assessment, on the other hand, is designed specifically as problem-solving research. Researchers conducting farmer assessment are usually those in charge of the rest of the technology-generation process, or have immediate access to them. Knowledge situations are formally incorporated. There is clearly no pro-innovation bias. Assessment is carried out as soon as possible (when recommendations have been established and farmers in the "subjective certainty" or the "risk action" categories have been found). Results, as noted above, are immediately used in decision-making that will either improve the recommendations, confirm them as useful, and/or facilitate their adoption.

CIMMYT itself has conducted several adoption studies as subject-matter research (Perrin and Winkelmann, 1976). In a study of the adoption of hybrid maize in Kenya, for example, it was found that adoption rates were not explained by such factors as the age or education of farmers, or attendance at demonstrations. Other factors were found to explain adoption, e.g., agroclimatic zone (Gerhart, 1975). However, the research objective was to explain adoption rates in the population, not to quickly assess the recommendations from the farmer's point of view, as feedback to researchers. Furthermore, no use of knowledge situations was made.

2.5.3 Reliance on Farmer Prescriptions

In the procedures for farmer assessment of new technology that were advocated above, heavy reliance is placed on information from farmers. Survey techniques are used to obtain positive, normative and prescriptive information; this is true whether or not farmer trials are formally used. Based on this information, hypotheses are formed and tested by researchers and suggestions are made for changes in agronomic experimentation and agricultural policy.

Prescriptions from farmers play a key role. If farmers prescribe the rejection of new technology for a given set of reasons, and if these reasons are supported by subsequent research, then a change in the technology or in agricultural policy will probably be called for.

Some researchers do not agree, however, with this reliance on farmer prescriptions. Gomez, for example, states that:

> It is my contention that the farmer's acceptance of new technology should be determined on the basis of physical, biological, and socioeconomic constraints to adoption rather than simply on the basis of what the farmer thinks. The farmer works under a set of constraints that are generally beyond his ability to remove. His acceptance or rejection of a cropping system gives no clear indication of what he might have done had the constraints been removed. Moreover, the farmer's ability to manage a particular cropping pattern on his farm depends a great deal on how he allocates resources between his own crop assigned to him for testing. We can probably expect that whenever there is any conflict over resource allocation, the farmer will give priority to his own crops. Thus his failure to properly implement an experimental cropping system is not conclusive evidence of the unsuitability of that system. The farmer's participation in on-farm trials should not be taken for granted; it should be evaluated critically (Gomez, 1977, p. 231).

Apparently, Gomez will accept positive and normative information from farmers ("constraints to adoption") but not prescriptions ("what the farmer thinks"). Yet, it is the farmer prescription against adoption that confirms the importance of the noted constraints! The fact that farmers cannot <u>currently</u> predict their own adoption decisions after constraints are eased should not be held against them. As noted above, farmer assessment of new technology should be left to those farmers who have obtained, to their satisfaction, sufficient information upon which to base a decision, i.e., farmers in the "subject certainty" or "risk action" categories. This same argument may be applied to the further observation of Gomez on practical difficulties in the implementation of farmer trials.

Norman and Palmer-Jones question the usefulness of normative information and prescriptions obtained from farmers:

> Several times the point has been made that, for the circumstances with which we are concerned, the farmer ultimately decides what to do, and therefore his opinion is relevant. But it may be very difficult to get a direct statement of his attitude. He has a self-conscious interest in the results of expressing opinion. Since he is likely to perceive that his private interest is in conflict with the society's welfare, his answers to such questions as "Was it a good thing?", "Would you grow it?" or "What would make it better?" are unlikely to be straightforward. The notorious unwillingness of farmers to express negative opinions about government initiatives, especially when facing government employees or those who are identified with government, would hardly need mention were it not that the expression of a few negative attitudes is often taken as proof of frankness. Farmers are likely to say that shortage of labor restricts their output. However, they are unlikely to say that they would probably not adopt a technology dependent on new scarce inputs because of doubt that a system that could deliver them would allow farmers to benefit from them. Also, giving too much attention to farmers' attitudes is likely to give undue weight to the most articulate. Finally, the use of certain methods of public opinion assessment (such as, public meetings to choose the most suitable varieties) may have unpredictable results because of the lack of experience with such techniques in the social system of an area (Norman and Palmer-Jones, 1977, p. 241).

Again, part of the problem may stem from inadequate identification of <u>which</u> farmers are to assess the new technology. If Norman and Palmer-Jones are simply giving a warning against asking farmers questions that they cannot be expected to answer, there is no inconsistency between their conclusion and that of the present study. Farmers in the "subjective certainty" and "risk action" categories <u>can</u> be expected to answer the necessary questions, however. If they are asserting that farmers are not likely to tell the truth, I would submit that the division of farmers into use classes, and the use of proper questions, would reduce this problem. Instead of asking all farmers, "Would you use this?", it seems more reasonable to ask users, "Why and how do you use this?"; to ask ex-users, "How did you use this and why did you quit?"; and to ask knowledgeable non-users, "Why did you decide not to use this and what do you use instead?". Furthermore, a body of literature exists to orient a researcher in obtaining accurate information from respondents of a survey. (See Lansing and Morgan, 1971, p. 129; Raj, 1972, Chapter 10; Yang, 1965, p. 15; Kearl, 1976, Chapters IV and IX; and others.)

2.5.4 Methodological Issues in Data Collection

This section is concerned with methodological issues in data collection for farmer assessment. The issues to be raised are the questionable necessity of using a "farmer's test," methods of stratifying the population into "use classes," and choice of survey method.

A "farmer's test" is production conducted by the farmer using the new technology. The farmer incurs all expenses and faces the corresponding risks alone, but receives free technical help from researchers. Follow-up surveys determine adoption rates and specific reasons for adoption or non-adoption. Farmers' tests are strongly advocated by Hildebrand (1976). This approach is rigorous but relatively rigid and time-consuming. The farmer's test may be unnecessary when (1) the new inputs or practices are already known, but not necessarily practiced (farmers may be "ex-users" who have taken a negative risk action), (2) the new input or practice is simple and its implications readily understood by farmers (farmers become "non-users" by reaching the subjective risk knowledge situation without using the practice), and (3) the change is only one of application level of an input already used. In these three situations, farm surveys may be used in place of farmer trials.

One of the proposed steps in farmer assessment is the stratification of the target population by "use-class," i.e., users, non-users, and ex-users of each input or practice. Pre-stratification of the target population by use-class, for a random survey, is usually impractical. How, for example, does one go about constructing a separate sampling frame for ex-users of insecticides? Post-stratification is easier. Simple screening questions such as, "Have you ever used fertilizer on maize?" and "Did you fertilize your maize this cycle?" can be used to stratify respondents in the field. A separate section in the questionnaire is applied to each stratum. Post-stratification may lead to under-representation of certain use-classes, however. This may be handled by increasing sample size or by conducting a separate, purposive survey of the stratum that was under-represented.

One of the issues in choice of survey method is whether a single-visit or a multiple-visit approach should be employed. When "farmer tests" are <u>not</u> conducted but, rather, dependence is placed on a general farm survey, the single-visit approach should be sufficient. Flow variables (e.g., labor use, family consumption, and family income from various sources) are usually of minor importance. Stress is placed on use history ("How did you employ the technology?"), opinions ("What were the advantages and disadvantages you found?"), and prescriptions ("Is it right to use the technology, or to avoid its use?"). However, when the "farmer trial" <u>is</u> employed, time-dated variables may increase in importance. This is because it is useful to constantly monitor the farmer's experience with new technology as it happens. In this case, frequent visits to respondents (or the use of farm records) will be helpful, though expensive, in obtaining this information. The advantages and disadvantages of frequent visit surveys are more exhaustively discussed in Kearl (1976).

Another issue in the choice of survey method is whether random or purposive surveys should be used. In general, random surveys are preferable because they allow the testing of hypotheses concerning the target population. For example, the hypothesis that "75 percent of target farmers consider earliness in maize as advantageous" is testable by means of a random farm survey. There may be occasions, however, in which insufficient numbers of a stratum of interest are found in a post-stratified sample, e.g., "ex-users of fertilizer." In this case, a purposive survey of "ex-users of fertilizer," in which respondents are chosen through judgemental criteria, is useful in the generation of hypotheses on fertilizer use by all "ex-users" in the population. The statistical testing of the hypotheses so generated, however, may only be conducted with reference to a population of which respondents are representative. As this population more closely reflects the whole target population of interest, the hypothesis testing becomes more relevant to this target population. For example, "ex-users" of fertilizer might agree that the use of fertilizer is not advisable because of late deliveries. If the selected "ex-users" closely reflect the whole target population of "ex-users," this conclusion may be accepted without further testing. Otherwise, independently obtained information should be obtained, e.g., through a random check of fertilizer suppliers. As another example, "ex-users of insecticides" may be a group of interest that is rare in the target population, hence few members of this group are represented in a random survey. To gain hypotheses on why it may be profitable or otherwise useful to drop insecticide use, members of this group could be sought through informal contacts and interviewed.

It may be that they have changed varieties or have begun using herbicides. In either case, the corresponding hypotheses may then be tested by agronomists, which may lead to improved recommendations.

A final issue in survey methods is whether surveys should be formal or informal. A formal survey is one in which a written questionnaire and trained enumerators are employed. An informal survey is one in which the researchers themselves talk with farmers and observe their fields. Examples of informal surveys are the "sondeo" used by ICTA, as reported in Hildebrand (1979), or the "exploratory survey" advocated by the CIMMYT Economics Group in Byerlee, et al. (forthcoming). The advantages of informal surveys are clear: they may be conducted and finished quickly and they place the researcher in direct contact with the farmer. Their disadvantages are equally clear. It is difficult to use them for hypothesis testing in a formal, statistical, sense and quantification of variables of interest will likely appear less convincing to second parties than that obtained through formal surveys.

The following chapter on data collection for the study area illustrates many of the topics discussed above: a purposive survey was used when post-stratification of a random survey led to the identification of few fertilizer users. Farmer trials were found necessary for the assessment of chemical weed control recommendations. An informal survey was used to improve the focus of subsequent formal surveys.

CHAPTER 3

DATA COLLECTION FOR FARMER ASSESSMENT IN THE STUDY AREA--SURVEYS AND FARMER TRIALS

Farmer assessment of new technology, as defined in Chapter 2, is a step in the general procedures advocated by CIMMYT for developing agricultural technologies usable by farmers. Coming after preliminary agronomic research but before widespread extension, its purpose is to convey information from knowledgeable farmers to researchers on how farmers are using a new technology, the advantages and disadvantages it displays, and the wisdom of employing it under various conditions. Specific procedures for farmer assessment were advocated in Chapter 2. These include: (1) specify clearly the technology to be assessed and identify substitutes and complements, (2) stratify farmers by "use class" for each input or practice, (3) conduct surveys and/or farmer trials, (4) form and test hypotheses regarding the positive and normative information gained from these surveys and farmer trials, and (5) use confirmed hypotheses to suggest re-direction of agronomic research and of agricultural policy.

The purpose of this chapter is to describe the specific purposes, sampling methods and implementation procedures employed in the several surveys and farmer trials that were used in farmer assessment of a new maize technology in Northern Veracruz, Mexico. This technology is based on agronomic results from CIMMYT on-farm experiments carried out by the Maize Training Program.

The surveys to be described include two random surveys, a purposive survey and farmer trials regarding the practice of herbicide-based zero tillage.

3.1 The Study Area and the Target Population

The surveys and farmer trials whose results are reported herein were conducted in Northern Veracruz, Mexico, in the area where CIMMYT's Maize Training Program carries out its field work. The area surveyed was restricted to the "municipio" (county) of Castillo de Teayo, the municipio of Tihuatlan (west of the Mexico-Tuxpan highway), and the municipio of Alamo Temapache (west of the Mexico-Tuxpan highway and south of the Tuxpan River). Figure 3.1 shows the location of the target area.

Although the geographic area for the survey was defined implicitly by the area in which the Maize Training Program conducts on-farm agronomic experiments (and explicitly as noted above), a further narrowing of the target population on socio-economic grounds was deemed necessary before conducting the survey.[1] Farmers fell into two land-tenure groups: "propietarios" (who own full title to their land) and "ejidatarios" (who are beneficiaries of land reform programs and who have use rights but not exchange rights to their fields). Agricultural land in the area under study is roughly split between these groups. Propietarios enjoy a larger mean farm size but dedicate most of their

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[1] In a real production program, policy makers with help from researchers should set both geographic and socio-economic criteria for target population selection.

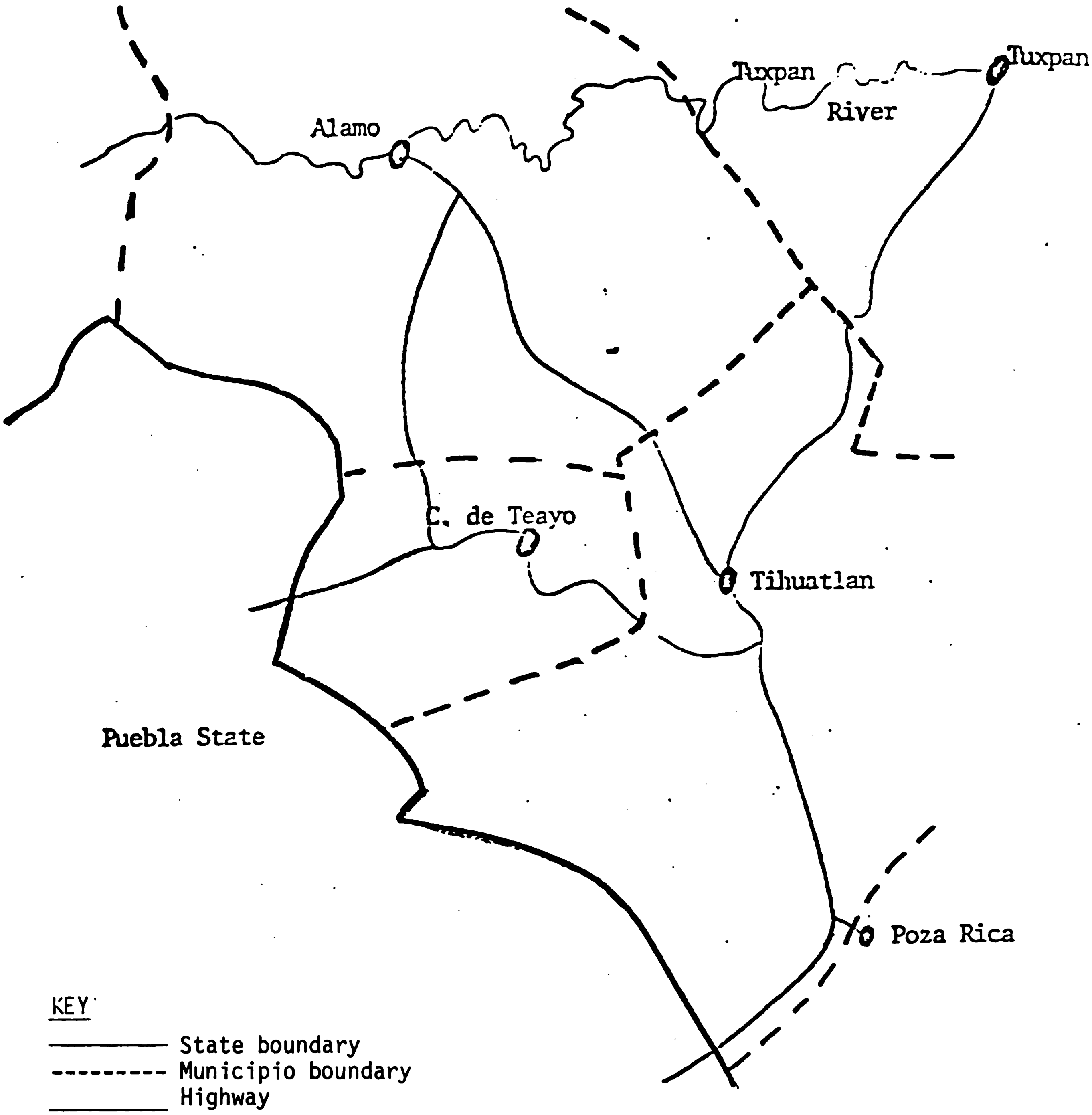

Figure 3-1 The Study Area: Counties of Tihuatlan, Teayo and Alamo-Temapache (west of Poza Rica-Tuxpan Highway and south of Tuxpan River), N. Veracruz

land to pasture or citrus, with very little in maize.[2] Ejidatarios, on the other hand, use a sizable percentage of their land for production of maize and other annual crops; they furthermore are more representative of the "small farmer" class that is usually of interest.

One further restriction on the target population was made: target farmers must cultivate maize. Farmers who only cultivate maize in association with citrus were not included in the target population for obvious reasons. Within relatively few years, the citrus stands will mature and close, leaving no room for maize or any other annual crop. Unlikely as it may seem, this latter restriction was a severe one in many ejidos. A widespread shift to citrus seems to be taking place (or, in other ejidos, has already taken place). One ejido had to be dropped from the sample because almost all farmers who grew maize grew it in association with citrus. Farmer statements to this effect were confirmed by visual inspection.

In the case of those ejidos located in older citrus producing regions (e.g., near Alamo), the deletion of farmers only producing maize in association with citrus led to marked effects on results, e.g., while it is known that farmers here enjoy relatively large farm sizes, farmers included in the target population seem to control relatively small farms.

It should, thus, be kept in mind that reported results are only representative of local target farmers, not all local farmers.

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[2]Informal conversations with local agricultural extension agents, and personal observation, were used in addition to data from the 1970 Ejido Census. See Direccion General de Estadistica (1975).

3.2 The Random Surveys

Two random surveys were conducted in the study area for the purpose, at least partially, of farmer assessment of new technology. The two surveys are called the August 1978 survey and the April 1979 survey, after their dates of field implementation.

The purpose of the August 1978 survey was more to fill a long-standing gap in researchers' knowledge of basic farmer practices and circumstances in the study area than farmer assessment. Among the more general questions on land use, capital stock and cultural practices, however, were specific questions on variety choice and credit terms that are valuable for farmer assessment.

The purpose of the April 1979 survey was primarily that of farmer assessment of recommendations concerning insecticide use, fertilizer use, planting densities and herbicide use. The post-stratified random surveys identified sufficient numbers of non-users, ex-users and users for most inputs and practices. However, they did not identify sufficient numbers of fertilizer users and users of herbicide-based zero tillage. Consequently, a purposive survey was conducted on fertilizer users. The complexity and novelty of herbicide-based zero tillage led to the choice of the farmer trial to assess this practice.

Implementation of the formal, random surveys was preceded by an informal, exploratory survey. The informal survey had specific goals:

(1) Delineate homogenous groups of target farmers, or recommendation domains.[3]

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[3]Byerlee, et al. (forthcoming) define a recommendation domain as a group of farmers within an agro-climatic zone with similar circumstances and for whom we can make more or less the same recommendations.

(2) Identify and define local terms needed to ask intelligent questions of farmers.

(3) Informally understand what farmers are doing and why they are doing it. This enables the formal questionnaire to be well focused.

(4) Delete undesirable questions from the survey.

(5) Facilitate the pre-coding of formal survey questions.

(6) Establish direct communication with local village authorities ("comisariados") to explain the purpose of and the mechanics of the survey and to enlist their support.

(7) Obtain information of a delicate nature. For example, during informal conversations farmers were frank in discussing their credit needs and the failure of the local official bank to meet them. They were not so frank in a formal interview in which they saw their answers being recorded.

The sampling procedure for the August 1978 survey will be discussed first. The exploratory survey showed that clustering by ejido would be a virtual requirement in drawing a random sample.[4] Farmer lists appropriate for sampling frames were organized by ejido. Likewise, it was found that higher response rates would be obtained if the survey were cleared by the appropriate ejido officials. Thus, the decision was made early in the survey planning process to use ejidos as primary sampling units, and farmers within ejidos as secondary sampling units.

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[4]The ejido is the village of ejidatarios, who are beneficiaries of land reform programs and who enjoy use rights but not exchange rights to their fields.

The exploratory survey distinguished three tentative recommendation domains (RDs), using soils as a major criterion. The selected RDs were composed of farmers growing maize on the following: RD1--medium-textured alluvial soils; RD2--flat vertisols, and RD3--sloped vertisols.[5] Ideally, the sample should be pre-stratified by RD but in the case of RD2 and RD3 this was impossible. An attempt was made to pre-stratify RD1 versus RD2 + RD3, however. Following procedures described by Cochran (1963, Chapter 11), the following steps were taken in drawing the sample for the August 1978 survey:

(1) A list of ejidos in the target area was drawn up, using the 1970 Ejido Census (Direccion General de Estadistica, 1975). A total of 110 ejidos were listed. Total number of farmers per ejido was noted from the same source.

(2) This list (and the corresponding estimates of number of farmers per ejido) was corrected and updated by extension personnel. New ejidos were added to the list and ejido size was checked with current records.

(3) Twenty ejidos known by extension personnel to grow little or no maize were deleted from the sampling frame. This, in effect, restricted the target population to ejidos where maize was important.

(4) The remaining 90 ejidos were pre-stratified into two groups--those falling into RD1 (alluvial soils) or those falling into RD2 or RD3 (vertisols). This was performed with the help, again, of extension personnel, with occasional observations in the field used as

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[5]More details on the mechanics and implications of RD selection for the study area will be presented in Chapter 4.

checks. Twelve ejidos (representing 1192 ejidatarios) formed RD1 and 77 ejidos (representing 4071 ejidatarios) formed RDs 2 and 3.[6]

(5) Three ejidos were chosen at random within the RD1 sampling frame. Probability of selection of a given ejido was proportional to the number of ejidatarios it contained. Subsequently, twelve ejidos were chosen by similar means within the combined RD2/RD3 frame.

It may be helpful to go into the reasons for this breakdown. A total sample size of about 130-140 farmers (assuming zero non-response) was desired as this would allow 30-50 respondents per RD. Zero non-response is never attained, however, so the target sample size was increased to 150. It was decided to select ten farmers from each ejido selected; previous studies (e.g., Perrin, 1977) had suggested that seven to eight farmers per ejido should give reasonable levels of precision but, again, over-sampling was performed in expectation of some non-response (and in view of the low marginal cost of additional interviews). Total number of ejidos to be selected, then, was fifteen.

RD1 ejidos represented 14 percent of target ejidos but 22 percent of target farmers (implying that these ejidos are relatively large). Three of the fifteen ejidos (20 percent) to be selected were thus allocated to RD1, with the remaining twelve to RDs 2 and 3. It might have

[6]A RD is defined as a set of farmers with similar circumstances for whom similar recommendations may be made. In this study, however, the <u>ejido</u> was used as the basis for pre-stratification, the implicit assumption being that all farmers within a given ejido faced similar circumstances. Although previous work (e.g., Perrin, 1977) has shown that variability within ejidos is less than between ejidos the implicit assumption is not strictly true. This is a practical demonstration of the difficulties in pre-stratifying by RD.

been wiser to allocate four ejidos, or even five, to RD1. As it turned out, non-response was much higher in RD1 than in the other ejidos, leading to a total RD1 sample size of 21 farmers, an uncomfortably low number.

(6) In order to select the ten farmers within each chosen ejido, a meeting was arranged with ejido authorities. A list of ejido members was requested, from which ten were randomly selected. Before accepting a farmer as one of the ten, however, an effort was made to ascertain that the farmer in question still lived in the ejido, and grew maize (apart from intercropped maize with citrus). In two ejidos, it was not possible to find ten farmers that met the latter condition, thus reducing the target sample size from 150 to 148.

(7) In the end, a sample size of 123 was achieved, with 21, 37, and 65 farmers respectively, from RDs 1, 2 and 3. Stratum weights were .225, .28, and .495 respectively.

To save costs in the April 1979 survey, the RD3 subsample was reduced to a target size of 44 by taking a random sample of previous RD3 respondents. The August 1978 stratum weights were maintained unchanged to calculate overall averages. The target size of the April 1979 survey was 100; in practice, 97 usable questionnaires were obtained.

Translations of the questionnaire used in both random surveys are in the Appendix.

3.3 The Purposive Survey on Fertilizer Use

Insufficient numbers of current fertilizer users were identified in either of the two random surveys. Only four of 123 farmers reported using fertilizer in the August 1978 survey, whereas only seven to 97 farmers were identified as "users" in the April 1979 survey. To obtain more information on the current practices of fertilizer users and to gain insights on their opinions, a purposive survey of fertilizer users was conducted in May 1979.

According to Kearl (1976), a purposive survey is characterized by its method of respondent selection. Instead of random selection from a sampling frame, respondents are selected through judgemental criteria. These respondents may not be representative of a given target population. Information obtained from them may be very useful in generating hypotheses, something which is important in farmer assessment. These hypotheses may also be tested using purposive data. Such testing is only conducted with reference to the population represented by the sample, however. Hypotheses on target population parameters cannot be formally tested with this data. Still, if it is judged that the purposive sample is "sufficiently" representative of the target population, formal hypothesis testing can yield useful information.

Two criteria were used to identify possible fertilizer users, although in neither of the two cases were all farmers meeting a criterion found to be current fertilizer users. First, "ex-collaborators" were interviewed. These were farmers who had at one time collaborated with the CIMMYT Maize Training Program in on-farm agronomic experiments regarding maize production. Seven "ex-collaborators" were interviewed. These were all farmers in the study area who had collaborated with CIMMYT's training program of on-farm experimentation within the last three years. Of the seven "ex-collaborators," only three farmers were current fertilizer users. Two more, however, reported expecting to use fertilizer in the future. Second, selected users of the official bank's program of directed credit were interviewed. This "bank-user" criterion was considered important because, as will be seen, the official bank is the major local source of fertilizer supply. The following procedure was used to identify "bank-users:" the two ejidos using the largest fertilizer volume via the bank were identified through bank records. These ejidos were visited and a list was constructed of "bank-users" for each ejido. A random selection of five farmers per ejido was then drawn. Furthermore, ejido leaders were asked to informally identify fertilizer users who did <u>not</u> obtain their fertilizer through the official bank. Two such farmers were found and interviewed. Of the twelve farmers identified as described above, only five of them were currently using fertilizer on maize. The other seven fell into the "ex-user" category.

In summary, through various means a total of fifteen fertilizer users were interviewed. Seven were interviewed in the random survey and eight in the purposive survey. The purposive survey did uncover additional fertilizer "ex-users," however. Translations of the questionnaires used in the purposive survey of fertilizer users are in the Appendix.

3.4 Farmer Trials of Herbicide-Based Zero Tillage

The only practice completely new to farmers in the study area in the recommendations developed from CIMMYT agronomic data is herbicide-based zero tillage. No farmers were found in the random surveys to use this practice. Furthermore, only one such farmer was found in a purposive search throughout the study area. This farmer was an "ex-collaborator."

Farmer assessment of this practice, then, could be left to neither random nor purposive surveys. Clearly, farmer trials were called for.

Accordingly, a search was made, largely among "ex-collaborators," for farmers willing to try the practice in question. They were to be provided with technical advice, but they themselves were to provide all inputs, including labor and management, and they were to incur the risks. Eight purposively chosen farmers expressed interest in this arrangement but only five of them actually purchased and applied the corresponding inputs.

Data were obtained from these five farmers trying herbicide-based zero tillage (plus three additional farmers who had been sufficiently inspired by the example of their neighbors to try the practice themselves) by means of a follow-up survey, conducted in September, 1979.

Given the purposive nature of respondent selection, and the fact that these farmer trials represent a very initial contact with a complicated practice, no definitive results were expected regarding the consistency of this practice with farmer circumstances. What was expected were hypotheses concerning inconsistencies, initial farmer innovations with this practice that may make it more practical, or initial changes in cropping patterns or labor allocation to make use of resources freed by the new practice.

A translation of the data collection instrument that was used is provided in the Appendix.

3.5 Survey Implementation

Although previous farm surveys in the target area had used extensionists as enumerators, the present surveys changed this precedent.

Enumerators were recruited from the farming population in the area to be surveyed. Selected enumerators were required to meet the following criteria: (a) young (18-24 year old) males; (b) sons of ejidatarios; (c) a minimum of a primary education; (d) ability to write clearly; (e) good knowledge of local farming conditions; (f) appropriate personal characteristics (enthusiasm, energy, responsibility, agreeable and relaxed manner); and (g) the ability to complete a 5-day training course. There was no shortage of candidates although the word was only passed informally. Using the above criteria, four prime candidates and two substitutes were selected. All four primary candidates were found to perform satisfactorily, however, and the substitutes were dropped. Personal characteristics, knowledge of farming conditions, and writing ability were judged by personal interviews, use of references, standardized writing exercises and observation of candidates' behavior toward one another.

Training proceeded through several stages for each survey conducted. Enumerators were first grounded in the purpose of the survey, the role and the character of the sponsoring agency (CIMMYT) and the way in which collected data would be used, and discussion was undertaken on how to gain a respondent's cooperation. They were then given a question-by-question explanation of the questionnaire of the moment, with possible ambiguities pointed out and clarified. Subsequently, they conducted mock interviews with each other, the researcher and the other enumerators criticized each performance. Finally, they were assigned interviews with local farmers, the results of which were carefully scrutinized for errors and inconsistencies. Data from these interviews were not used in subsequent analysis. These mock interviews did provide further opportunities for pretesting the questionnaire, however, and several changes suggested by farmers or enumerators were incorporated even at the final hour.

A common problem in survey implementation is how to handle non-response. Non-response contains two components: The inability to contact a selected farmer and the unwillingness of a respondent to answer parts of the questionnaire.

For the random surveys, the former class of non-response was handled as follows: If a selected farmer was not at home on the day of the interview, the enumerator was required to make at least one re-visit in search of him (on their own initiative they often made up to three re-visits). They were allowed one substitution of farmers per ejido, i.e., only one substitute farmer per ejido was allowed for another who had not been located after the re-visits. If two or more farmers could not be located after the re-visits, then, sample size was reduced in that ejido. A similar procedure prevailed in the case of farmers who were selected but who were found <u>not</u> to grow maize (or who only planted it in association with citrus). Again, only one substitution was allowed; subsequently, sample size was allowed to decline.

Of the 148 questionnaires sent out in the August 1978 survey, a total of 123 usable questionnaires (including substitutions) were obtained. Twelve farmers could not be located and twelve did not grow maize.

The second class of non-response (refusing to answer selected questions) was very rare. Indeed, only one farmer refused to be interviewed. Enumerators were trained, however, to distinguish between three kinds of "non-answers:" (1) the "valid zero response," e.g., the farmer owns zero horses; (2) the "not appropriate" response, e.g., hectares of maize sprayed with insecticide (but the farmer formerly stated that he did not use insecticide); and (3) the "non-response," e.g., the farmer declines to answer or could not be found.

CHAPTER 4

A DESCRIPTION OF THE STUDY AREA

The purpose of the present chapter is to offer a comprehensive description of the study area, with special emphasis on common farmer practices and the agro-physical and socio-economic circumstances within which these practices are carried out. In addition, the three recommendation domains used in the study area will be delineated and described.

4.1 The Physical Environment

The geographical limits to the study area, as described in Chapter 3 and illustrated in Figure 3-1 of that chapter, are as follows: the "municipio" (county) of Castillo de Teayo, the municipio of Tihuatlán (west of the Mexico City-Tuxpan highway), and the municipio of Alamo-Temapache (west of the Mexico City-Tuxpan highway and south of the Tuxpan River). Thus, the study area is located in the northern part of the State of Veracruz, on the average about 50 km from the Gulf of Mexico. Climate maps of the area are available and indicate that the entire study area has a tropical, sub-humid environment. Annual rainfall is in the range of 1200-1500 mm, while mean temperature is in the range of 24°C-26°C (Instituto de Geografía, 1970). The topography is that of gently rolling hills, with occasional small enclaves of flat land. Altitude is about 60 meters above sea level.

Rainfall demonstrates marked seasonal fluctuations, a not uncommon occurrence in the tropics. June to October are considered the "wet" months, though occasional rains may fall any time. Average rainfall by month may be seen in Figure 4-1.

In the 1970 Ejido Census (Dirección General de Estadística, 1975), the combined municipios of Castillo de Teayo, Alamo-Temapache and Tihuatlan were reported to have 133,824 hectares of cropland, the definition of which includes annual cropland, pasture and land in permanent crops. Area in annual crops was 40,337 hectares, of which 23,048 hectares was reported planted to maize during the 1969 B (wet) maize cycle, which begins in June. 21,097 hectares, or 92% of this maize was planted by "ejidatarios."[1]

Soils or topographical maps are not available but agronomists and soil scientists familiar with the area have identified three soil types: (1) a brown, medium-textured alluvial soil found in the wide flood plains of the Tuxpan River, (2) a black, heavy-textured "vertisol" with zero or negligible slope; and (3) the same vertisol on moderate to steep slopes.[2]

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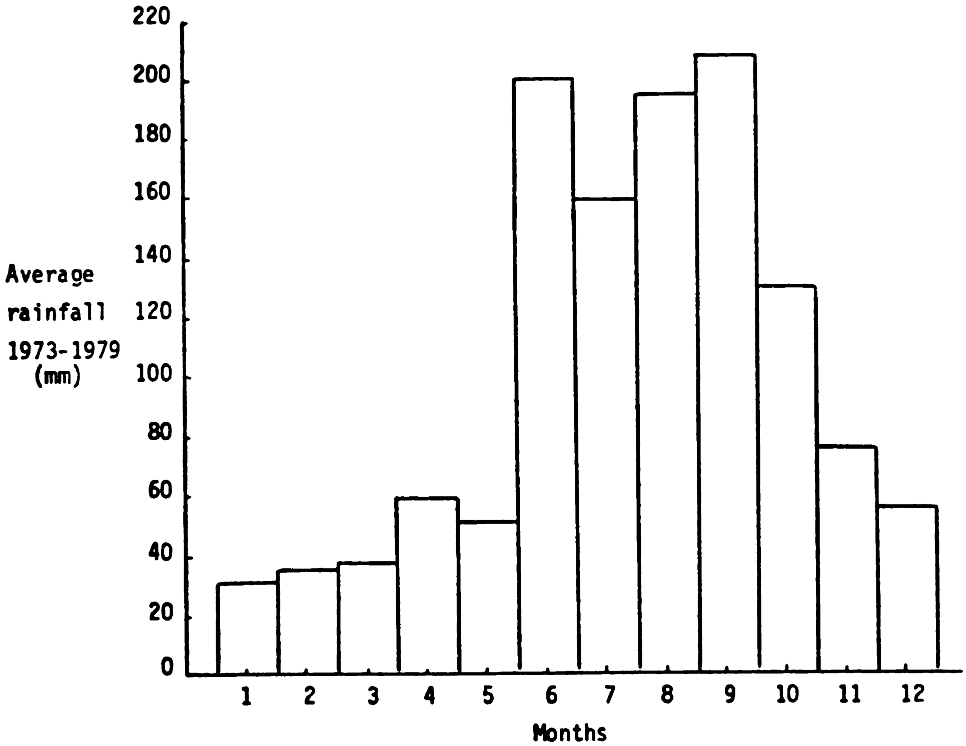
[1]Only parts of the municipios of Alamo-Temapache and Tihuatlan were included in the study area. The area in cropland, annual cropland, and in maize, then, is somewhat smaller for the study area than that reported above. The percent of cropland in annual crops (30%) and the percent of annual cropland in maize (57%), however, is probably similar.

[2]This information was obtained through personal communication with CIMMYT agronomists. A "vertisol" is described by Buckmann and Brady (1969, p. 313) as follows: "This order of mineral soils is characterized by high content of swelling-type clays which in dry seasons cause the soils to develop deep, wide cracks." "Their very fine texture and their marked shrinking and swelling characteristics make them less suitable for crop production than soils in the surrounding areas. They are sticky and plastic when wet and hard when dry. As they dry out following a rain, the period of time when they can be plowed or otherwise tilled is very short."



Source: CIMMYT meteorological records, Poza Rica Experiment Station

Figure 4-1 Average Monthly Rainfall, Poza Rica, Veracruz

Considerable soil testing has been conducted by CIMMYT's Maize Training Program, the results of which indicate that soils tend to contain sufficient P and K, although pH levels tend to be high (7.8 - 8.2).

The physical characteristics of the study area allow two maize cycles per year.

4.2 The Socio-Economic Environment

Socio-economic circumstances faced by farmers include such factors as land tenure, the quality of extension and credit services, physical infrastructure, and product and input markets.

4.2.1 Land Tenure

The question of land tenure in the study area has already been briefly addressed, in Chapter 3. There it was noted that large private-property owners ("propietarios") are excluded from the target population. The farmers of interest are the smaller "ejidatarios," who are beneficiaries of the national land reform program. They enjoy use rights to the parcel of land that is allotted to them, but they are not legally allowed to sell or rent this land. Nonetheless, informal rental arrangements are not unknown. Children of ejidatarios can inherit the ejido land of their parents.[3]

Land tenure seems to affect target farmers in two ways. First, "ejidatarios" are not generally eligible for loans from commercial banks. Sources of credit are the informal credit market (friends, relatives, moneylenders, input suppliers and trucker-merchants) and the official government bank for local "ejidatarios," the "Banco de Crédito Rural

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[3]Exploratory Survey, July 1978.

delGolfo". Second, the "ejidatario" may continue to use his land only with the consent of the "ejido" authorities, the "comisariado." The theoretical ability of the "comisariado" to confiscate a farmer's parcel seems to be employed with great infrequency, however. Consequently, the fear of such confiscation by local farmers seems small; indeed, the widespread cultivation of permanent crops (citrus, bananas, etc.) is an index of the security felt by these farmers, and their willingness to undertake productive investment.[4]

4.2.2 Official Credit and Agricultural Extension

In the study area, the official credit service and the extension service are formally linked. Farmers obtain access to official credit by joining a credit circle in the "ejido." One, elected to the position of "socio delegado," is given the responsibility of handling the paperwork in the bank on behalf of all members. Bank field-workers called "inspectores del campo" visit credit circles to determine credit needs for each participating farmer. Loans are given both in kind (inputs) and in cash (for custom machinery hire, or hired labor). Credit needs for each crop are estimated by multiplying the area chosen by the farmer to be sown to that crop under the loan program by a fixed "per hectare" production cost for the recommended technology.

The role of the extension service seems to be threefold: (1) Advise the bank on the recommended technology for each crop. Typically, this is performed by analyzing the results of on-station experiments carried

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[4]Farmer attitudes concerning possible land confiscation were obtained in the July 1978 exploratory survey. More details on farmer cropping systems will be found in a later section.

out by the national research institute, INIA (Instituto Nacional de Investigación Agrícola). (2) Consult with individual credit-users on technical difficulties encountered in crop production. (3) Obtain data from "ejidos" for statistical-reporting purposes. For example, extensionists are occasionally asked to produce estimates of total production and planted area for the major crops in the "ejidos" to which they are assigned.[5]

Nominal interest charges by the official bank are low. The bank charges 12% simple annual interest, which likely represents a negative real rate of interest given Mexico's chronic problem of inflation. Total cost of credit is somewhat higher, however, when obligatory premiums for crop insurance and service charges are included.[6] An additional component of the cost of credit was identified by farmers in the April 1979 survey: They claimed that inputs purchased on credit from the official bank are more expensive than current market prices. Many also reject the crop insurance program due to what they feel is unjust administration.

The effect on the farmer can then be summarized as follows: The bank does provide a source of agricultural credit and technical assistance to farmers otherwise not eligible for credit. Credit users are obliged to use the production technology determined by the bank. Farmers are, further, obliged to participate in a crop insurance program.

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[5]Personal communication, Head of Extension, Tihuatlan.

[6]Information on the operation of the official bank was obtained from Ing. Sergio Zamorano, Head of Extension in the study area, and from various extensionists and bank field inspectors.

4.2.3 Physical Infrastructure

Regarding physical infrastructure, the study area is remarkably favored. A good network of paved roads and all-weather gravel roads, with necessary bridges, exists. This transport network is a consequence of the activities of the Mexican Petroleum Company (PEMEX), whose current and past wells are scattered throughout the region. This affects farmers, of course, by decreasing the transport cost of purchased inputs and of farmer products.

4.2.4 Maize Marketing

The marketing of maize in the study area seems to be acceptably efficient in the sense of harboring few monopsonistic elements (García, 1978). A large number of trucker-merchants, or "coyotes," compete at the farm gate for farm produce of all kinds: maize, beans, squash, citrus, bananas and other minor crops. They provide an assembly function. This private system is backstopped by a government entity, CONASUPO (Compañía Nacional de Subsistencias Populares). CONASUPO maintains a minimum price of maize for farmers.[7] In practice, however, CONASUPO seems to buy relatively little maize directly from farmers. By controlling the quantity of maize imports, it is able to maintain a market price low enough to please consumers and to enable "coyotes" to out-bid CONASUPO for farmers' maize. (See García, 1978, p. 39.)

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[7] At the time of the study, the minimum price of clean maize, 14% moisture, delivered to the CONASUPO warehouse, was $2.90 M.N. (Mexican Pesos) per kilogram. The MN was exchanging for $22.50 MN = $1.00 US. CONASUPO performs many functions besides intervention in maize markets. Its primary role is to provide subsizided basic consumer goods through its own retail outlets.

The combination of competitive "coyotes" in the private system and increased CONASUPO imports during periods of production decline have lead to farm-gate maize prices that are relatively stable seasonally. Table 4-1 illustrates this.

The effect on farmers is clear: Maize markets are flexible and efficient and are likely to be able to handle large increases in production brought about by the introduction of new maize technology. This would merely entail reduction in maize imports and/or an increase in CONASUPO purchases from farmers, and hence would not likely affect farm-gate prices.

4.2.5 Input Markets

Input markets are divisible into three cases. These are the labor, fertilizer, and the purchased input (e.g., herbicides, insecticides, improved seeds and sprayers) markets.

The labor market was studied in the April 1979 formal survey. Survey results indicate that only 1.5 family members, including the farmer, work full-time on the farm, from a mean family size of 6.5 persons.[8] This scarcity of full-time family labor is not offset by the availability of part-time family labor: Only one farmer in seven could count on at least one part-time worker. There is therefore widespread reliance on hired laborers, especially during the busy months of June-August and December-January: 90% of farmers reported that family labor was insufficient to carry out the required farm chores

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[8]The definition of "family" used here includes the farmer and his nuclear family, including children who live away from home.

Table 4-1

Monthly Price of Maize in Veracruz by Source of Supply for 1977-1978[1]

	1977		1978									
Source of Supply	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg	$/Kg
Producer Selling at Farmgate[2]	2.30	2.30	2.40	2.50	2.65	2.80	2.95	2.80	2.80	2.90	3.00	2.95
Intermediary (Selling to Assembler)[2]	2.50	2.50	2.60	2.70	2.90	3.15	3.30	3.00	3.00	3.15	3.25	3.20
Regional Assembler[3] (FOB Price)	2.65	2.65	2.75	2.90	3.15	3.35	3.50	3.40	3.40	3.60	3.70	3.50

[1]These prices are for maize at 14% moisture, in pesos per kilogram.

[2]Unshelled

[3]Shelled

SOURCES: Conversations with farmers, intermediaries and assemblers in Northern Veracruz, exploratory survey, February 1979.

during these months, and that hired labor was necessary. Almost all (78%) farmers reported that hired laborers come from the same "ejido" as the farmer. This reflects the presence of a group of local inhabitants without access to "ejido" land. There is only a mild market reaction to seasonal demand for hired labor, however, with only a $10 MN seasonal spread over a $50 MN/day annual average. Full-time hired workers are not common, only 5% of farmers reporting such an arrangement. Exploratory survey work indicates that hired labor is generally contracted by the day. Finally, farmers complain of the sheer unavailability of hired labor during peak demand periods.

Farmers in the study area fall into the "employee" category as well as the "employer" category. Twenty-seven percent of farmers reported, in the April 1979 survey, working from time to time as hired agricultural laborers. Seven percent reported earning income as custom machinery operators, while another seven percent reported earning income from such other employments as store owner, "coyote," citrus merchant or livestock merchant. All agreed, however, that such off-farm employment produced less than half of their income and occupied less than half of their time.

The effect on farmers is that, while depending on farm production for most of their income, they must also depend on hired laborers to carry out much of the necessary farm chores. Profitable new technology that saves labor during peak use periods is therefore likely to be attractive to farmers.

Fertilizer production, imports, exports and internal distribution are in the hands of a single company, FERTIMEX. Farmers may only obtain fertilizer at the retail level from authorized distributors of FERTIMEX. In or near the study area, the only distributors of fertilizer are the official banks of Papantla, Poza Rica and Alamo, and the Citrus Growers Association of Alamo (Asociación de Citricultores). The Mexican Tobacco Company (TABAMEX) furnishes fertilizer to tobacco-growers in the study area, a small amount of which seems to be diverted to maize production. Though all sources of fertilizer (with the exception of TABAMEX) claim to sell fertilizer for cash as well as for credit, almost all fertilizer is sold on credit.[9]

The effect on farmers is obvious: Most farmers cultivating maize must go to the official bank if they wish to use fertilizer. If they purchase that fertilizer on credit, they must also cultivate maize according to the technical recommendations dictated to the bank by the extension service, as noted above.

The markets for other purchased inputs used in maize production do not demonstrate this monopolistic structure. Herbicides, insecticides, improved seeds, sprayers, etc., are available at a number of specialized input stores, the "farmacias veterinarias". Some of the more popular inputs (e.g., some insecticides) are available in the ejido itself.

4.3 Recommendation Domains Delineated in the Study Area

A recommendation domain (RD) is a group of farmers with similar agro-climatic and socio-economic circumstances, who use a similar technology and for whom a common technological recommendation may be made.

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[9]Conversations with officials and field inspectors of the official bank in Poza Rica. The credit terms of the Citrus Association are not known.

Three tentative RD's were delineated in the study area. The major criterion used was that of soils: RD1 is composed of farmers growing maize on medium-textured alluvial soils; RD2, on black vertisols of zero or negligible slope; and RD3, on black vertisols of medium to steep slopes. Climatic considerations (altitude, rainfall, temperature) were not used as they are roughly homogeneous over the study area. Likewise, it was considered unnecessary to incorporate land tenure or farm size as criteria because the restrictions of the target population to "ejidatarios" removes the variability the population demonstrates with respect to these variables. Other socio-economic variables such as infrastructure and access to product or input markets were, likewise, roughly similar over the study area. The RD classification based on soils proved useful in that changes in farmer cropping patterns and maize technology correspond well to changes in RD's, as delineated.

One problem arises, however, in that it is possible for one farmer to belong to more than one recommendation domain. The only difference between RD2 and RD3 is that of slope. In the post-stratification of random survey respondents into RD's, there were, fortunately, very few cases in which the proper RD classification was not immediately apparent. In these cases, RD classification was determined by the slope of the bulk of the farmer's land available for annual crops.

4.4 Farmer Practices[10]

4.4.1 Land and Land Use

The farmers in the study area have use-rights to an average of 9.6 hectares of land. This varies by RD, with farmers whose land is located

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[10] All information contained in this section is from either the August 1978 or the April 1979 random survey.

on a river floodplain (RD1) tending to have less land. The distribution of farm size with a breakdown by RD may be seen in Table 4-2.

It does not seem that land holdings are fragmented to any great degree; 82% of the farmers report having only either one or two plots of land. Farmers in RD3 have somewhat more consolidated holdings than those of RD1 or RD2, controlling a mean of 1.6 plots as opposed to 2.2 and 2.1 respectively in RD1 and RD2.

Land use is distinctly different over RD's. (See Table 4-3.) Farmers in RD1 emphasize the cultivation of annual crops, with permanent crops as secondary in importance. In RD2, there is a lesser (but still strong) emphasis on annual crops, with pasture increasing in importance. In RD3, area in both annual and permanent crops declines in favor of pasture. The percent of a farm's area in maize is greater if that farm is located in RD1.

Informal conversations with farmers as well as direct observation of farmers' fields led to the hypothesis that farmers are shifting out of maize production in favor of citrus production and pasture establishment. In fact, average annual crop area per farm was estimated in the April survey at 3.5 hectares. However, the respondents further reported that five years ago they worked an average of 5.9 hectares of annual cropland. In other words, annual cropland currently stands at only 61% of the level at which it stood five years ago. A majority of farmers (58% of respondents) reported having reduced their annual cropland area, while most of the rest (34%) reported no change. A small proportion of respondents (8%) reported an <u>increase</u> in annual crop area due to an increase in farm size during the period in question.

Table 4-2

Size Distribution of Farms by RD[1]

Farm Size	RD1	RD2	RD3	All RD's
	%	%	%	%
< 5 hectares	24	5	20	16
5-9 hectares	62	46	32	42
10-14 hectares	10	24	25	22
15-19 hectares	4	6	11	8
> 19 hectares	0	19	12	14
Avg. Size (hectares)	6.7	11.1	10.0	9.6

[1]Chi-square significant at .07 level for farm size by RD.

SOURCE: August 1978 random survey.

Table 4-3

Land Use by RD

	RD1 (alluvial)		RD2 (flat vertisols)		RD3 (sloped vertisols)		All RD's	
Land Use[1]	Ha[2]	%[3]	Ha[2]	%[3]	Ha[2]	%[3]	Ha[2]	%[3]
Maize[4]	3.1	46	4.6	41	2.9	29	3.4	36
Annual Crops	3.7	55	4.8	43	3.2	32	3.8	40
Permanent Crops	2.2	32	3.5	31	2.7	27	2.8	30
Pasture	.2	3	1.7	15	2.8	28	1.9	19
Forest	0.1	1	0.3	3	0.4	4	0.3	3
Fallow	0.5	7	0.8	7	0.9	9	0.8	8
Total	6.7	100	11.1	100	10.0	100	9.6	100

[1]Permanent crops include citrus, bananas and other perennials. Annual crops include maize, beans, squash and others similar. Annual cropland was <u>not</u> estimated by summing the area of the various annual crops harvested (which depends on the rotation followed) but rather by the farmer's estimate of his "tierra de labor," a generic term for "physical area normally reserved for the planting of annual crops." "Fallow" does <u>not</u> include "tierra de labor" that is temporarily idle.

[2]Averages are per farm, in hectares.

[3]Percentage of total.

[4]One cycle only. (Chi-square for RD by percent of farm used for maize is significant at the .25 level).

SOURCE: August 1978 random survey.

Of those farmers who reduced their annual crop land area, most (55%) replaced it with citrus while a few (12%) established new pasture. Furthermore, 60% of all respondents (not just those who have already replaced some annual crop land) reported plans to reduce area in annual crops in the near future. This expected future reduction amounts to about 1.6 ha. per farm. At some future point in time, then farmers expect to maintain only about 1.9 hectares of land in annual crops.

In response to another question, farmers indicated that 1-2 ha. of maize per cycle, with a mean of 1.7 ha. per cycle, would be sufficient to insure the family food supply, including animal feed. This result, together with the previous one, implies that farmers intend to continue cultivating maize for family needs but will reduce their marketable surplus considerably. This conclusion is directly supported by farmer responses to another question: Only 21% of respondents reported plans to abandon maize cultivation completely despite the fact that 85% of them state that maize production is unprofitable, and 25% of them complain of its riskiness. Almost all farmers (94%) state that the single advantage of maize cultivation lies in the fact that therby the family food supply is assured.

There seems to be only minor variation in this pattern over RD's. In RD1 (alluvial soils), the movement away from maize seems to be relatively slow but this is likely due to the already strong position of citrus in that RD, and to the existence of a profitable maize-tobacco rotation.

4.4.2 Labor Use

Information on peak work periods was gathered in the August survey by asking farmers to list their busiest months. Farmers report the months of May-August as being the months of peak work load. (See Figure 4-2.) This is a period of harvesting one cycle of maize while planting the next. Farmers only reported maize and bean activities although the question was not restricted to those two crops.

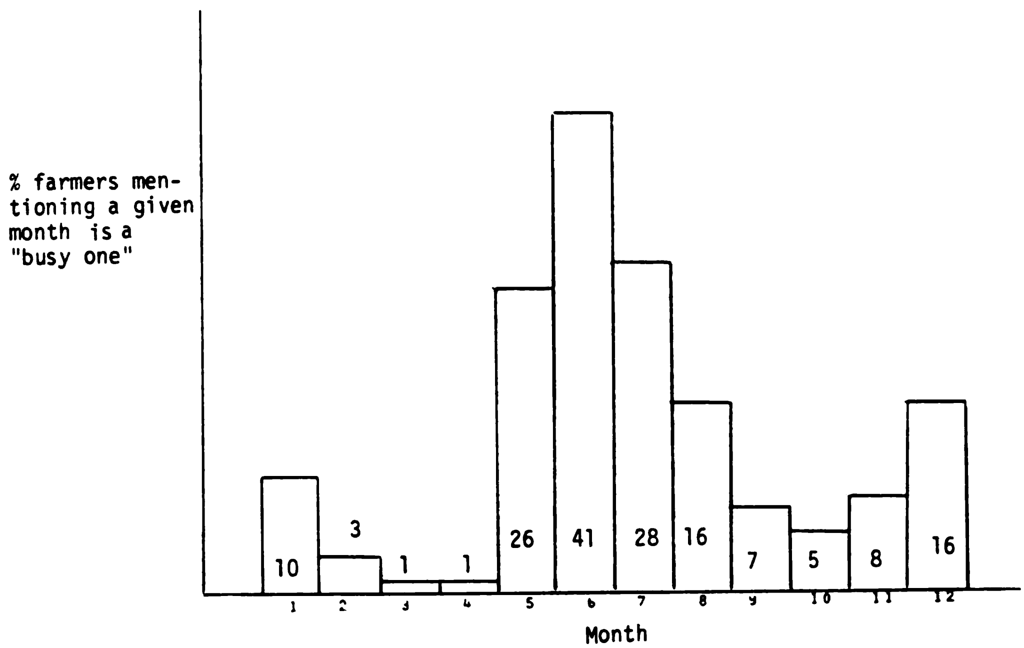
A secondary peak in labor use comes in the December-January period, when farmers are harvesting beans and sowing and weeding dry cycle maize. Labor use in citrus production or livestock activities appears to have fewer seasonal peaks. Information on labor supply and the labor market may be found in Section 4.2.5.

4.4.3 Capital Stock

The formal surveys were not designed to include an exhaustive census of farmer capital. Data were gathered on ownership of capital items deemed important in maize production, i.e., power sources and tillage equipment.

Farmers reported owning an average of about 1.0 horses. However, only about half of these horses were used for such farm work as pulling a plow or a cultivator. Informal conversations with farmers indicate that the other half are used for riding and carrying cargo. Almost all RD1 farmers using horses for farm work own their animal traction equipment, whereas RD3 farmers do not.

For all RD's, about one farmer in ten owns a tractor. For RD1, however, this figure is about one farmer in three. No farmers in RD3



SOURCE: August 1978 random survey

Figure 4-2 Distribution of "Busy Months," All RD's owned a tractor. As well as work on the owner's farm, 65% of owned tractors were used to perform custom work for neighbors. All owned tractors were reported as being in operating condition at the time of the interview. (See Table 4-4.)

4.4.4 The Cropping System

Maize is grown during two distinct seasons in the area under study. There is a "tonalmil" (dry cycle) planting around December and a "temporal" (wet cycle) planting around June. Most farmers (98%) report planting maize in both cycles. An equally high percentage of farmers maintain that they use the same land planted in "temporal" maize for a subsequent planting of "tonalmil" maize, and vice-versa.

Patterns of crop rotation are listed in Table 4-5. The relative importance of each listed pattern, by RD, is given in Table 4-6.

Clearly, the most important pattern is the simple double-cropping of maize. Relay planting of maize, beans, and squash is fairly important in RD's 2 and 3 but much less so in RD1. On the other hand, the maize-tobacco and maize-citrus patterns are more prevalent in RD1. It is interesting to note that the various maize-bean-squash patterns are just variations on a central theme. Informal conversations with farmers suggest that they move from one maize-bean-squash pattern to another fairly easily (and frequently) in response to the influences of both weather and the market.

4.4.5 Maize Cultural Practices

Cultural practices were identified for both cycles. Questions in each survey were restricted to the current cycle. That is, the August 1978 survey investigated maize production in the June-November 1978

Table 4-4

Capital Ownership Patterns, by RD

Capital Item	RD1 (alluvial soils)	RD2 (flat vertisols)	RD3 (sloped vertisols)	All RD's
Average number of items owned:	units	units	units	units
Horses	1.3	0.7	1.0	1.0
Horses used for tillage	1.1	0.2	0.4	0.5
Tractors	0.4	0.1	0.0	0.1
Percent of Farmers owning a given item:	%	%	%	%
Horses	86	49	52	57
Horses used for tillage	76	16	24	30
Tractors	33	11	0	10
Tractors used for custom work[1]	85	50	--	65

[1]Percent of farmers owning tractors who use them for custom work.

SOURCE: August 1978 random survey.

Table 4-5

Annual Crop Rotations

Rotation Number and Symbol	Sequence	Month[1] Planted	Month[1] Harvested
1 (M-M)	Maize Maize	Dec. June	June Oct.
2 (M-M-B)	Maize Maize Beans	Dec. June Sept.	June Oct. Jan.
3 (M-S-M-B)	Maize Squash Maize Beans	Dec. April June Sept.	June July Oct. Jan.
4 (M-S-M-I)	Maize Squash Maize Idle	Dec. April June Oct.	June July Oct. Dec.
5 (M-B-M-B)	Maize Beans Maize Beans	Dec. May June Sept.	June Aug. Oct. Jan.
6 (I-S-M-B)	Idle Squash Maize Beans	Jan. April June Sept.	April Aug. Oct. Jan.
7 (M-T)	Maize Tobacco	June Nov.	Oct. March
8 (M-I)	Maize Idle	Dec. June	June Dec.
9 (M-C)	Maize Maize Citrus	Dec. June Dec.	June Oct. Dec.

[1]Give or take a month.

SOURCE: August 1978 random survey.

Table 4-6

Percent of Farmers Reporting a Given Annual Cropping Pattern, by RD

	Pattern No.	Pattern Symbol	RD1 (alluvial soils) %	RD2 (flat vertisols) %	RD3 (sloped vertisols) %	All RD's %
Patterns with Two Crops of Maize per Field per Year	1	M-M	53	31	37	37
	2	M-M-B	9	33	33	30
	3	M-S-M-B	5	6	7	7
	4	M-S-M-I	5	6	3	4
	5	M-B-M-B	0	3	3	2
	9	M-C	14	6	11	10
	Σ(1 to 5)+9	-	86	85	94	90
Patterns with One Crop of Maize per Field per Year	6	I-S-M-B	0	6	3	3
	7	M-T	10	0	0	2
	8	M-I	4	0	0	0
	Σ(6 to 8)	-	14	6	3	5
	Total	-	100	91	97	95
	Other	-	0	9	3	5

SOURCE: August 1978 random survey.

cycle, whereas the April 1979 survey dealt with the December 1978 - June 1979 cycle. The one exception refers to practices carried out in the June 1978 cycle after the August 1978 survey - these were handled in the April 1979 survey. In both surveys, most farmers had completed the second weeding before being interviewed. Cultural practices of interest included the following: chapeo (slashing or chopping with a machete), burning, hoeing before planting, plowing, first harrowing, second harrowing, furrowing, planting, re-planting, thinning, first weeding, second weeding, third weeding, doubling, harvesting and post-harvest activities. (See Table 4-7.)

In general, there seems to be little change over cycles in the selection of cultural practices by farmers. About 23% of farmers chop, of which about 70% go on to burn the residues. Only about 25% of them plow before planting, with similar estimates for harrowing and furrowing. Almost half of the farmers prepare their land with a hoe. About 40% of farmers reported partially or fully re-planting their stands, but virtually no one reported thinning them. After planting, most weeding was performed with a hoe (79%) but a few farmers reported using horse cultivation (16%) or tractor cultivation (.5%).

Cultural practices vary considerably over RD's. RD1 tillage (on alluvial soils) is highly mechanized, with plowing, harrowing and furrowing being practiced by more than half of the farmers. Land preparation in RD3 (sloped vertisols) is performed, however, completely by hand. There are similar differences over RD's with respect to weeding methods. Finally, RD1 farmers more commonly carry out such activities as hilling-up and doubling.

Table 4-7

Percent of Farmers Using Selected Cultural Practices, by RD and Cycle (NA = Not Available)

Practice	June 1978 (Wet) Cycle				December 1978 (Dry) Cycle			
	RD1 %	RD2 %	RD3 %	All RD's %	RD1 %	RD2 %	RD3 %	All RD's %
Chopping	21	3	32	21	11	13	28	20
Burning	21	3	17	14	11	13	17	15
Hoeing[1] (pre-planting)	16	34	73	49	11	27	72	46
Plowing[1]	64	38	0	25	68	30	0	24
1st Harrowing	58	59	0	30	78	56	0	33
2nd Harrowing	32	14	0	11	42	13	0	13
Furrowing	63	38	0	25	68	30	0	24
Re-planting	45	26	35	34	83	41	48	54
Thinning	0	0	1	0	NA	NA	NA	NA
1st weeding (horse)	NA	NA	NA	NA	53	9	3	16
1st weeding (tractor)	NA	NA	NA	NA	14	6	0	5
1st weeding (hoe)	NA	NA	NA	NA	33	85	97	79
2nd weeding	60	83	80	76	NA	NA	NA	NA
3rd weeding	10	14	17	15	NA	NA	NA	NA
Hilling-up	65	20	5	23	NA	NA	NA	NA
Doubling	75	46	37	48	NA	NA	NA	NA

[1] Chi-square for tillage method (hoeing vs. plowing) by RD is significant at the .01 level.

It is likely, however, that the incidence of cultural practices will be found less interesting than the way in which farmers combine them. Table 4-8 then, presents the organization of tillage practices, by RD and cycle. It may be seen that RD1 farmers who plow prefer a relatively "complete" land preparation system, including plowing, one or two harrowings, and a furrowing. Farmers in RD2 who plow, however, are content to work their land less. They tend to avoid the second harrowing and many do not furrow. Of course, no RD3 farmers plow at all.

There has been some controversy regarding the amount of labor required per hectare to perform various cultural practices. It is possible that part of this controversy is due to the fact that labor requirements depend on field conditions, e.g., a weedy field takes longer to hoe than a relatively clean one. Nonetheless, the mean estimates reported by farmers in Table 4-9 should prove useful in most general analysis where labor requirement parameters are needed. Table 4-9 shows that from 9 to 16 man-days (including the labor of the farmer, his family and hired hands) are required to chop a field with a machete and burn the residues. Similarly, around 12 man-days are needed to prepare a field for planting, by hoe. Of some interest is the result that the second manual weeding uses somewhat less labor than the first one. RD effects do not seem to be important, nor do effects of cycle.

We have seen that not all cultural practices are performed by hand, but that many are performed by horse or tractor. We have also seen that not all farmers own tractors or use their horses for field

Table 4-8

Percent of Farmers Using Selected Sets of Tillage Practices, by RD and Cycle

Set of Practices	June 1978 Cycle				December 1978 Cycle			
	RD1 %	RD2 %	RD3 %	All RD's %	RD1 %	RD2 %	RD3 %	All RD's %
Plow H_1 H_2 F[1]	32	14	0	11	37	10	0	11
Plow H_1 F	26	21	0	12	26	17	0	11
Plow F	5	3	0	2	0	3	0	1
Plow H_1	0	0	0	0	5	6	0	3
Plow H_1 H_2	0	0	0	0	0	3	0	1
H_1 H_2 F	0	0	0	0	5	0	0	1
H_1 only	0	24	0	7	5	20	0	6
Chop Burn	21	3	17	14	11	13	17	15
Chop Only	0	0	10	5	0	0	9	4
Hoe	16	34	68	47	11	27	72	45
Chop Hoe	0	0	10	5	0	0	2	1

[1] H_1 = 1st harrowing H_2 = 2nd harrowing   F = furrowing

Table 4-9

Man-Days of Labor Input per Hectare for Selected Cultural Practices, by Cycle

Practice	June 1978 Cycle	December 1978 Cycle
	Man-days	Man-days
Chop	14.5	8.0
Burn	0.6	0.7
Hoe	12.2	11.5
Plow[a]	NA[b]	0.3
Harrow[a]	NA	0.2
Furrow[a]	NA	NA
Plant	5.3	5.2
Re-plant	1.5	1.7
1st weeding (horse)[a]	NA	2.0
1st weeding tractor[a]	NA	0.4
1st weeding (manual)	11.7	11.0
2nd weeding (manual)	9.1	10.5
Hilling-up	2.0	NA
Doubling	3.4	NA
Harvest	6.7	NA

[a]Labor associated with machinery or animal power use.

[b]Not available.

operations, but rather rely on custom work. In expectation of this occurrence, farmers were asked to report on their use of custom tractor or animal-traction service, with emphasis on price. Results are shown in Table 4-10.

It is interesting to note the relatively large variability of custom hire prices (CV's in the range of 10% - 50%); there doesn't seem to be any "standard price" for plowing and harrowing. This may be due to the different costs of travel to and from farmers' fields; different field conditions (slope, moisture, rockiness, etc.); institutional considerations (some farmers own tractors in association with other farmers, all paying for the tractor by "renting" it when needed - at prices somewhat below those of the market); and timing (farmers demanding service at period of peak demand will likely pay a higher price).

4.4.6 Use of Purchased Inputs on Maize

Farmers in the study area do not make use of many of the purchased inputs available to them. Briefly, most farmers apply insecticides but few use herbicides, fertilizers or improved varieties.

The major open-pollinated improved variety that is commercially available to farmers is the "Tuxpenito" variety. "Tuxpenito" was originally selected by CIMMYT in 1972, but since then it has been maintained and distributed by PRONASE (Promotora Nacional de Semillas), the Mexican seed authority. Tuxpenito was selected for shortness of stature. It also demonstrated earliness of maturity, and marginally improved yields. Only 7% of farmers report planting this variety. Hybrids are also available but,

Table 4-10

Custom Hire Prices for Selected Practices, by Cycle

Practice	June 1978 Wet Cycle				December 1978 Dry Cycle			
	Mean Price	Modal Price	CV[1]	% farmers using	Mean Price	Modal Price	CV[1]	% farmers using
	pesos/ha	pesos/ha	%	%	pesos/ha	pesos/ha	%	%
Tractor plowing	810	800	31	13	650	--	28	13
Tractor harrowing	305	200	50	11	292	300	21	8
Tractor plowing and harrowing	955	--	33	10	880	--	10	11
Horse furrowing	240	--	--	3	215	--	37	6
Horse weeding	250	--	--	5	210	200	32	5

[1]Coefficient of variation

SOURCE: August 1978 random survey.

again, only about 7% of farmers report using them. Around 86% of farmers, then, apparently prefer to plant the local variety, "Criollo."

In contrast, the great majority (80%) of farmers report using insecticides on their maize. The preferred practice is the application of 250 cc/ha of Foley (50% methyl parathion) once or twice. A majority of farmers appear to apply these insecticides with their own hand sprayers.

Only small numbers of farmers apply fertilizers and almost all are in RD1 (alluvial soils). No farmers used herbicides in either cycle surveyed. (See Table 4-11.)

Further detail on farmer use of purchased inputs will be presented in the discussion on farmer assessment of maize recommendations in the study area.

4.4.7 Production, Yield and Use of Maize

Production and harvested area data were obtained for the December 1977 cycle (August 1978 survey) and the June 1978 cycle (April 1979 survey). The disposition of maize was likewise studied for both cycles. On an average harvested area of 3.5 ha, farmers produced somewhat over 4.0 MT of maize, giving an implicit yield of about 1.1 MT/ha. June cycle yields were moderately higher than December cycle yields, reaching 1.35 MT/ha.[11] An average of 63% of total production was sold and 10% stored as feed, leaving some 27% of total production (or 1,100 kg.) stored for human consumption. (See Table 4-12.)

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[11]The December 1977 cycle was troubled by drought whereas the June 1978 cycle was affected by excess moisture and consequent soil waterlogging. Farmers felt that yields in both cycles were below "normal."

Table 4-11

Percent of Farmers Using Selected Purchased Inputs, by RD

Purchased Input	RD1 (alluvial soils)	RD2 (flat vertisols)	RD3 (sloped vertisols)	All RD's
	%	%	%	%
"Tuxpeñito" seed[a]	0	18	3	7
Insecticides[b]	62	86	82	80
Herbicides[b]	0	0	0	0
Hand sprayer[b]	NA	62	63	NA
Fertilizer:				
1978 wet cycle[a]	14	2	0	3
1979 dry cycle[b]	29	2	0	7

[a]August 1978 survey.

[b]April 1979 survey.

Table 4-12

Maize Production and Use Statistics, by RD and Cycle

Variable	December 1977 Cycle				June 1978 Cycle			
	RD1	RD2	RD3	All RD's	RD1	RD2	RD3	All RD's
Harvested Area (ha)	3.3	4.9	2.8	3.5	3.2	4.2	3.5	3.5
Total Production (MT)	4.0	5.7	3.1	4.0	5.3	5.5	4.0	4.7
Yield (MT/ha)	1.2	1.2	1.1	1.1	1.7	1.3	1.2	1.35
% of total production sold	57	63	56	58	68	71	65	67
% of total production stored	43	37	44	42	32	29	35	34
% of total production fed to animals	12	11	9	9	12	11	10	11
Quantity stored for human consumption (MT)	1.2	1.4	1.2	1.3	1.1	1.0	1.0	1.0

4.4.8 Maize Marketing

Almost all farmers in the April 1979 survey (91%) sold a part of their maize harvest, but only 25% reported making two sales and only 9% reported three sales. Furthermore, the second sale was frequently made at the same price as the first sale, leading to an average farm gate price of maize (weighted by volume in case of multiple sales) very close to the average price for the first sale, $2.49 and $2.47 M.N. per kg, respectively.[12] RD1 prices were consistently lower than the overall average.

Almost all farmers (95%) sold their maize to "coyotes" (trucker-merchants) rather than CONASUPO, the official purchasing agency, despite the fact that CONASUPO's "base price" was $2.90/kg. Farmers, in informal conversations gave the following reasons for this behavior.

1) The $2.90/kg is for dry (14% moisture) and clean maize. Farmers rarely sell maize this dry, hence face severe price discounts.

2) Farmers pay transport costs when they sell to CONASUPO, unlike when sold to a "coyote."

3) CONASUPO pays with checks, entailing trips to the bank in the city: The coyote pays in cash, immediately - and at times offers a credit service.

Table 4-13 gives details by RD on maize marketing for the June 1978 cycle.

4.4.9 Maize Storage

Of the 97 farmers interviewed in the April 1979 survey, a sub-sample of 78 was asked to provide information on maize storage. A majority of respondents (79%) stored their maize on the cob, with the

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[12] The "$" sign represents Mexican pesos. One US dollar = 22.5 pesos.

Table 4-13

Maize Marketing Statistics, by RD (June 1978 Cycle)

Variable	RD1	RD2	RD3	All RD's
% farmers selling at least once	96	90	89	91
% farmers selling at least twice	7	44	23	25
% farmers selling at least thrice	NA	NA	NA	9
% farmers selling to "coyotes"	NA	NA	NA	95
% farmers selling to CONASUPO	NA	NA	NA	2
Average price of maize (pesos/Kg)[1]	2.33	2.49	2.58	2.49
Harvest price of maize (pesos/Kg)[2]	2.32	2.47	2.54	2.47

[1]Farm gate price of shelled maize ($/kg), weighted by sales volume in case of multiple sales.

[2]Farm gate price of shelled maize ($/kg), first sale only.

husk intact. However, 20% of the respondents stored their maize on the cob, with the husk removed. Only one respondent reported storing shelled maize.

Farmers noted two serious problems in maize storage: insects and rats. 61% of farmers reported that both pests are common problems, while 36% noted that insects are the only common pests. Excess humidity leading to grain rot was not seen as a storage problem for two obvious reasons -- storage method (on the cob) and preparation of grain for storage (farmers report leaving the grain in the field until it is well "toasted").

In an effort to reduce losses of grain to insects, farmers use various strategies. Many (44%) make a special effort to store only clean (i.e., non-infested) maize while others (41%) applied insecticide. A few (10%) applied lime, at times mixed with insecticide (3% of respondents).

Most farmers typically store maize for 5-6 months. As noted above, however, this storage is not without loss. Almost all respondents (90%) were of the opinion that maize may only be stored for 2-3 months with negligible insect damage (less than 10% grain loss).[13] There was less of a consensus on how long maize could be stored with only moderate insect damage (less than 30% grain loss). Most felt that storage could reach at least four months with damage restricted to this level.

Those farmers using lime applied on the average one kg. for each 125 kg. of grain. A single application was made at the time the maize was placed in storage. Those farmers using insecticides tended to apply

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[13] Those opinions were based on the storage of the local variety without insecticide treatment.

either DDT or methyl parathion. Virtually all farmers using insecticides stored their maize with the husk intact, so the insecticides were applied on the husk rather than directly on the grain itself. Application rates for DDT averaged about 1 kg. of commercial product per 1500 kg. of grain. Like lime, insecticides were applied once, when the maize was placed in storage.

4.5 Farmer Problems in Maize Production

The complete list of problems which typically affect farmers is a lengthy one.[14] Soils and climate, insects and diseases, government rules, institutional constraints and many more are likely to present problems to a given farmer. The identification of farmer problems is not a difficult task. The difficulties begin when one is required to first separate the "important" problems from the "unimportant" ones, and then identify which "important" problems are susceptible to solution (or improvement) by technological change. Several criteria are available to determine the "importance" of a problem in crop production, yield loss and profit loss being the most common. Some work on assigning priorities to problems has been conducted by De Datta *et al* (1978) and Pinstrup-Andersen (1976). At times, of course, it becomes difficult to directly estimate the effect of a problem (e.g., difficulty in obtaining an input) on yields or profit.

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[14] A "problem" is defined by Johnson and Zerby (1973) as an indeterminate situation, present or projected, which is regarded as unsatisfactory and for which a more satisfactory alternative situation is desired.

To complicate matters, different problems, in a different order of importance, will be revealed by different methods of problem identification. A field visit by a trained agronomist will allow him to pin-point yield limiting factors at that point in time (e.g., visible insect damage, disease incidence, obvious nutrient deficiencies, planted density, etc.). Farm interviews will likely yield inferior data on these factors (e.g., farmers may confound plant disease with drought effects) but will probably yield superior data on factors not immediately apparent in the field (e.g., drought incidence, historical patterns of insect attack, seasonal unavailability of labor or other inputs, marketing problems, land tenure problems, etc.). For this reason, both farm survey data and field observation by agronomists were used in problem identification.

Prior to the surveys, researchers hypothesized that five problems were likely to be of importance: Drought, excess soil moisture, insects, disease and lodging. Farmers did not fully agree: They deleted two of the above "problems" and added many others.

Drought was overwhelmingly considered a problem: 83% of farmers reported having lost at least one maize crop in the last five years due to drought.[15] All RD's were about equally affected.

Lodging was also considered an important problem by farmers; it is considered second in importance to drought. 45% of farmers reported at least one crop loss in the last five years due to lodging. Just as drought effects pertain largely to the dry "A" cycle, lodging problems

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[15]A lost harvest was considered to be one with a yield of less than 500 kg/ha.

are considered important mostly in the wet "B" cycle (especially in the month of September). Little difference was, again, noticeable over RD's.

Excess moisture was considered serious in RD1 (alluvial soils) and moderately serious in RD2 (flat vertisols). The former reflects outright flooding of the floodplains while the latter reflects the poorly-drained nature of heavy vertisols. These soils become impossible to work after moderate rains.

Few farmers thought insects and diseases to be serious problems in maize cultivation - the former because they are easily controlled with available insecticides and the latter because farmers seem to perceive low disease incidence. (It also seems, however, that farmers attribute virus disease symptoms to insect attack - a reasonable position given the importance of insect vectors.)

The additional problems noted by farmers will only be listed. Detailed discussion of each may be found elsewhere in the text. The more commonly mentioned problems include: (1) scarcity of hired labor during peak demand periods, (2) low maize prices, attributed to government policy, (3) dissatisfaction with the credit terms for credit from the official bank, and (4) insect attack of maize in storage.

As expected, the production problems identified by agronomists in their visits to farmers' fields were considerably different than those noted above. In all, nine farmers' fields were visited by 18 agronomists.[16]

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[16]The agronomists used were 18 CIMMYT maize production trainees, from various countries. All have professional degrees plus the benefit of CIMMYT training. Two different trainees visited each field. Visits were made once per field, well after flowering.

The fields were not chosen at random; however, all but one belonged to farmers interviewed in one of the two formal surveys and all farmers belonged to RD3. Agronomists were requested to list, in order, the two most important factors limiting yields. The responses were clearly heterogeneous, likely due to differences between the fields inspected. Planted density and weed control were seen as primary limits to yields, with variety and nitrogen in secondary positions. See Table 4-14.

Table 4-14

Distribution of Agronomists' Opinions on Yield Constraints (RD3)

Constraint	Percent of agronomists selecting a given constraint as first or second in importance in explaining yield losses
	%
Most important constraint:	
Plant density	27
Weed control	27
Variety	20
Nitrogen	13
Soil insects	7
Weather	7
Second most important constraint:	
Nitrogen	39
Density	13
Weed control	7
Disease	7
Variety	7
Soil insects	7
"Management"	7
Cost of production	7
Farmer ignorance	7

CHAPTER 5

FERTILIZER IN THE STUDY AREA: RECOMMENDATIONS AND FARMER ASSESSMENT

In this chapter, recommendations regarding maize fertilization practices for farmers in the study area are obtained through analysis of agronomic data. These recommendations are subjected to farmer assessment, leading to suggestions for changes in agricultural research and research on agricultural policy.

First, however, an overview is given of the CIMMYT on-farm agronomic experiments conducted in the study area, previous economic analysis of data from these experiments and analytical methods used in the current study. This background refers to all CIMMYT on-farm experiments in the study area, not just those dealing with fertilizer and serves as background to later chapters on weed control, variety and density, and insect control. For convenience, this material is presented in conjunction with the first practice to be treated and will not be repeated in later chapters.

5.1 The CIMMYT Experiments and Previous Analyses of their Results[1]

CIMMYT's Maize Training Program has conducted on-farm agronomic experiments in the study area since 1973. A wide range of experiments

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[1]Data for this section were obtained from a review of experimental field books and from personal communication with the CIMMYT agronomists in charge of the on-farm experiments in the study area.

has been conducted. Factorial experiments, especially 2^4 factorials, have been used to identify production limiting factors. Results of these experiments were used in the design of further experiments, whose purpose is the determination of economic levels of inputs for overcoming limiting factors. Since the factorials themselves are rarely used directly in making recommendations, they will not be discussed further.

The "levels" experiments, used in formulating recommendations, take many forms. Experiments have been conducted to examine weed control practices, nitrogen and phosphorous doses, variety choice, planted density, and insect control practices. Most experiments also attempt to measure some interactions between practices, e.g., nitrogen and density.

Although details on the objectives and treatments associated with each experiment will be deferred to later sections, it is useful to comment on some of the common characteristics of these experiments. First, they make use of relatively small plots. Individual plots in the nitrogen by phosphorous experiment are composed of 6 rows, each one five meters in length; plot size is 24 m^2. Second, these are all replicated experiments using standard experimental designs to increase precision: Randomized complete blocks, split-plots and complete factorials are the most common designs. Third, the experiments are planted, cared for and harvested by trainees in production agronomy who are "learning by doing." Mistakes in experimental procedures are minimized, however, by the close supervision these trainees receive at the hands of the CIMMYT agronomists. Nonetheless, it should not be forgotten that the primary purpose for conducting these experiments is that of training LDC agronomists in procedures for on-farm experimentation. Finally, an effort was made to place trials on "representative" fields of "representative" farmers, for each RD. Little data were gathered, however, on the characteristics of the fields (e.g., past management) or of the farmers, their owners. Thus, the universe to which experimental results may be extrapolated is not as clearly defined as would be desirable.

Most economic analysis of the experimental data available in the study area has only been conducted on an experiment-by-experiment basis. A pooled economic analysis, however, was conducted by Perrin (1976). In this study, yields from common treatments were averaged across years and across sites, within each of the two maize cycles. Partial budgeting was employed to calculate rates of return to increased expenditure. Simultaneously, the lower tail of the distribution of net benefits was examined to compare the riskiness of alternative treatments.

Perrin concluded that "the data from these trials indicate that the returns to fertilizer, to insecticides, and to improved varieties ... are sufficient to warrant their recommendation to farmers. The fertilizer response data clearly indicate that fertilizer recommendations should be ... about 50 kg of N per hectare in winter, and perhaps slightly more in the summer." (Perrin, 1976, p. 30).

Currently, however, many more data (from more kinds of experiments) are available than were available to Perrin. A re-analysis of the available agronomic data was therefore performed.

5.2 Procedures for the Economic Analysis of Agronomic Data

Several analytical methods are available to formulate recommendations for farmers from agronomic data. Barlow et al (1978) advocate the use of "whole farm analysis" based on linear programming, especially where considerable changes in the "within-farm utilization" of land, capital and labor may result from a change in technology. However, if changes in the cropping system (i.e., within-farm utilization of resources) are relatively unimportant, they feel that costs and returns analysis or other forms of partial budgeting are sufficient.

In the case of fertilizer, recommendations are frequently formulated by the application of production function analysis to experimental data. Many methodological works on this subject are available, including Baum et al (1956), Heady and Dillon (1961) and Dillon (1968). Normally, optimal fertilizer application rates are estimated by equating the marginal product of an element, as determined by differentiation of a fitted production function, with the ratio of prices of that element and the product in question. A recent study by Byerlee and Harrington (1980), however, shows that the optimal level of fertilizer obtained in this fashion is sensitive to the assumptions made on prices and costs. When realistic assumptions were made, production function analysis of experimental data gave similar results as those obtained through partial budgeting.

In the present study, partial budgeting is used to formulate recommendations from experimental data. (In the case of fertilizer, both partial budgeting and production function analysis are used). Budgeting results are then modified judgmentally in view of risk or changes in the flow of cash or labor demand.

The specific budgeting procedures used in this study are taken from Perrin, Winkelmann, Moscardi and Anderson (1976) and are as follows:

(1) Identify common treatments, or treatments applied in more than one experiment. Where sufficient observations on common treatments are available, group them by RD and/or by cycle (referring to the two maize cycles in the study area). For example, common nitrogen and phosphorous treatments have been applied in N by P trials for 27 experiments.

(2) Calculate the average yield for each common treatment, grouped by RD and/or cycle as noted above.

(3) Yields are adjusted downwards 20% to approximate the difference between experimental and farmer yields due to management factors; it also adjusts for normal field losses to insects and other pests between the time when researchers harvest (25-30% moisture) and when farmers harvest (18-20% moisture). (See Galt, 1977, for precise estimates of these losses.)

(4) This adjusted yield is multiplied by a field price for maize ("farm gate" market price less harvest cost, shelling cost and transport cost from the field to the "farm gate") to obtain a gross benefit for each treatment.

(5) From this gross benefit, those "costs that vary" within the experiment are subtracted to obtain a net benefit.

(6) "Dominated" treatments are eliminated from further consideration. A treatment is considered dominated if simultaneously its net benefit is lower and its "costs that vary" are higher than those corresponding to another treatment.

(7) Marginal rates of return to increased expenditure (MRR) are calculated for undominated treatments, as follows:

$$MRR = \frac{NB_2 - NB_1}{VC_2 - VC_1} \times 100$$

where NB_2 = net benefits for treatment 2

NB_1 = net benefits for treatment 1

VC_2 = costs that vary in treatment 2

VC_1 = costs that vary in treatment 1

and where treatments 1 and 2 are two alternative treatments in an experiment, treatment 1 associated with a lower level of net benefits and costs.

(8) A decision rule is used to tentatively select a treatment. The usual rule is to increase expenditure by going from less expensive to more expensive treatments, until the MRR has been reduced to a level just greater than the opportunity cost of capital to farmers. For the study area, the opportunity cost of capital is assumed to be in the range of 40-50% per cycle, reflecting a shortage of capital.

(9) Analysis of the relative riskiness of treatments may be made for experiments whose treatments involve considerable expense. Assuming that farmers are more interested in the lower tail of the distribution of net benefits, and not just the variance of net benefits, the net benefits in the lower part (usually the lower 20-25%) of the net benefit distribution are averaged for each treatment. If a profitable treatment demonstrates such an average inferior to those of other treatments, a subjective adjustment may be made in the recommendation.

While the procedures outlined above were used in the economic analysis of agronomic data in the study area, an alternative method was also employed, for comparative purposes, in the specific case of the N by P experiments. In this case, a quadratic response function was fitted to the data, first derivatives were taken and marginal conditions were employed to identify optimum levels of N and P.

5.3 Analysis of Fertilizer Response Data for the Study Area

Two kinds of fertilizer experiments were conducted over a 1973-1979 time frame: Levels of nitrogen by levels of phosphorous and levels of nitrogen by planted density.

5.3.1 Nitrogen by Phosphorous Experiments

A total of 27 nitrogen by phosphorous experiments were used in the analysis of fertilizer levels. This number of experiments allowed the disaggregation of data by RD, and in the case of RD2, by cycle. This disaggregation is especially desirable because RD by fertilizer interactions may be expected in light of the soils criterion for RD delineation. The "tonalmil" or December-June cycle will be referred to as the "A" cycle while the "temporal" or June-October cycle will be referred to as the "B" cycle. The common treatments are all combinations of the following levels of N and P: N = 0, 50, 100 or 150; P = 0 or 40 kg/ha. In these experiments, an "improved" variety (usually "Tuxpeñito") was used at a density of 50,000 plants/hectare, with chemical weed control. The field price of maize was estimated at $2.18/kg of shelled maize. This was obtained by subtracting transport cost ($.10/kg), shelling cost ($.10/kg) and harvest cost ($.27/kg) from the average farm-gate price of $2.65/kg.[2] Planting was estimated to require six man-days per hectare and fertilization an additional two man-days per hectare. In view of the active nature of the labor market, the opportunity cost of family labor was considered equivalent to the market wage of $50/day. Both urea (46% N) and triple-super phosphate (46% P) are available to farmers at $3.5/kg. Adding $.20/kg transport cost from store to field, and dividing by percent nutrient content, we find that both N and P cost $8.04/kg, in the field.

In RD1 (alluvial soils), the results of four experiments are available (see Table 5-1). There appears to be a substantial N and P response; the recommendation is to apply 50 kg/ha N and 40 kg/ha P. (In a paired comparison "t" test between yields associated with the N = 50,

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[2]The "$" sign refers to Mexican pesos.

Table 5-1

Economic Analysis of Four Nitrogen by Phosphorous Experiments, RD1, Combined Cycles

Variable	N0[1] P0	N0 P40	N50 P0	N50 P40	N100 P0	N100 P40	N150 P0	N150 P40
Average Yield (MT/ha)[2]	3.8	3.9	3.8	4.8	4.5	5.0	3.9	5.0
	(.55)	(.63)	(.36)	(.76)	(.28)	(.68)	(.68)	(.70)
Adjusted Yield[3] (MT/ha)	3.0	3.1	3.0	3.8	3.6	4.0	3.1	4.0
Gross benefits[4] (pesos/ha)	6627	6802	6627	8371	7848	8720	6802	8720
Labor (man days/ha)	6	8	8	8	8	8	8	8
Labor value[5] (pesos/ha)	300	400	400	400	400	400	400	400
N cost[6] (pesos/ha)	0	321.6	0	321.6	0	321.6	0	321.6
Costs that vary (pesos/ha)	300	721.6	802	1123.6	1204	1525.6	1606	1927.6
Net Benefits (pesos/ha)	6327	6080	5825	7247	6644	7194	5196	6792
	x	MRR = 112% →						

[1]The number accompanying the symbol of each element refers to application rates in kg/ha.

[2]Number in parentheses are standard errors.

[3]Reduced 20%.

[4]Field price of maize = \$2.65/kg - .10 (transport) - .10 (shelling) - .27 (harvest) = \$2.18/kg.

[5]Wage = \$50/day.

[6]Urea costs \$3.5/kg + .20 (transport) or \$3.7/kg; therefore N costs \$8.04/kg.

[7]TSP = \$3.5/kg + .20 (transport) or \$3.7/kg; therefore P = \$8.04/kg.

Table 5-2

Lowest Net Benefits in N by P Experiments, RD1
Combined Cycles

Net Benefit	N0 P0	N50 P40
Lowest Net Benefit	3519	3881
Second Lowest Net Benefit	6153	7073
Average of Lowest and Second Lowest	4836	5477

P = 40 treatment and the N = 0, P = 0 treatment, yields were found to differ significantly at the .10 level (t = 2.49).) This recommendation does not appear, through the limited evidence at hand, to be riskier than the non-use of fertilizer. The lower tail of the net benefit distribution for N = 50 and P = 40 appears to be higher than the corresponding part for the N = 0, P = 0 distribution. (See Table 5-2.)

Lower tail for Risk Analysis

(2) In RD2 flat vertisols, for each maize cycle, the application of 50 kg/ha of nitrogen without any phosphorous is best. In paired comparison "t" tests between yields associated with the N = 50, P = 0 treatment and the N = 0, P = 0 treatment, calculated "t" values equaled 2.76 for Cycle B and 1.95 for Cycle A, indicating differences significant at the .05 and .10 levels respectively. Again, these recommendations do not appear to be riskier than the non-application of fertilizer, given the limited evidence. See Tables 5-3 to 5-6.

(3) Finally, four N by P experiments performed in RD3 were analyzed. Results indicate that the proper rate of fertilization is N = 0, P = 40 kg/ha. No response to N may be seen. (Yields associated with the N = 0, P = 40 treatment were significantly different from those associated with the N = 0, P = 0 treatment, at the .05 level (t = 3.21).) It is possible that this surprising result will change (soil tests?) with the accumulation of more evidence over more years.[3] Again, the recommendation does not appear riskier than non-fertilization. See Tables 5-7 and 5-8.

(4) To go beyond partial budget analysis, a quadratic response function was fit to the fertilizer data for RD2 (flat vertisols). Separate

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[3]The surprise lies not in the P response but in the lack of response to N.

Table 5-3

Economic Analysis of Ten Nitrogen by Phosphorous Experiments, RD2, Cycle A (December-June)

Variable	N0[1] P0	N0 P40	N50 P0	N50 P40	N100 P0	N100 P40	N150 P0	N150 P40
Yield (MT/ha)[2]	3.18 (.25)	3.42 (.27)	3.62 (.22)	3.81 (.29)	3.71 (.27)	3.54 (.24)	3.55 (.26)	3.57 (.29)
Adjusted yield[3] (MT/ha)	2.5	2.7	2.9	3.0	3.0	2.8	2.8	2.9
Gross Benefits[4] (pesos/ha)	5544	5964	6313	6644	6470	6174	6191	6226
Labor (man-days/ha)	6	8	8	8	8	8	8	8
Labor value[5] (pesos/ha)	300	400	400	400	400	400	400	400
N cost[6] (pesos/ha)	0	0	402	402	804	804	1206	1206
P cost[7] (pesos/ha)	0	321.6	0	321.6	0	321.6	0	321.6
Varying costs (pesos/ha)	300	721.6	802	1123.6	1204	1525.6	1606	1927.6
Net Benefits (pesos/ha)	5244	5242	5511	5521	5266	4648	4585	4298
	x MRR = 53% →		x MRR = 3% →					

[1] The number accompanying the symbol of each nutrient refers to application rate in kg/ha.

[2] Numbers in parentheses are standard errors.

[3] Reduced 20%, MT/ha.

[4] Field price of maize = \$2.65/kg - .10 (transport) - .10 (shelling) - .27 (harvest) = \$2.18/kg.

[5] Wage = \$50/day.

[6] Urea costs \$3.5/kg + .20 (transport) or \$3.7/kg; therefore N costs \$8.04/kg.

[7] TSP = \$3.5/kg + .20 (transport) or \$3.7/kg; therefore P = \$8.04/kg.

Table 5-4

Lower 20% of Distribution of Net Benefits in N by P Experiments, RD2, Cycle A

Net Benefits	N0 P0	N50 P0
Lowest Net Benefit	3013	4081
Second Lowest Net Benefit	3885	4255
Average of Lowest and Second Lowest	3449	4168

Table 5-5

Economic Analysis of Nine Nitrogen by Phosphorous Experiments, RD2, Cycle B (June-October)

Variable	N0[1] P0	N0 P40	N50 P0	N50 P40	N100 P0	N100 P40	N150 P0	N150 P40
Yield (MT/ha)[2]	2.93	2.74	3.48	3.24	3.64	3.81	3.57	3.72
	(.35)	(.33)	(.27)	(.32)	(.28)	(.32)	(.39)	(.34)
Adjusted Yield[3] (MT/ha)	2.3	2.2	2.8	2.6	2.9	3.0	2.9	3.0
Gross Benefit[4] (pesos/ha)	5110	4778	6069	5651	6345	6645	6226	6487
Labor (man-days/ha)	6	8	8	8	8	8	8	8
Labor value[5] (pesos/ha)	300	400	400	400	400	400	400	400
N cost[6] (pesos/ha)	0	0	402	402	804	804	1206	1206
P cost[7] (pesos/ha)	0	321.6	0	321.6	0	321.6	0	321.6
Varying costs (pesos/ha)	300	721.6	802	1123.6	1204	1525.6	1606	1927.6
Net Benefits (pesos/ha)	4810	4056	5267	4527	5115	5119	4620	4560
	x $\xrightarrow{\text{MRR = 91\%}}$							

[1]The number accompanying the symbol of each nutrient refers to application rates in kg/ha.

[2]Numbers in parentheses are standard errors.

[3]Reduced 20%, MT/ha

[4]Field price of maize = \$2.65/kg - .10 (transport) - .10 (shelling) - .27 (harvest) = \$2.18/kg.

[5]Wage = \$50/day.

[6]Urea costs \$3.5/kg + .20 (transport) or \$3.27/kg; therefore N costs \$8.04/kg.

[7]TSP = \$3.5/kg + .20 (transport) or \$3.7/kg; therefore P_2O_5 = \$8.04/kg.

Table 5-6

Lower 22% of Distribution of Net Benefits in N by P Experiment, RD2, Cycle B

Net Benefits	N0 P0	N50 P0
Lowest Net Benefit	2124	2093
Second Lowest Net Benefit	2316	4918
Average of Lowest and Second Lowest	2220	3505

Table 5-7

Economic Analysis of Four Nitrogen by Phosphorous Experiments, RD3, Combined Cycles

Variable	N0[1] P0	N0 P40	N50 P0	N50 P40	N100 P0	N100 P40	N150 P0	N150 P40
Yield (MT/ha)[2]	2.84 (.63)	3.24 (.74)	2.78 (.73)	3.33 (.78)	2.96 (.60)	3.53 (.65)	3.25 (.87)	3.71 (.58)
Adjusted yield[3] (MT/ha)	2.3	2.6	2.2	2.7	2.4	2.8	2.6	3.0
Gross Benefit[4] (pesos/ha)	4953	5651	4848	5807	5162	6156	5668	6470
Labor (man-days/ha)	6	8	8	8	8	8	8	8
Labor value[5] (pesos/ha)	300	400	400	400	400	400	400	400
N cost[6] (pesos/ha)	0	0	402	402	804	804	1206	1206
P cost[7] (pesos/ha)	0	321.6	0	321.6	0	321.6	0	321.6
Varying cost (pesos/ha)	300	721.6	802	1123.6	1204	1525.6	1606	1927.6
Net Benefits (pesos/ha)	4652	4928	4046	4683	3958	4630	4062	4542
	x	$\xrightarrow{\text{MRR} = 65\%}$						

[1]The number accompanying the symbol of each nutrient refers to the application rate in kg/ha.

[2]Numbers in pa entheses are standard errors.

[3]Reduced 20%, MT/ha.

[4]Field price of maize = \$2.65/kg - .10 (transport) - .10 (shelling) - .27 (harvest) = \$2.18/kg.

[5]Wage = \$50/day.

[6]Urea costs \$3.5/kg + .20 (transport) or \$3.7/kg; therefore N costs \$8.04/kg.

[7]TSP = \$3.5/kg + .20 (transport) or \$3.7/kg; therefore P = \$8.04/kg.

Table 5-8

Lower 50% of Distribution of Net Benefits in N by P Experiments, RD3, Combined Cycles

Net Benefits	NO PO	NO P40
Lowest Net Benefit	1967	1894
Second Lowest Net Benefit	3850	3917
Average of Lowest and Second Lowest	2908	2905

equations were fitted for the two maize cycles, cycle A (dry) and cycle B (wet). The equation used was of the form:

$$Y = b_0 + b_1N + b_2N^2 + b_3P + b_4P^2 + b_5NP + u$$

where Y = adjusted yield in kg/ha

N = kg/ha of nitrogen

P = kg/ha of phosphorous

b_i = parameters, i from 0 to 5

u = disturbance term

For data from the main maize cycle (cycle B), the fitted equation was:

$$\begin{array}{llllllll} Y = & 2394.11 & + 8.97\ N & - .03\ N^2 & - 3.23P & - .004\ P^2 & + .02\ NP \\ & (11.56) & (1.9) & (-1.06) & (-0.39) & (-0.04) & (0.52) \end{array}$$

where numbers in parentheses are "t" values.

In the equation, the signs of the N, N^2 and NP terms are as expected. An apparently total lack of P response, however, leads to an unexpected negative sign in the P term, which is, however, insignificant. The proper P dose is therefore considered to be zero.

The low R^2 of .15 causes some concern although the overall F ratio is 3.87 (significant at the .01 level) and the parameter for N is significant at the .05 level. Is the apparent response to N only due to random variation? It is hypothesized that the low R^2 is due to parallel changes in yields over experiments and over years, within

RD's. That is, yield response due to treatments are similar for experiments within an RD, though absolute yields may vary.[4]

This hypothesis was tested by means of a pooled analysis of variance. Yield data for all RD2, cycle B experiments were pooled and the ANOVA was conducted using N, P and Experiment as explanatory factors. N and Experiment were found to significantly affect yields at the .01 level, but P was not even significant at the .50 level. However, yield changes do not appear to shift in a parallel fashion as hypothesized, as the N by Experiment interaction term was also significant at the .01 level.

Further evidence on the existence of a response to N is found in the statistical analysis of individual RD2, cycle B experiments. Of nine such experiments, a significant response to N at the .10 level was found in five of them.

The available evidence indicates that, with reasonable confidence, a response to N does exist in RD2, cycle B.

The marginal product of nitrogen for RD2 (wet or "B" cycle) is:

$$MP_N = 8.97 - 0.06N + .02\ P$$

but P is assumed to be set at zero so this reduces to:

$$MP_N = 8.97 - .06N.$$

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[4]An alternative explanation for the low R^2 is suggested by the work of Hoffnar and Johnson (1966). They found that the R^2 of response functions increased with increases in plot size from 1/100 acre to 1 acre. Plot size for the experiments under discussion is 24 m^2 or about 1/170 acre. The Hoffnar-Johnson hypothesis could not be tested with the current data due to lack of variation in plot size.

Using the field prices for N and maize, as noted above, of \$8.04/kg and \$2.18/kg respectively, the profit-maximizing condition of:

$$MP_N = \frac{P_N}{P_Y}$$

is operationalized as:

$$8.97 - .06N = \frac{8.04}{2.18} \qquad \text{or} \qquad N = \frac{\frac{8.04}{2.18} - 8.97}{-.06}$$

Thus, one finds that the optimal level of N is 88 kg/ha. This is somewhat higher than the 50 kg/ha recommendation arrived at through budgeting procedures. However, extra costs associated with fertilizer use were not included. These costs include increased labor cost for application of fertilizer (estimated as 2 man-days per 100 kg of fertilizer, or one peso per kilogram of fertilizer) and the cost of capital (40% of the expense for fertilizer and application labor, or 3.62 pesos per kg of fertilizer). Therefore, the optimal level of N is reduced to

$$N = \frac{\frac{(8.04) + (4.62)}{2.18} - 8.97}{-.06}$$

or 53 kg/ha. This is very close to the 50 kg/ha for N determined through partial budgeting.

Regarding cycle A, the dry cycle, the corresponding quadratic response function using pooled data only achieved an R^2 of .04. This appears to be due to even more variation over experiments than was observed in cycle B. An ANOVA, using pooled RD2, cycle A yield data, was conducted using N, P and Experiment as explanatory factors. As with cycle B data, results using cycle A data found the effects of N, Experiment and the N by Experiment interaction to be significant at the .01 level. Furthermore, the effect of N on yields was found to be significant at the .10 level in six of eleven RD2, cycle A experiments.

The quadratic response function for RD2, cycle A is as follows:

$$\underset{(14.9)}{Y = 2664.7} + \underset{(1.67)}{6.7N} - \underset{(-1.59)}{.04N^2} + \underset{(0.2)}{1.46P} - \underset{(-0.4)}{.03P^2} + \underset{(.33)}{.01\ NP}$$

where numbers in parentheses are "t" values.

Therefore,

$$MP_N = 6.7 - .08N + .01P$$

If we follow the evidence in the ANOVA to the effect that there is no response to P, then,

$$N = \frac{\frac{(8.04 + 4.62)}{2.18} - 8.97}{-.08}$$

or N = 40 kg/ha.

In summary, it appears that farmers should apply somewhat more N in the (wet) B cycle than in the (dry) A cycle, just as Perrin noted.

5.3.2 Nitrogen by Density Experiments

Eight nitrogen by plant density experiments were carried out in RD1 and RD2. As noted, the N by P experiments were conducted using a planted density of 50,000 plants/hectare. The purpose of this new set of N by D experiments is to simultaneously select an optimal combination of nitrogen level and density of planting. The Tuxpeñito maize variety was used in the N by D experiments, just as it was used in the N by P experiments.

The density changes in the experiments created a need for adjustments in both maize field price and seed value. See footnotes 3 and 4 of Table 5-9. The price of nitrogen and the wage rate were those used in the analysis of the nitrogen by phosphorous experiments.

Only three experiments were available from RD1 (alluvial soils). Nonetheless, pooled analysis of these experiments confirms the recommendations implicit in the N by P experiments: 50 kg/hectare of nitrogen and a density of 50,000 plants/hectare. This was selected over the alternatives, based on combination of 0, 50, or 100 kg/ha of N and 25,000, 50,000 and 75,000 plants/ha. (See Table 5-9.)

In RD2 (flat vertisols), the results of five experiments with the common treatments noted above were pooled for economic analysis. Again, the results of the N by P experiments are confirmed: 50 kg/ha of N and 50,000 plants/ha. (See Table 5-10.)

Paired comparisons between yields associated with the N = 50, D = 50,000 treatment (the recommendation) and the N = 0, D = 25,000 treatment (the farmer practice) led to calculated "t" values of 3.06 and 2.90 for RD1 and RD2 respectively. Both indicate differences in yields significant at the .10 level.

No data are available for RD3 (sloped vertisols).

5.3.3 Social Costs and Benefits of Fertilizer Use and a Summary of Fertilizer Recommendations

All of the analysis presented above uses fertilizer prices paid by farmers. Allgood et al (1979), however, report that fertilizer in Mexico receives a government subsidy. They note that in 1978, retail

Table 5-9

Economic Analysis of Three Nitrogen by Density Experiments, RD1, Combined Cycles

Variable	N0[1] D25	N0 D50	N0 D75	N50 D25	N50 D50	N50 D75	N100 D25	N100 D50	N100 D75
Yield (MT/ha)[2]	2.8	3.3	3.67	3.17	4.13	4.0	2.73	4.0	3.77
	(.55)	(.46)	(1.15)	(1.96)	(.11)	(.64)	(.22)	(.17)	(.67)
Adjusted yield[3] (MT/ha)	2.2	2.6	2.9	2.5	3.3	3.2	2.2	3.2	3.0
Gross Benefit[4] (pesos/ha)	4950	5623	6019	5605	7038	6560	4827	6816	6183
Labor (man-days/ha)	6	6	6	8	8	8	8	8	8
Labor value (pesos/ha)	300	300	300	400	400	400	400	400	400
N value (pesos/ha)	0	0	0	402	402	402	804	804	804
Seed value[5] (pesos/ha)	31.5	63	94.5	31.5	63	94.5	31.5	63	94.5
Varying costs (pesos/ha)	331.5	363	394.5	833.5	865	896.5	1235.5	1267	1298.5
Net Benefits (pesos/ha)	4619	5260	5624	4771	6173	5664	3591	5549	4884
		MRR = 156%							
	MRR = 203%		MRR = 117%						

[1]The number accompanying "N" refers to the application rate in kg/ha of nitrogen; the number accompanying "D" refers to the planted density in thousands of plants per hectare.

[2]Numbers in parentheses are standard errors.

[3]20% reduction, MT/ha.

[4]Field price = $2.65 - .10 (transport) - .10 (shelling) - harvest cost: D25 = .24/kg, 50 FP = $2.21/kg; D50 = .32, 50 FP = $2.13/kg; D75 = 40/kg 50 FP $2.05/kg.

[5]Seed price = $2.65/kg + $.5/kg per cycle depreciation on initial investment = $3.15/kg; D25 = 10 kg; D50 = 20 kg; D75 = 30 kg of seed/ha.

Table 5-10

Economic Analysis of Five Nitrogen by Density Experiments, RD2, Combined Cycles

Variable	N0[1] D25	N0 D50	N0 D75	N50 D25	N50 D50	N50 D75	N100 D25	N100 D50	N100 D75
Yield (MT/ha)[2]	2.64	3.06	3.1	2.60	3.53	3.28	2.69	3.61	3.58
	(.31)	(.54)	(.58)	(.31)	(.58)	(.49)	(.36)	(.58)	(.63)
Adjusted yield[3] (MT/ha)	2.1	2.4	2.5	2.1	2.8	2.6	2.2	2.9	2.9
Gross Benefit[4] (pesos/ha)	4667	5214	5084	4597	6015	5800	4755	6151	5871
Labor (man-days/ha)	6	6	6	8	8	8	8	8	8
Labor value (pesos/ha)	300	300	300	400	400	400	400	400	400
N value (pesos/ha)	0	0	0	402	402	402	804	804	804
Seed value (pesos/ha)	315	63	94.5	31.5	63	94.5	31.5	63	94.5
Varying cost (pesos/ha)	331.5	363	394.5	833.5	865	896.5	1235.5	1267	1298.5
Net Benefits (pesos/ha)	4336	4851	4690	3763	5150	4901	3520	4884	4573
	x MRR = 1634% →		x MRR = 60% →						

[1]The number accompanying "N" refers to the application rate in kg/ha of nitrogen; the number accompanying "D" refers to the planted density in thousands of plants per hectare.

[2]Numbers in parentheses are standard errors.

[3]20% reduction, MT/ha.

[4]Field price = \$2.65 - .10 (transport) - .10 (shelling) - harvest cost: D25 = .24/kg, 50 FP = \$2.21/kg; D50 = .28, 50 FP = \$2.13/kg; D75 = .32/kg, 50 FP = \$2.05/kg.

[5]Seed price = \$2.65/kg + \$.5/kg per cycle depreciation on initial investment = \$3.15/kg; D25 = 10 kg; D50 = 20 kg; D75 = 30 kg seed/ha.

prices for urea in Mexico were 35% lower than the average price paid by US farmers. This subsidy is not explicitly calculated as a percent of fertilizer price, but rather FERTIMEX (Fertilizantes de Mexico, the government fertilizer monopoly) "receives funds from the government treasury to balance revenues against costs" in a global sense (Algood et al, 1979, p. 46). Conservatively, it is assumed that urea receives a subsidy of 30%. When this subsidy is removed, rates of return to fertilizer use remain acceptable. The most marginal case is that of RD2 (flat vertisols) for the dry or "B" cycle. Rates of return to application of 50 kg/ha of nitrogen fall from 53% to 24% when the subsidy is removed. This is still likely to be above the minimum desired social rate of return.

Based on the above, the following is recommended for farmers in the study area:

RD1, both cycles:	50 kg/ha nitrogen and 40 kg/ha phosphorous.
RD2, cycle A (dry):	40-50 kg/ha nitrogen and 0 phosphorous.
RD2, cycle B (wet):	50 kg/ha nitrogen and 0 phosphorous.
RD3, both cycles:	0 nitrogen and 40 kg/ha phosphorous.

5.4 Farmer Assessment of Fertilizer Recommendations

Experimental results notwithstanding, few farmers fertilize their maize. The August 1978 and April 1979 random surveys found only three and six percent of farmers, respectively, using chemical fertilizers on maize. Almost all fertilizer use was found in RD1.

5.4.1 Data Collection for Farmer Assessment of Fertilizer Recommendations

Many of the data on the practices and perceptions of "users" and "ex-users" were gathered in the April 1979 random survey, described in

Chapter 4. Only 6 of 97 respondents in that survey were identified as "users," all of them in RD1 (alluvial soils). In an effort to gather more information on "users," a purposive survey was conducted in May 1979.

Two criteria were used in the purposive survey to identify possible fertilizer users, although in neither case were all farmers identified found to be current users. First, "ex-collaborators" were interviewed. These were farmers who had at one time collaborated with the CIMMYT Maize Training Program in on-farm agronomic experiments, regarding maize production, in the study area. Second, participants of the directed credit program of the official bank were interviewed, the official bank being the major source of fertilizer supply.[5] These "bank-users" as well as the "ex-collaborators" were asked to identify further farmers using fertilizer outside of the auspices of the official bank. Two such "independent fertilizer users" were identified and interviewed. up to last

5.4.2 Division of Farmers by Use Class and Recommendation Domain

The April 1979 random survey identified six farmers (6% of respondents) currently using fertilizer, all in RD1. Based on their current use of fertilizer on maize and on their expressed expectation of continuing the practice, all six were classed as "users." A further 21 farmers (22% of respondents) had used fertilizer on maize in the past, but had decided to drop this practice, and expressed no expectation

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[5]The "official bank" is the Banco Rural de Crédito del Golfo, a government bank aimed at local "ejidatarios."

of taking it up again in the future. These were classed as "ex-users." Of the 21 "ex-users" so identified, 8 corresponded to RD1 and another 9 to RD2.

At first glance, it would appear that the rest of the respondents would fall into the class of "non-users." However, under the strict definition of "non-users" (farmers who have never used and who have decided <u>not</u> to use a given input or practice based on, for them, sufficient information), no indisputable "non-users" were encountered. Only 16 farmers (23% of those farmers who had never used fertilizer) claimed to be "familiar" with them; even this is likely to be an over-estimate because only 10 of them could correctly name any chemical fertilizer and none of them could distinguish between urea and 18-46-0.

Among the 18 respondents of the purposive survey (six "ex-collaborators," ten "bank-users" and two "independent fertilizer users"), only 4 farmers were classed as "users," again based on current use and expectations of future use. The remaining 14 respondents were divided into ten "ex-users" (using the same criteria as for the random survey), two "non-users" (who had been convinced by CIMMYT trials not to use fertilizer on their lands), and two farmers still without sufficient information to decide.

Combining both surveys, then, a total of ten "users" and thirty-one "ex-users" were interviewed. The number of respondents by use class and recommendation domain (RD) for each survey may be seen in Table 5-11. As expected, the purposive survey covered RD2 (flat vertisols) almost exclusively because most CIMMYT trials have been conducted on flat

Table 5-11

Number of Respondents on Maize Fertilization, by Use Class, Recommendation Domain, and Survey

Survey and Use Class	RD1 (Alluvial Soils)	RD2 (Flat Vertisols)	RD3 (Sloped Vertisols)
April 1979 random survey:			
Users	6	0	0
Ex-users	8	9	4
May 1979 purposive survey:			
Users	1	3	0
Ex-users	0	10	0
Non-users	0	2	0
Other	0	2	0

vertisols and because official bank loan activities are restricted to maize production using tractor tillage.

5.4.3 Positive Information: Farmer Fertilizer Use Patterns

Fertilizer "users" in RD1 (alluvial soils) applied nitrogen but not P_2O_2 or K_2O. The modal form of nitrogen used was ammonium nitrate (5 of 6 cases), obtained from the tobacco company, "TABAMEX," which sells inputs and purchases tobacco from tobacco producers. Apparently, these farmers were supplied with an excess of fertilizer for tobacco or otherwise diverted fertilizer meant for tobacco towards maize. Most farmers planted the local variety ("criollo") at a density of around 43,000 plants per hectare. Rates of nitrogen applied ranged from 23 kg/hectare to 67 kg/hectare, with a mean of 46 kg N/hectare. All farmers currently using fertilizer reported an identical method of application: At the first weeding, a handful of fertilizer is dropped near the plant within the row and covered with earth during the process of weeding. This is carried out 20-30 days after planting. Using this method of application, "users" expected maize yields to increase by an average of 460 kg/hectare. This is considerably more than the 140 kg/hectare increase predicted by agronomic experiments in RD1 for the "N = 50 kg/ha P = 0 kg/ha" treatment.

Fertilizer "users" in RD2 (flat vertisols) report a similar practice of fertilization to that of RD1. Only nitrogen is applied, at an average dose of 69 kg N/hectare. The variety being fertilized was "criollo" at a planted density of around 38,000 plants/hectare.

The fertilizer was purchased, with a cash payment, from the official bank in Papantla (a town about 30-50 kilometers from farmers' fields). Application methods were identical to those of RD1 farmers. The expected yield increase due to fertilization was about 500 kg/hectare (See Table 5-12).

No RD3 fertilizer "users" were discovered, hence the case of RD3 regarding fertilization of maize will not be further pursued.

While there are few differences in fertilization practices between "users" in RD1 and RD2, the case of "ex-users" is dramatically different: RD1 "ex-users," in their last use of fertilizer on maize, used practices similar to those of "users," while RD2 "ex-users" practices were quite different. Most RD1 "ex-users" applied nitrogen only, at an average dose of 45 kg/hectare, to the "criollo" variety. Yield increase expectations are in line with those of "users:" About 450 kg/hectare due to fertilization. (See Table 5-13.)

RD2 "ex-users," on the other hand, applied either 18-46-0 or 18-9-18, at an average nitrogen dose of 22 kg/hectare, to the "Tuxpeñito" variety. Yield increase expectations were only around 250 kg/hectare for that increase attributable to fertilization. All "ex-users" purchased their fertilizer on credit through the official bank in Poza Rica. In May 1979, this bank was charging $4.20/kg for both 18-46-0 and 18-9-18. (See Table 5-13.)

The distinct fertilization practices of RD2 "ex-users" were due to their collaboration with the Poza Rica branch of the official bank. These farmers report that they had no choice over fertilizer formula

Table 5-12

Fertilizer Use by "Users," RD1 and RD2 (1979 A Cycle)[a]

Variable	RD1	RD2
% using N only	100	100
% using 18-46-0	0	0
Mean N dose (Kg/ha)	46	69
% buying on credit from Official Bank	14	33
% buying from Tabamex	57	0
Mean planted density (plants/ha)	43,000	38,000
% planting "criollo"	71	67
% planting Tuxpeñito	14	0
Mean expected yield increase (Kg/ha)	460	300
Number of Observations	7	3

[a]RD1 data from April 1979 random survey, with the exception of one observation from May 1979 purposive survey; RD2 data from May 1979 purposive survey.

Table 5-13

Fertilizer Use by "Ex-Users," RD1 and RD2
(for Last Cycle Fertilizer was Used)

Variable	RD1 (April 1979 random survey)	RD2 (April 1979 random survey)	RD2 (May 1979 purposive survey)
% using N only	88	22	0
% using 18-46-0 or 18-9-18	0	67	100
Mean N dose (Kg/ha)	45	22	22
% buying on credit from Official Bank	25	100	100
Mean planted density (plants/ha)	45,000	45,800	48,000
% planting criollo	63	22	10
% planting Tuxpeñito	13	67	60
Mean expected yield increase (Kg/ha)	450	250	233
Number of observations	8	9	10

or over the variety to be planted if they wished to obtain a loan. No other fertilizer supplier was available to sell them fertilizer on credit.

5.4.4 Normative Information -- Farmers' Perceptions of the Advantages and Disadvantages of Fertilizer Use

The ten fertilizer "users" from RD's 1 and 2 (alluvial soils and flat vertisols, respectively) were asked in an open-ended question to list what they perceived as the advantages and disadvantages of fertilizer use, on maize. The advantages centered on the expected yield increase reported above. The disadvantages included increased lodging problems, the expense of fertilizer acquisition and the riskiness of fertilizer use in the context of possible drought. Fully half of the "users" felt, however, that there simply were no disadvantages to fertilizer use.

Researchers had hypothesized that fertilizer use might bring as a consequence increased weed growth problems. No fertilizer "user" was willing to agree with this, however. Researchers had also hypothesized that there might be some difficulty in obtaining fertilizer in the first place. Again, "users" rejected this idea -- at least, insofar as they were personally concerned (see Table 5-14).

Regarding "ex-users," RD1 "ex-users" demonstrated perceptions of the advantages and disadvantages of fertilizer use that were similar to those of "users" (see Table 5-15). Almost all RD1 "ex-users" were pleased with yield increases but a few were concerned with fertilizer expense and the possibility of loss during a drought.

Table 5-14

"User" Perception of Advantages and Disadvantages of Fertilizer Use, RD1 and RD2

Advantages and Disadvantages	% of "Users" Reporting
Advantages:	
Yield increase	90
Plant turns green	10
Disadvantages:	
Lodging increase	30
Expensive	10
Risky (drought)	10
Increased weeds	0
Difficult to obtain	0
No disadvantages	50

Table 5-15

Percent of "Ex-Users" Perceiving Selected Advantages and Disadvantages of Fertilizer Use, by RD and Survey

Advantages and Disadvantages	RD1 (April 1979 random survey)	RD2 (April 1979 random survey)	RD2 (May 1979 purposive survey)
	%	%	%
Advantages:			
Yield increase	86	67	70
Plants turn green	14	33	20
No advantages	0	22	20
Disadvantages:			
Increased lodging	14	22	0
Risky (drought)	29	67	70
Expensive	43	11	20
Implies working with Official Bank	14	56	60
Difficult to obtain	14	11	0
Increased weed problem	0	0	10

RD2 "ex-users" however, revealed strikingly different perceptions. Responses from both the April 1979 random survey and the May 1979 purposive survey lead to similar conclusions: Fewer RD2 "ex-users" are convinced of the existence of a yield increase. They are, furthermore, more concerned with two problems associated with fertilizer use: The riskiness of fertilizer use in the face of possible drought and the perceived necessity to collaborate with the official bank in order to obtain fertilizer.

It was pointed out in Chapter 4 that farmers consider drought to be a major production limiting problem. Fear of drought, however, does not lead to farmer prescriptions against fertilizer use.

The second major disadvantage that was noted by RD2 "ex-users" merits additional explanation. The necessity of collaborating with the official bank was viewed as a disadvantage associated with fertilizer use. Fertilizer was viewed as only available through the official bank. More importantly, the official bank was seen as an important source of credit for maize production. This production credit included cash for payment of hired labor and custom tractor service, as well as insecticides, seeds and fertilizer delivered in kind. In this context, the decision regarding fertilizer use becomes inextricably tied to the decision regarding collaboration with the official bank. It is therefore necessary to briefly summarize what RD2 "ex-users" see as the advantage and disadvantages of working with the official bank. This question was addressed in the May 1979 purposive survey.

Almost all respondents agreed that the advantage of working with the official bank was that it provided cash and inputs that helped overcome seasonal cash flow problems. They were, however, concerned with the disadvantages of such collaboration:

(1) Late delivery of inputs was noted, in open-ended questions, by 50% of respondents.

(2) 40% of respondents claimed that working with the official bank was risky -- a lost harvest due to drought could lead to confiscation of family maize, crop insurance notwithstanding.

(3) 30% of respondents complained of the implementation of the crop insurance component of the loan program, because the official inspections of low-yielding fields were delayed (thus delaying the planting of a subsequent crop) and/or related in inflated yield estimates (thus disqualifying the farmer from compensation).

Finally, there is even some evidence that supports the hypothesis that the inclusion of fertilizer itself in the loan package is also viewed as a disadvantage. The respondents of the May 1979 purposive survey were asked to state their preference regarding the inclusion or exclusion of fertilizer in their bank loan. 60% of them reported preferring a loan without fertilizer, 20% of them with fertilizer, while the remaining 20% declined to answer the question.

One major disadvantage to use of the bank's fertilizer recommendation in RD2 is its sheer unprofitability. The official bank, as noted, normally includes in a loan for maize 100 to 150 kg/hectare of 18-46-0. In May 1979, farmers reported paying \$4.20/kg for this fertilizer. Agronomic evidence leads to the conclusion that there is no response to P in RD2. Therefore, the only element of value to farmers that is included in 18-46-0 is the nitrogen. Nitrogen, then, costs \$4.20/.18 per kg, or \$23.33/kg. Adding transport cost (from the bank's storeroom to the farmer's field) of \$ .20/kg, one obtains (\$4.20 + \$ .20)/.18 or \$24.44/kg of nitrogen. In the form of urea, however, nitrogen is much cheaper: Urea was reported by

RD2 "users" as costing \$3.50/kg. The field price of nitrogen from urea (46% nitrogen), then, is (\$3.50 + \$ .20)/.46 or \$8.04/kg, about a third of the cost than from 18-46-0.

This price difference determines fertilizer profitability, given maize prices and agronomic yields. This holds true whether experimental yields or farmer expected yields are used in calculations of profitability. Budgets found in Table 5-16 illustrate this.

5.4.5 Farmer Prescriptions Regarding Fertilizer Use

All fertilizer "users" from RD1 (alluvial soils) and RD2 (flat vertisols) prescribe continued use of fertilizer, using their present practice.

The case of RD1 "ex-users," however, is curious. Their fertilizer use practices (for the last time they fertilized maize) were similar to those currently used by "users." Furthermore, they had perceptions on the good and bad aspects of fertilizer use that are similar to those of "users." Why, then, did they reject the fertilization of maize when "users," under similar circumstances, accepted this practice? RD1 "ex-users" were asked this specific question, to which they gave two principal answers: They were either dropping maize cultivation completely, or were cultivating maize in rotation with heavily-fertilized tobacco (for which reason they felt no additional fertilizer was needed for maize). Of eight "ex-users," four reported the former answer while three reported the latter. For these farmers, the relatively simple issue of maize fertilization is over-shadowed by broader issues of land use and cropping patterns.

Table 5-16

Fertilizer Use Budgets, Urea vs 18-46-0, RD2

Variable	Experimental Yields			Farmer Expected Yields		
Treatment	N=0	N=50	N=50	N=0	N=69	N=69
Source of N		urea	18-46-0		urea	18-46-0
Adjusted yield (Kg/ha)	2.54	2.90	2.90	1.25[a]	1.75[a]	1.75[a]
Gross benefit ($/ha)[b]	5537	6322	6322	2725	3815	3815
Quantity of N (Kg/ha)	0	50	50	0	69	69
Price of N ($/Kg)		8.04	24.44		8.04	24.44
Cost of N ($/ha)	0	402	1222	0	555	1686
Man-days/ha	0	2	2	0	2	2
Cost of labor ($/ha)[c]	0	100	100	0	100	100
Costs that vary ($/ha)	0	502	1322	0	655	1786
Net benefits ($/ha)	5537	5820	5000	2725	3160	2029
	MRR = 56% →			MRR = 66% →		

[a]The yield without N is taken from the April 1979 survey. Yields with 69 Kg/ha N are obtained by adding to this the expected yield increase (purposive survey).

[b]Field price of maize = $2.18/Kg.

[c]Wage = $50/day.

RD2 "ex-users" reject the use of fertilizer on maize -- at least, they reject the use of 18-46-0 on maize. From the information presented above, this rejection could be based on risk considerations (the fear of loss due to drought), the various problems associated with the use of official credit, or sheer unprofitability. In fact, the latter two of these are interlinked. The unprofitable practice used by "ex-users" was prescribed by the official bank. From the farmers' point of view, a decision to drop fertilizer is identical to a decision to drop the use of official credit, since fertilizer is normally part of the bank's standard loan package for maize.

The difficulty is that no alternative source of fertilizer on credit is available to RD2 "ex-users." RD2 "users" obtain their urea, for cash, from the official bank in Papantla, as noted above. It cannot be determined at this date whether "ex-users" do not purchase urea in Papantla due to lack of credit facilities (if farmers in the study area wish to borrow from an official bank, they are constrained to work through the Poza Rica branch) lack of information, or transport cost. Possible lack of information could include insufficient understanding of the difference in profitability in the use of urea vs. 18-46-0, or merely a lack of knowledge relative to the availability of urea in Papantla.

Under proper market conditions, it appears that many RD2 "ex-users" would become "users." In both the April 1979 random survey and the May 1979 purposive survey, "ex-users" were presented with a hypothetical situation, based on a recommendation for 100 kg/hectare of urea: If a "new fertilizer," costing $370/hectare (without application labor) were to raise their yields 300-400 kg/hectare, would they adopt its use as a standard practice? Would they maintain its use even in the face of no yield increase in 30% of the maize cycles, due to drought? Of the 19 RD2 "ex-users," 14 of them (74%) reported that these terms would be very acceptable and that they would use this "new fertilizer."

5.5 Suggestions for Change in Research and Policy Related to Fertilizer

Farmer assessment of fertilizer use leads to several conclusions: (1) Most farmers in RD's 1 or 2 who have access to, and who have used, inexpensive sources of nitrogen (urea, ammonium nitrate) find that the use of that element (at about 50 kg/hectare) is appropriate; (2) "Ex-Users" in RD1, nonetheless, have dropped the use of inexpensive nitrogen because they have either dropped maize as a crop or because they now grow maize in rotation with heavily-fertilized tobacco; (3) "Ex-users" in RD2, on the other hand, have dropped the use of 18-46-0 because of its unprofitability and because they no longer wish to collaborate with the official bank; and (4) Relatively few farmers have sufficient information on fertilizers upon which to base an adoption decision. In light of the above, the following suggestions may be made.

5.5.1 Suggestions for Changes in Research Relative to Fertilizer -- RD1

Of primary concern is why farmers observe an economically satisfactory response to nitrogen alone, whereas experimental results indicate that only a combination of N and P_2O_5 is profitable. To begin, it should be observed that data from only three fertilizer trials in RD1 were available for analysis. All three were conducted with the same farmer in the same ejido, during three different maize cycles. As a further observation, all but one of the fertilizer "users" were from a different ejido than that in which fertilizer trials were conducted; equally, the random surveys found no fertilizer "users" in the ejido in which experiments took place.

It is apparent that the internal homogeneity of the recommendation domain of interest is open to serious question. As of yet, it is not clear in what way the two ejidos are different. One suggestion for a change in fertilizer research in RD1, however, is immediately apparent: Researchers should include sites from different ejidos for future RD1 fertilizer trials.

Results from farmer assessment of fertilizer use also suggest that stratification of experiments by crop rotation would be of interest. The two rotations of particular concern are: (a) two maize cycles per year, i.e., a maize-maize rotation, and (b) a tobacco crop followed by a maize crop, within a single year. In the latter rotation, the tobacco should have been fertilized heavily, as recommended by "TABAMEX" and practiced by most tobacco cultivators.

5.5.2 Suggestions for Changes in Research and Policy Relative to Fertilizer Use -- RD2

Despite the large amount of variation encountered in the experimental data, there is consistency between experimental results and results of farmer assessment regarding effects of fertilizer use in RD2. "Users" are happy with the yield increase due to the application of about 50 kg/hectare of nitrogen, in the form of urea. This yield increase was predicted by experiments. Yield risk due to drought is present but does not appear to be a discouraging factor, insofar as fertilizer use is concerned, for most farmers.

Of concern, however, is the low level of information that RD2 farmers have regarding fertilizer. Most farmers have never tried fertilizers and few claim to be familiar with them.

Suggestions for changes in research and policy regarding fertilizer use, then, center around the role of the extension service and the official bank. A purpose of any extension service is to reduce the cost to farmers of obtaining information on useful inputs and practices. The local extension service is constrained, however, to the promotion of bank recommendations, which in this case implies the promotion of 18-46-0. This unprofitable practice has been rejected by numerous "ex-users" in RD2. Clearly, then, expansion of fertilizer use in RD2 would be greatly facilitated by the bank's switching of urea (or some other inexpensive source of nitrogen) for 18-46-0 in its technological package, and by an expanded program of demonstrations and farmer trials regarding urea use by the extension service. Researchers could aid policy-makers (in the bank and in INIA) by conducting specific experiments for their benefit comparing the profitability of urea and 18-46-0 in farmers' fields.

On a broader level, the difficulty that farmers experience in obtaining inexpensive sources of nitrogen can be partially attributed to the national fertilizer marketing system. As noted in Chapter 4, the "FERTIMEX" company has a monopoly on fertilizer production and distribution within Mexico. Fertilizer can only be sold through authorized distributorships. As it happens, there are no authorized distributorships in the study area, beyond the agencies noted (official bank, Citrus Association). If any store were allowed to sell fertilizer to farmers, and were allowed to fit fertilizer sales to farmer demand, then the problem of availability would likely be alleviated. A private system of fertilizer distribution may not be profitable to input suppliers, however, until more farmers learn more about the fertilizers appropriate to their area, which returns one to the key role of the extension service (and perhaps to private advertising).

CHAPTER 6

WEED CONTROL IN THE STUDY AREA: RECOMMENDATIONS AND FARMER ASSESSMENT

CIMMYT agronomists consider inadequate weed control as the problem that most limits maize production in the study area. Weed control recommendations and their assessment by farmers is, therefore, of great interest.

6.1 Weed Control Recommendations

Three kinds of experiments were conducted to examine alternative weed control practice. These were: (1) chemical vs. manual (i.e., hoe) control under conditions of conventional tractor tillage, (2) chemical weed control alternatives under conditions of zero tillage,[1] and (3) chemical vs. manual weed control at different levels of nitrogen application. No experiments involving mechanization (of tillage or weed control as experimental variables) were conducted.

Five experiments were carried out on flat vertisols to specifically look at alternative methods of weed control, after a "blanket"

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[1]Herbicide-based zero tillage is a practice whereby soil movement is completely avoided. A herbicide, usually paraquat, is used to kill off existing cover. Then, atrazine (in the case of maize) may be used to avoid subsequent weed emergence.

tractor tillage. Common treatments included the following: (1) no weed control ("check"), (2) normal manual control, involving weedings with a hoe at 15 and 45 days after planting ("manual control"), (3) a pre-emergence application of atrazine in the form of Gesaprim 50, 50% a.i. ("Gesaprim 50"), and (4) a pre-emergence application of atrazine and Igran in the form of Gesaprim Combi, 40% a.i. each ("Gesaprim Combi"). Given that data from only 5 experiments were available, no breakdown was undertaken by cycle or RD. Results shown in Table 6-1 indicate that "Gesaprim Combi" is the appropriate choice. Expenditures are low and net benefits are high; indeed, the "Gesaprim Combi" treatment dominates all treatments except the "check," over which it offers a 75% MRR. This is hardly relevant, however, because the farmer practice is not represented by the "check" but by "manual control." Although yields for "manual control" are not significantly different (.50 level) from those for "Gesaprim Combi," the latter treatment is cost-reducing. The "Gesaprim Combi" treatment reduces per hectare labor requirements from 20 man-days to 2.5 man-days. Most of this reduction takes place in the period of peak labor demand. This use of herbicides probably represents a cash savings, given farmer dependence on hired labor. Consequently, risk would be decreased if this practice were adopted. Given that family labor is saved during a peak demand period, and that an active labor market exists in which many farmers participate, the value of family labor is assumed equal to the market wage.

Economic analysis was also conducted of the results of four experiments dealing with weed control under conditions of zero

Table 6-1

Economic Analysis of Five Experiments on Weed Control, Conventional Tractor Tillage

Variable	Check	Manual Control	Gesaprim 50	Gesaprim Combi 80
Yields (MT/ha)[1]	3.02 (0.35)	3.88 (0.40)	3.72 (0.44)	3.92 (0.40)
Adjusted yields[2] (MT/ha)	2.42	3.10	2.98	3.14
Gross Benefit[3] (pesos/ha)	5267	6767	6488	6836
Labor (man-days/ha)	0	20	2.5	2.5
Labor value[4] (pesos/ha)	0	1000	125	125
Herbicide Quantity (Kg/ha commercial)	0	0	4	2.5
Herbicide value[5] (pesos/ha)	0	0	960	712.5
Sprayer cost[6] (pesos/ha)	0	0	57	57
Costs that vary (pesos/ha)	0	1000	1142	894
Net Benefits (pesos/ha)	5267	5767	5345	5941
	x	MRR = 75% →		

[1]Numbers in parenthesis are standard errors.

[2]20% reduction.

[3]Field price of maize = \$2.65 - .27 (harvest cost) - .10 (transport) - .10 (shelling) = \$2.18/kg.

[4]Wage = \$50/day. Opportunity cost of family labor = market wage.

[5]Gesaprim 50 = \$240/kg; Gesaprim Combi 80 = \$285/kg.

[6]\$2000 sprayer over 5 years, 2 cycles per year and 3.5 ha/cycle = \$57/year/cycle/ha. Other costs are ignored (e.g., repairs).

tillage. Common treatments included are no control ("check"), the farmers' practice of normal soil preparation followed by two hoeings ("manual control"), 1 kg per ha of Gesaprim 50 (50% atrazine) combined with 2.25 lt per ha Gramoxone (18% paraquat), and 2 kg per ha of Gesaprim 50 combined with the same amount of Gramoxone. These treatments are called "1 kg Gesaprim" and "2 kg Gesaprim," respectively. Again, one finds that herbicide control is recommended. The most profitable level of application is the higher dose noted: 2.25 lt of Gramozone and 2 kg. Gesaprim 50 per hectare. This "2 kg Gesaprim" treatment leads to both increased yields and reduced costs when compared to the "Manual Control" treatment. The "t" value from paired comparisons for yields from these two treatments is 3.09, significant at the .05 level. The corresponding budgets may be seen in Table 6-2.

Additional evidence on the relative profitability of weed control practices may be found in six nitrogen by weed control experiments. Common weed control treatments include a single hoeing 30 days after planting ("one weeding"), chemical weed control using 2.5 kg/ha Gesaprim Combi (40% atrazine + 40% igran) ("Gesaprim") and complete manual control entailing three hoeings ("three weedings"). The usual farmer practice of two hoeings was not commonly included in these experiments. Nitrogen application levels were 0 kg/ha ("N_0") or 100 kg/ha ("N_{100}"). Both zero tillage and conventional tillage were used.

Once more, chemical control of weeds is preferred to manual control, as may be seen in Table 6-3. Within each level of nitrogen application, the MRR of chemical control over a single weeding is in

Table 6-2

Economic Analysis of Four Experiments on Weed Control, Zero Tillage

Variable	Check	Manual Control	1 Kg[1] Gesaprim	2 Kg[2] Gesaprim
Yields (MT/ha)[3]	1.5 (0.7)	3.4 (0.3)	3.7 (0.4)	4.05 (0.3)
Adjusted yields[4] (MT/ha)	1.2	2.72	3.0	3.24
Gross Benefits[5] (pesos/ha)	2616	5930	6453	7063
Labor[6] (man-days/ha)	0	30	6.5	6.5
Labor value[7] (pesos/ha)	0	1500	325	325
Herbicide value[8] (pesos/ha)	0	0	790	1030
Sprayer cost[9] (pesos/ha)	0	0	57	57
Varying costs (pesos/ha)	0	1500	1172	1412
Net Benefits (pesos/ha)	2616	4430	5281	5651
	x——	MRR = 227%	——→	
			x——	MRR = 154% ——→

[1]2.25 lt/ha Gramoxone plus 1 kg/ha Gesaprim 50.

[2]2.25 lt/ha Gramoxone plus 2 kg/ha Gesaprim 50.

[3]Numbers in parentheses are standard errors.

[4]20% reduction.

[5]Field price of maize = $2.65 - .27 (harvest cost) - .10 (transport) - .10 (shelling) = $2.18/kg.

[6]Zero till requires 4 MD/ha chopping with machete + 2.5 MD/ha herbicide application.

[7]Wage = $50/day. Value of family labor = market wage.

[8]Gramoxone = $250/liter; Gesaprim 50 = $240/kg.

[9]$2000 sprayer for 5 years, 2 cycles per year and 3.5 ha/cycle = $57/cycle/ha. Other expenses (e.g., repairs) are ignored.

Table 6-3

Economic Analysis of Six Nitrogen by Weed Control Experiments

Variable	One Weeding N0	Gesaprim N0	Three Weedings N0	One Weeding N100	Gesaprim N100	Three Weedings N100
Yield (MT/ha)[1]	2.93	3.48	3.28	3.47	4.08	3.55
	(.36)	(.29)	(.44)	(.24)	(.24)	(.20)
Adjusted yield[2] (MT/ha)	2.3	2.8	2.6	2.8	3.3	2.8
Gross Benefit[3] (pesos/ha)	5110	6069	5720	6052	7115	6191
Labor (man-days/ha)	12	2.5	26	14	4.5	28
Labor value[4] (pesos/ha)	600	125	1300	700	225	1400
Herbicide quantity (Kg/ha)	0	2.5	0	0	2.5	0
Herbicide value[5] (pesos/ha)	0	712.5	0	0	712.5	0
Sprayer cost[6] (pesos/ha)	0	57	0	0	57	0
N cost[7] (pesos/ha)	0	0	0	80	804	804
Varying costs (pesos/ha)	600	894.5	1300	1504	1798.5	2204
Net Benefits (pesos/ha)	4510	5175	4420	4548	5317	3987
	MRR = 226%		MRR = 16%			

[1]Numbers in parentheses are standard errors.

[2]20% reduction, MT/ha.

[3]Field price of maize = \$2.65 - .10 (transport) - .10 (shelling) - .27 (harvest) = \$2.18/kg.

[4]Wage = \$50/day.

[5]Gesaprim Combi 80 = \$285/kg.

[6]\$2000 sprayer over 5 years, 2 cycles per year, 3.5 ha/cycle = \$57/cycle/ha/year.

[7]Urea = \$3.5/kg + .2 transport = \$3.7/kg, so N = \$8.04/kg (Urea = 46% N).

excess of 200%. Nitrogen application (at least, to the high level used in the experiment) is not profitable, however. Under the selected weed control practice, the application of 100 kg/ha of N results in only a 16% MRR. This is in line with results obtained in other fertilizer level experiments, in which it was determined that only 50 kg/ha of N was profitable. The profitability of herbicides over a single hoeing in the case of N = 0 is largely due to an observed yield difference of 550 kg/ha ("t" = 3.16 for paired comparisons, significant at the .05 level). Finally, it should be noted that there seems to be little complementarity between nitrogen application and improved weed control.[2]

In summary, chemical weed control of some kind is recommended in the context of private costs and returns. If zero tillage is selected, the recommendation would be to apply 0.4 lt of Gramozone and 1.0 kg of Gesaprim 50, per hectare. If tractor tillage is selected, the recommendation is to apply a pre-emergence dose of 2.5 kg/ha of Gesaprim Combi 80. No experimental evidence is available upon which to base a private decision on zero versus conventional tillage for either flat or sloped vertisols.

Herbicide use in maize production, however, entails costs and returns beyond those identified for individual farmers, for one maize cycle. Multi-cycle costs and benefits accruing to individual farmers as well as social costs and benefits are of interest in making recommendations.

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[2]Table 6-3 indicates that 100 kg/ha of N increases yields by about 400 kg/ha, regardless of weed control practice. In the individual experiments, F values for the N by weed control interaction term in the ANOVA are in the range of 0.5-0.7.

One multi-cycle cost to private farmers is the possible effect of chemical weed control on intercropping and relay cropping systems. Atrazine residues from a maize crop may not allow a concurrent or subsequent crop of beans or squash. Another multi-cycle private cost may be a change in the weed population on annual croplands. Reliance on herbicides may induce a build-up of weeds resistant to those herbicides. Further use of chemical weed control, then, may depend on the use of more complicated and expensive herbicide "cocktails." No experimental evidence is available from the study area to shed light on either of these two possible problems.

Social benefits and costs associated with herbicide use on maize include pollution effects, employment effects and market effects. Herbicide residuals act as a pollutant with some negative value to society. The substitution of herbicide for hired labor in the tillage and weeding of maize fields should lead to increased unemployment among very small farmers and landless laborers. There seems to be a substantial class of landless laborers in the study area, largely composed of adult sons of ejidatarios who have not yet inherited their own land. That relatively few alternatives exist for these laborers is indicated by the fact that wages (50 pesos or about US$2.20 per day), though high by standards of other developing countries, are fairly low by Mexican standards. In other areas of Mexico, daily wages for hired agricultural laborers may reach 100-130 pesos (US$4.44 - $5.78).

Finally, the effects of chemical weed control on maize prices and imports must be considered. If chemical weed control is widely adopted and fulfills its promise of increased yields, what will be the effects on product markets? As production costs decline, prices should decrease in company with increased production. This would be of benefit to urban consumers, who would enjoy a decrease in the real cost of food. If maize is currently imported, however, imports would likely drop, leaving prices unchanged. In the first case (declining prices) producers gain little as price decreases compensate for production increases; consumers are the real gainers. In the second case (declining imports), farmers and importers of non-maize products gain, and consumers of maize gain little.

For purposes of farmer assessment, the chemical weed control practice is tentatively recommended. Before a broad extension program is begun, however, questions of multi-cycle private costs and benefits, and social costs and benefits, should be addressed by policy-makers.

6.2 Farmer Assessment of Weed Control Recommendations

As seen above, chemical weed control is recommended over hand cultivation in the context of single-cycle private costs and returns. While the issue of chemical control versus manual control of weeds is clear, the sub-issue of "zero tillage with chemical weed control" and "conventional tillage with chemical weed control" is not. Although CIMMYT agronomists clearly prefer the former (Soza *et al*, 1978), they used zero tillage only on sloped vertisols (RD3) and conventional tillage only on flat vertisols and alluvial soils (RD's 1 and 2). Therefore, the implicit recommendation is for zero tillage in RD3 and conventional tillage in RD's 1 and 2. This seems reasonable, given that no RD3 farmers perform tractor or animal traction tillage.

6.2.1 Efforts at Data Collection -- Surveys vs. Farmer Trials

An attempt was made to conduct farmer assessment of chemical weed control in the April 1979 random survey. From that survey, it became clear that chemical weed control using the herbicides in question is virtually unknown in the study area. Although 20% of farmers had tried a herbicide in the past (and another 36% claimed to be familiar with herbicides), their experience only extended to various formulations of 2,4-D. The use of 2,4-D was universally rejected because it did not control grassy weeds, an important problem in the maize production area. No farmer claimed familiarity with any formulation of either paraquat or atrazine. Hence, not even "non-users" (in the strict sense of "farmers who have never used and who have decided not to use a given input or practice based on, for them, sufficient information") were to be encountered among respondents of the random survey.

In view of this result, a purposive survey of "users" and "ex-users" of chemical weed control was proposed. Again, it was not possible to identify a sufficient number of farmers with the requisite experience; only one farmer, an ex-collaborator with CIMMYT's on-farm research and training program, was identified who reported having tried the CIMMYT recommendation.

In this circumstance, use of farmer trials was considered necessary. A search was undertaken for farmers willing to try the practice of chemical weed control. The specific practice used in the farmer trials was herbicide-based zero tillage. Accordingly, an emphasis was placed on locating RD3 farmers (farmers with sloped vertisols). (In fact, all collaborators had at least one field on sloped vertisols and one field on flat vertisols). The arrangement made with cooperating farmers was as follows: The researchers would provide detailed instructions on how to carry out the practice, and they would occasionally visit the fields in question. The farmer would provide all inputs and labor, and would keep all of the production. He would also make himself available for survey purposes. The farmer was expected to plant 1/2 to 1 hectare of maize, using herbicide-based zero tillage, as part of the farmer trial. The trial was set for the December 1978 - June 1979 maize cycle.

Eight farmers purposively chosen from RD's 2 and 3 expressed interest in this arrangement but only five of them actually purchased and applied the corresponding inputs during the farmer trial period. Farmers were chosen to represent widely separated regions of the study area. Of the five farmer trials, two were carried out with ex-collaborators of the CIMMYT on-farm research/training program.

The data used in farmer assessment were obtained in a follow-up survey carried out in September, 1979. The five cooperators in question were interviewed, as were three of their neighbors who were sufficiently interested in the practice to try it on their own in the June-October 1979 cycle.

6.2.2 Division of Cooperating Farmers into Use Classes

It was clearly impossible to divide farmers into use classes until after their experience with chemical weed control in the farmers' trial. As of the September 1979 follow-up survey referred to above, however, four of the five original collaborators clearly fell into the "user" category, while one farmer was clearly an "ex-user."

The distinctions noted were based on two criteria: The farmer's expressed decision to continue or not continue the use of chemical weed control, and the use or non-use of chemical weed control by the farmer in the June-October 1979 maize cycle (the cycle subsequent to that one in which farmer trials were conducted). The two criteria were consistent in all cases, i.e., all farmers expressing a decision to continue using the recommended herbicides did, in fact, use them in the June 1979 planting.

The case of the three farmers who were inspired by the example of the farmer trials to try the recommended herbicides themselves must be handled somewhat differently. Although all expressed, in the September 1979 survey, an intention to continue with the practice in question and although all of them did apply recommended herbicides in the June 1979 planting, the confirmation of continued use in a second cycle could not be observed at that date. These will be only tentatively classed as "users."

6.2.3 Positive Information -- Farmers' Use of Chemical Weed Control

Seven of the eight farmers with experience concerning the recommended weed control practice were either definitely or tentatively classed as "users," as noted above. The most salient feature of their use of chemical weed control was their choice of the field on which to employ this practice: Although all farmers had both sloped and flat maize fields, sloped fields were clearly preferred for herbicide use. Four farmers confined their use of recommended herbicides to slopes, two used them on both slopes and flat land and another used them only on flat land. On the other hand all farmers also reported carrying out conventional weed control practices on their flat lands, all but one using tractor tillage and horse cultivation.

In the September 1979 survey, each farmer reported the cultural practices employed in the field receiving chemical weed control and one randomly chosen field receiving conventional weed control. The selection by farmers of sloped fields for herbicide use goes far to explain the intra-farm difference in cultural practices between the two kinds of fields. That is, differences in cultural practices due to weed control method are compounded with differences in practices due to slope of the field. Therefore, emphasis will be placed on the comparison between cultural practices associated with chemical weed control (September 1979 survey) and standard tillage and weed control practices for RD3 (August 1978 and April 1979 random surveys).

Regarding the fields receiving chemical weed control, most farmers chopped the weeds with a machete in preparation for sowing and herbicide application. One farmer applied herbicides with no prior preparation. Only one farmer found it necessary to carry out a weeding after planting; he attributed this to the low dose of herbicide applied (1.5 kg/hectare of Gesaprim 50, or 75% of the recommended dose). The distribution of cultural practices may be seen in Table 6-4.

The standard practice for RD3 emphasizes the use of a hoe for both tillage and weeding. Most farmers perform two manual weedings.

Table 6-4

Distribution of Cultural Practices, by Weed Control Method

Practice	Percentage of Farmers Using a Practice		
	Users of Chemical Weed Control (Slopes)[1]	RD3 Farmers[2]	Users of Chemical Weed Control (Flats)[1]
	%	%	%
Chopping	57	32	0
Hoeing	14	73	14
Plowing (tractor)	0	0	57
Harrowing (tractor)	14	0	71
Furrowing (horses)	14	0	42
Application of herbicides	100	0	0
1st Weeding	14	97	100[3]
2nd Weeding	0	80	14

[1]September 1979 survey, regarding June 1979 maize cycle.

[2]August 1978 random survey, regarding June 1978 maize cycle.

[3]Tractor or horse cultivation.

Finally, farmers who used chemical weed control on sloped vertisols also used conventional tillage and weed control on flat vertisols. (See Table 6-4.)

Regarding herbicide doses, only four of seven "users" applied Gramoxone; all "users" applied Gesaprim 50. For users of Gramoxone, the average dose was 3.4 lt/hectare, about 50% above the recommended dose. The Gesaprim 50 dose averaged 2.1 kg/hectare, very close to the recommendation. This hides some variation of course: The farmer applying 4 kg/hectare of Gesaprim 50 is offset by the two farmers each applying 1.5 kg/hectare. Among "users," no farmer reported having to make more than one application of herbicides.

The cost of chemical weed control on slopes, conventional weed control on flat lands (as reported by "users"), and standard weed control practices on slopes (as reported by farmers in the April 1979 random survey) is of interest.[3] Briefly, chemical weed control involves fewer costs than the alternatives. (See Table 6-5.)

Note that the only costs included are those that vary due to the choice of weed control and land preparation practice; other costs are assumed constant. Given the nature of the labor market, family labor is assumed perfectly substitutable for hired labor at the market wage of $50/day. Nonetheless, it should be noted that cash costs may increase or decrease when herbicides are adopted, depending

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[3]Strictly speaking, cost information contains a normative element. It will be included here, however, for the sake of continuity.

Table 6-5

Costs that Vary Due to Changes in Weed Control Method

Cost	Chemical Weed Control[1]	Standard RD3 Practice[2]	Conventional Weed Control[1]
Labor[3] (man-days/ha)	8.8	32	10.0
Labor value (pesos/ha)	440	1600	500
Tractor cost (pesos/ha)	100	0	640
Herbicide costs[4] (pesos/ha)	489	0	0
Costs that vary (pesos/ha)	1029	1600	1140

[1]Averages from September 1979 survey, for June 1979 maize cycle.

[2]Averages from August 1978 random survey, for June 1978 maize cycle.

[3]Only labor for tillage and weed control practices, including herbicide application, is included. Other labor requirements, e.g., for insect control or sowing, are assumed constant.

[4]Herbicide cost is considerably below that found in the budgets used in the analysis of experimental data because farmers purchased Gesaprim 50 at a subsidized price.

on the percent of total labor input that is hired. Farmers may hire up to 21 man-days (66% of physical labor used in the standard RD3 tillage and weed control practice) before the cash costs of that standard practice exceed those of herbicide use.

Users of chemical weed control were divided on the subject of yield effects of that practice. Four of them expected no yield increase over that obtained with standard RD3 practices while three of them expected some yield increase. No farmer expected chemical weed control to lead to lower yields.

So far, all attention has been given to the seven "users." One farmer was, however, categorized as an "ex-user." His circumstances, as well as his practices, were different than those of the "users." The "ex-user" attempted to use the recommended herbicides, without prior machete chopping or hoeing, to clear and maintain clean a heavily over-grown field containing much woody material. Repeated herbicide applications were insufficient to prevent re-growth and consequently the maize crop was lost.

In summary, it may be said that most farmers (the seven "users") did a reasonable job of carrying out the recommended practice. The practice, in its turn, led to the expected results of decreased labor input, decreased costs and (possibly) increased yields, when compared to the alternative, i.e., the usual local tillage and weed control practice for slopes, which centers on the use of the hoe.

6.2.4 Normative Information -- Farmers' Perceptions of Advantages and Disadvantages of Chemical Weed Control

Farmers were asked to list the advantages and disadvantages of chemical weed control. They were allowed to answer freely and were not constrained to a discrete set of pre-coded answers. The seven "users" overwhelmingly agreed that a saving of operator labor was the most important advantage, though many also noted a saving on expense for hired labor. The most significant disadvantage was that the two herbicides were occasionally difficult to obtain. Three farmers also noted that the practice as formally recommended led to poor control of a problem weed, "chuchuyante;"[4] one farmer noted, however, that the addition of another herbicide, Tordon[5] to the herbicide mix handled the problem nicely. See Table 6-6 for the complete distribution of perceived advantages and disadvantages.

Farmers were also specifically asked what additional tasks they would undertake in place of the now unnecessary hoeings on maize (See Table 6-7). No farmer expected to increase maize area; on the contrary, the most common response was to the effect that freed labor be best used in intensification (pruning, weeding, etc.) of citrus orchards, though one farmer decided that an annual vacation would be in order.

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[4]Family caryophyllaceae.

[5]The commercial herbicide Tordon is composed of two parts 2,4-D and one part "Tordon," which is chemically known as 4, amino-3, 5, 6-trichloropicolinic acid plus 2,4,5-T.

Table 6-6

Farmer Perception of Advantages and Disadvantages of Chemical Weed Control

Advantages and Disadvantages	% of "Users" Reporting:[a]
Advantages:	
Saves operator time	86
Saves hired labor expenses	43
Maintains a cleaner field	29
Leads to higher yields	29
Disadvantages:	
Occasional problems of availability	43
Poor control of "chuchuyate"	43
Gramoxone too expensive	14
No disadvantages	29

[a]Percentages sum to over 100% because multiple answers were allowed.

Table 6-7

Expected Use of Operator Labor Freed by Use of Chemical Weed Control, "Users" Only

Expected Operator Labor Use	% "Users" reporting:
	%
Intensify citrus production	57
Weed bananas more frequently	29
Expand banana area	14
Plant beans	14
Plant papaya	14
Stop using hired labor in maize	14
Rest and/or travel	14

Two other advantages to chemical weed control were hypothesized by researchers: Decreased insect damage and improved timeliness of planting.[6] "Users" were asked if insect damage had been greater in fields with chemical weed control or with conventional weed control. Six "users" perceived more insect damage under conventional weed control. Whether this is due, in fact, to weed control measures or to slope is uncertain. One farmer detected no difference in insect damage over the two fields. Only one farmer found that herbicide use allowed him to plant on time in the face of weather that delayed the planting of his field using conventional weed control.

An important expected disadvantage of chemical weed control, the problem of residuals, was not well addressed in the study. Farmers were asked to report any difficulty with a squash or bean crop planted after the maize crop, that might be attributable to herbicide residuals. Only two "users" reported such a post-maize crop but saw nothing out of the ordinary in that crop's development.

Another expected disadvantage to the use of chemical weed control in maize production was lack of alternate employment opportunities for owned tractors and horses. No "users" reported owning a tractor, but five of them owned a horse that was used for agricultural purposes. In fact, of course, little or no displacement took place, as "users" had only used hoes on sloped land.

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[6]These hypotheses were inspired by comments from a farmer in an informal conversation.

6.2.5 Farmer Prescriptions Regarding Chemical Weed Control

The seven "users" of the recommended herbicides clearly prescribe the use of these herbicides, i.e., they have processed the positive and normative information available to them (some of which is summarized above) and have made the decision to use chemical weed control, at least on slopes. Four "users" have both expressed this determination and practiced it (by continuing chemical weed control after the farmer trial) while the other three, the tentative "users," have only expressed this decision.

Users were asked to select the preferred weed control practice for three weather conditions: Drought, excess moisture and normal weather. Despite their limited acquaintance with herbicides, chemical weed control was overwhelmingly preferred for all three. See Table 6-8.

Table 6-8

Expressed Farmer Preference for Weed Control Practice, by Weather Condition

Weather Condition	% Users who prefer:		
	Chemical Weed Control %	Conventional Weed Control %	Indifferent %
Drought	86	0	14
Excess moisture	100	0	0
Normal weather	100	0	0

Of special interest are farmer suggestions for modifications of the recommendations. These suggestions are prescriptions in that they reflect actual farmer decisions regarding the right way in which to use chemical weed control:

(1) If "chuchuyate" is a problem weed, one farmer suggests adding the herbicide "Tordon" to the herbicide mix;

(2) Four "users" emphasize the need for a machete chopping prior to herbicide applications, the required labor input depending on the weed population;

(3) One farmer, who has been using chemical weed control for four cycles, notes that Gramoxone applications become increasingly small and eventually unnecessary as fewer and fewer weed seeds germinate. He views Gramoxone use as an initial investment and not as a recurrent expense.

No farmer prescription is yet apparent regarding the use of chemical weed control on flat lands.

6.3 Suggestions for Change in Research and Policy Related to Chemical Weed Control

In general, collaborating farmers were pleased with the results of farmer trials regarding the recommendation for chemical weed control. Farmers having tried this practice are continuing its use, with a few modifications. A few ideas on changes in experimentation stem from these modifications introduced by farmers. Other ideas for changes stem from the fact that neither past experiments nor farmer assessment addressed several questions of obvious interest.

6.3.1 Suggestions for Change in Agronomic Research

In the past, chemical weed control experiments have only been conducted on a given field for one or two continuous cycles. It is apparent that the division of chemical weed control experiments into those dealing with the initial cycle of herbicide use, and those dealing with the effects of continued use, would be useful.

For example, the formal "zero tillage" recommendation prescribes the use of paraquat to kill off existing weed cover. One farmer, however, notes that after several cycles of herbicide use, paraquat use is no longer warranted by the weed cover. One or more "extended experiments," each conducted for several cycles on the same field, would allow researchers to make more precise herbicide dose recommendations for conditions of continued herbicide use. If it is true that continued use of paraquat is unnecessary, the chemical weed control recommendation would become even more attractive to farmers. These same "extended experiments" would also provide currently unavailable information on the effects of atrazine residuals on subsequent crops of squash and beans.

In addition, "extended experiments" would provide information relative to shifts in the weed population that are due to dependence on chemical weed control. Such research could lead to recommendations for herbicide mixes and doses that change over time -- or to recommendations for crop rotations helpful in controlling problem weeds. This suggestion, though general, was inspired by a specific modification made by one farmer in the herbicide recommendation; he advocated the inclusion of "Tordon" in the herbicide mix to control the problem weed, "chuchuyate."

Experiments on chemical weed control under zero tillage conditions have been restricted to RD3 (sloped vertisols). Experiments using zero tillage should be performed in RD's 1 and 2, also.

Effectiveness of these experiments would be enhanced if a direct comparison were made between zero tillage and conventional tillage. No experiments comparing the two tillage systems are needed for RD3 (sloped vertisols) because farmer assessment of chemical weed control (in which most farmers also used zero tillage) in that RD indicates that farmers prefer it to the current practice of hoeing.

In farmer assessment of chemical weed control, farmers perceived more insect damage under conditions of conventional weed control (on flat lands) than under conditions of chemical weed control (on slopes). Furthermore, farmers' expectations of yield loss due to insect pests (under conditions of conventional tillage) are substantially greater than the yield loss observed in insect control experiments (under conditions of chemical weed control), even when slope is held constant.

Two roads are open to examine the substitute relation between insecticides and herbicides that is suggested by the above. The first is to conduct insect control experiments under conditions of conventional tillage and weed control, to see if the profitability of insecticide use is increased by the presence of more weeds. The second (and probably better approach) is to conduct factorial experiments with the following treatments: Chemical weed control (recommended practice) and conventional weed control (farmer practice) by no insect control (possible future recommendation) and one early application of insecticides (farmer practice). If strong substitution is found to exist, one further piece of research would be of great interest: Farmer assessment of insect control under conditions of chemical weed control. If adoption of herbicides induces herbicide "users" to drop insecticides, this would increase the profitability of herbicide use and enhance its attractiveness to farmers.

6.3.2 Extension Activity Related to Chemical Weed Control

Given the favorable farmer assessment of chemical weed control, as given by collaborators in farmer trials, it would seem logical that a next step be the training of extensionists in use of herbicide recommendations, and the promotion of these recommendations to farmers. As the activities of the extension service are tied to the policy of the official bank, however, this proposed change in extension activity depends on policy change to be discussed immediately below.

6.3.3 Policy Change and Chemical Weed Control

The status of most target farmers as "ejidatarios" means that few sources of production credit are open to them. The major exception to this is the official bank, with two branches in the study area. The Poza Rica branch of the official bank, the branch attending most target farmers, has maintained for several years a policy whereby loans are restricted to fields tilled by tractor.[7] In effect, this constrains bank activities to flat lands. "Users" of chemical weed control prefer to use this practice on sloped fields. Bank policy, then, precludes loans involving the chemical weed control practice favored by farmers. Furthermore, the bank's current technology has

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[7]Extension agents in the study area, personal communication.

no place for chemical weed control. Herbicides are simply not included in the loan.

This is unlikely to be, however, a major obstacle to adoption of this practice by RD3 farmers. It was shown in Table 6-5 that chemical weed control is cost reducing and probably reduces cash requirements. Of greater importance is the potential role of the extensionist in providing information to farmers.

The favorable assessment given by farmers to chemical weed control, in conjunction with the small number of farmers using this practice and the equally small number that know of it, lead to the conclusion that it has been lack of information regarding the practice that has constrained farmer adoption. If the extension service were used in a program of expanded farmer trials and demonstrations, herbicide use on maize would very likely grow rapidly. The extension service is constrained, however, to promote the current bank technology, which is formally obtained from INIA (Instituto Nacional de Investigación Agrícola). The implication is that, if the official bank's maize recommendations were modified to allow inclusion of herbicides, the extension service could proceed in the indicated direction.

All of the above assumes that chemical weed control should be recommended, however, even in the context of social costs and benefits. As mentioned in section 6.1, these include the costs and benefits of herbicide residuals, of increased unemployment in the study area, and of effects on maize prices and imports. Before a decision is made to change the policies of the official bank and INIA, independent analyses of the above questions should be conducted.

CHAPTER 7

MAIZE VARIETIES AND DENSITIES--
RECOMMENDATIONS AND FARMER ASSESSMENT

7.1 Results of Variety Experiments

The only set of experiments useful in pooled economic analysis of variety comparisons on farmers' fields are the six experiments on "variety by density."[1] The variety by density experiments include the comparison of five varieties by three levels of a target plant population: 25,000, 50,000 and 75,000 plants/hectare. The varieties selected for comparison usually include some experimental material not available to farmers. In fact, only two varieties available to farmers could be identified as common to the six experiments in question: the farmers' variety ("criollo") and "Tuxpeñito," an early, short statured, open-pollinated maize variety sold in the study area as an improved variety.[2] The Tuxpeñito seed compared with criollo seed in the experiments was obtained from PRONASE

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[1]Regular "variety trials" have been carried out under (unrepresentative) experiment station conditions. Moreover, the farmer's local variety, "criollo," was often not included in the comparison. The unreplicated "verification" trials also offer an opportunity for variety comparisons. The identification of common treatments over experiments, however, was found to be extremely difficult because of frequent changes over cycles.

[2]"Tuxpeñito" is, in fact, derived from "criollo" and reflects the results of eleven cycles of selection for shortness of stature.

(Promotora Nacional de Semillas). A common application of 100 kg/ha of nitrogen was applied; weed control was based on herbicides.

Since only six variety by density experiments were identified that contained common treatments, no breakdowns by RD or by cycle were made. Experimental results indicate that the only profitable movement is from "criollo" at 25,000 plants/hectare to "Tuxpeñito" at 50,000 plants/hectare. A MRR of more than 300% was obtained through a modest yield increase, with little additional cost. (See Table 7-1.) A "t" test using paired comparisons found yields for "Tuxpeñito, D = 50,000" and for "Criollo, D = 25,000" to be significantly different at the .20 level (t = 1.57).

The density recommendation noted above confirms the recommendation derived from analysis of nitrogen by density experiments. (See Chapter 5.) Experimental evidence indicates that an interaction between the varieties and densities noted above does exist: Tuxpeñito does comparatively better at higher densities. This may be seen by a glance at Table 7-1: The change from a target density of 25,000 plants/hectare to one of 50,000 plants/hectare brings about a 200 kg/ha adjusted yield increase for Tuxpeñito but only a negligible increase for criollo.

7.2 Farmer Assessment of Maize Varieties

Economic analysis of agronomic data indicates that "Tuxpeñito" is recommended over the local variety, "criollo," if accompanied by an increase in target density from 25,000 to 50,000 plants per hectare. No breakdowns by recommendation domain or maize cycle were obtained.

Table 7-1

Economic Analysis of Six Variety by Density Experiments, Combined RD's and Cycles

Variable	Criollo D25[1]	Tuxp. D25	Criollo D50	Tuxp. D50	Criollo D75	Tuxp. D75
Yield (MT/ha)[2]	2.8	2.6	2.8	3.1	3.0	3.1
	(.28)	(.20)	(.37)	(.53)	(.41)	(.57)
Adjusted yield[3] (MT/ha)	2.2	2.1	2.2	2.4	2.4	2.5
Gross benefit[4] (pesos/ha)	4950	4597	4771	5112	4920	5089
Seed cost[5] (pesos/ha)	26.5	31.5	53	63	79.5	94.5
Varying cost (pesos/ha)	326.5	331.5	353	363	379.5	394.5
Net Benefit (pesos/ha)	4624	4265	4418	4749	4540	4690
	MRR = 342%					

[1]D25 = 25,000 plants/ha, etc.

[2]Numbers in parentheses are standard errors.

[3]Reduced by 20%, MT/hectare.

[4]Field price of maize = \$2.65/kg - .10 (transport) - .10 (shelling) - harvest cost: If D = 25 then harvest cost - \$.24/kg, so FP = \$2.21/kg; If D = 50, then H.C. = .32/kg, so FP = \$2.13/kg; If D = 75, then H.C. = \$40/kg so FP = \$2.05/kg.

[5]Criollo = \$2.65/kg. Tuxpeñito = \$3.15/kg. For each 10,000 plants/ha, 4 kg/ha of seed is required.

Nonetheless, only 12% of farmers in the study area planted this variety in either the 1978 B (wet) cycle or the 1979 A (dry) cycle. Another 7% planted a hybrid but most farmers (81%) planted "criollo."

All of the information used in farmer assessment of varieties, to be presented below, was obtained in the August 1978 random survey. Not all respondents of that survey were requested to give information on maize varieties, however. A random subsample of 83 farmers (67% of all respondents) were selected for this task.

7.2.1 Division of Farmers by Use Class

The 83 farmers selected to report on maize varieties were divided into use classes according to their use of the Tuxpeñito variety. As noted, 12% of these respondents reported planting Tuxpeñito. However, not all of these "current users" should be fully classified as "users." Almost half of these "current users" expect to drop the use of this variety because they are planting citrus seedlings in fields previously reserved for Tuxpeñito maize. As the citrus orchards reach maturity, Tuxpeñito production will decline and eventually disappear in these fields. However, farmers will continue to cultivate some "criollo" maize in other fields. In this context, only 7% of the 83 respondents can be fully classed as "users," in the sense that they currently use Tuxpeñito and expect to continue with its use.

Fully 46% of respondents report having personally tried "Tuxpeñito" at one time or another. As only 12% are currently using the variety in question, 34% (i.e., 46% - 12%) may be classed as "ex-users." The small group of current users who expect to drop the variety in question, as noted above, could be added to these "ex-users." To maintain clarity in the interpretation of user classes, however, these "expected future ex-users" (as we may call them) will be excluded from both "user" and "ex-user" groups.

Of the remaining respondents, not all may be classed as "non-users." While 54% of the 83 respondents have never planted Tuxpeñito, only 36% of all respondents reported rejecting the use of Tuxpeñito based on, for them, sufficient information. The information used by these farmers was obtained from conversations with other farmers and from observation of the other farmers' fields.

The remaining farmers (18% of respondents), who reported being unfamiliar with "Tuxpeñito", are excluded from the analysis.

7.2.2 Positive Information -- Farmer Use of Maize Varieties

"Users" of Tuxpeñito planted it at an average planted density of 49,282 plants per hectare.[3] They had planted Tuxpeñito, on at least one part of their land, for an average of 3.5 maize cycles. No Tuxpeñito "user" reported using fertilizer with that variety.

"Ex-users" of Tuxpeñito planted it, during their final use of this variety, at a density very similar to that employed by "users:" 47,820 plants per hectare, on the average. Average number of cycles in which this variety had been used was somewhat lower, at 1.9 cycles. Again, no "ex-users" were discovered who reported having used fertilizer with Tuxpeñito.

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[3] Density was calculated for each farmer from survey data on distance between hills and the number of seeds per hill. Roughly one-third of those seeds will not lead to a harvestable plant, so a planted density of 49,000 plants/hectare would lead to a harvested density of roughly 32,500 plants/hectare.

It is interesting to compare use practices by these same "ex-users" of Tuxpeñito when they reverted to "criollo." For the 1978 B (wet) cycle, "ex-users" of Tuxpeñito planted "criollo" at the lower average density of 40,763 plants per hectare. This is very comparable to the average density of 40,124 plants per hectare reported by "non-users" for the same cycle for "criollo." Neither "non-users" nor "ex-users" reported using fertilizer on "criollo."

7.2.3 Normative Information -- Farmer Perceptions of the Advantages and Disadvantages of Using Tuxpeñito

Respondents were requested to list, in an open-ended question, the advantages and disadvantages of Tuxpeñito use. All farmers -- "users," "ex-users" and "non-users" -- are in general agreement regarding these attributes. Resistance to lodging and the characteristic of earliness were the perceived advantages, with "users" also perceiving a yield increase over criollo. Major disadvantages included susceptability to insect attack in storage, the thickness of the cob and increased insect foliar damage. "Ex-users" also perceived a yield decrease when switching from "criollo" to Tuxpeñito, whereas the primary concern of "non-users" was the investment cost of the seed, with the implication that yield increase expectations are low given the low investment cost of 250 pesos per hectare. See Table 7-2 for the percentage of farmers perceiving given problems and advantages, by use class.

It was mentioned in Chapter 4 that many farmers view lodging as a fairly serious problem in maize production. It is easy to

Table 7-2

Percent of Respondents Reporting Listed Advantages and Disadvantages of Tuxpeñito Maize, by Use Class

Advantages and Disadvantages	Users	Ex-Users	Non-Users
Advantages:			
Lodging Resistence	86	86	44
Earliness	86	76	22
Yield Increase	43	14	22
No Advantage	0	10	0
Disadvantages:			
Insect Damage in Storage	86	95	17
Cob Thickness	57	71	20
Foliar Damage by Insects	57	33	7
Seed Price	0	0	33
Yield Decrease	0	57	13
Difficulty of Shelling	0	10	10
Lack of Drought Tolerance	0	14	0

understand why they view as an advantage the ability of the short Tuxpeñito variety to remain upright during the strong September winds. It is equally easy to understand their appreciation of Tuxpeñito's earliness: A shorter maize cycle increases the flexibility of cropping patterns, reduces cash flow problems by allowing an earlier source of income, and smooths out the demand for labor during the peak May-July period. There is more time to harvest the dry cycle crop and prepare the land for the next cycle.

Regarding disadvantages, farmers were specifically asked which of the listed problems was most important. 71% of "users" and 79% of "ex-users" stated that the most important problem with Tuxpeñito was its susceptibility to weevil damage in storage. In informal conversation with an exploratory survey, many farmers noted that maize comes from the field already infested and that, for practical purposes, it was impossible to store for purposes of human consumption for any length of time. These farmers blamed this difficulty on poor husk cover: They noted that the Tuxpeñito husk is weak, loose and does not entirely cover the ear. The "criollo" husk, on the other hand, they view as tight and completely covering the ear. Furthermore, in these same informal conversations, farmers indicated that the second most commonly mentioned problem with Tuxpeñito -- thick cobs -- is related to this storage problem. Farmers think that the inadequate husk of Tuxpeñito is caused by an extraordinary thickness of cob.

An attempt was made to measure storage losses for Tuxpeñito maize. While farmers felt that "criollo" could be stored for 2-3 months with only 10% loss and 4-5 months with about 30% loss, they rejected the idea of Tuxpeñito storage for more than 1-2 months. In support of this conclusion, it was found that all "users" sell their Tuxpeñito maize immediately after harvest, storing none for family consumption. In light of decreasing annual crop area and an increasing relegation of maize production to the supply of family food requirements that must accompany this shift in land use, this lack of storability becomes serious indeed.[4]

7.2.4 Farmer Prescriptions Regarding Maize Varieties

Tuxpeñito "users" prescribe the use of the Tuxpeñito variety at a planted density of nearly 50,000 plants per hectare, for cash sale rather than for family consumption. For maize cycles with adverse weather (drought or excess moisture), "users" felt that little difference exists between the performance of Tuxpeñito and criollo, i.e., if they could forecast bad weather they would be indifferent to variety. At any rate, the use of Tuxpeñito is not seen as risky in the light of possible bad weather. For sowing on hillsides, however, even "users" prescribe "criollo." They feel that the yield advantage of Tuxpeñito appears more markedly on flat, well-tilled soils.

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[4]Farmers are not alone in complaining of storability problems with Tuxpeñito. A CONASUPO warehouse official in the study area informed me that Tuxpeñito maize must be fumigated twice as often as criollo maize.

Clearly, for the few "users," the perceived advantages outweigh the disadvantages. They perceive a yield increase not perceived by "ex-users" or "non-users," and have learned to handle the poor storability of the variety by simply not storing it.

"Ex-users" prescribe the use of "criollo" at a planted density of around 40,000 plants per hectare. "Ex-users" attribute this decision largely to the perceived lack of storability of Tuxpeñito.

Finally, "non-users" prescribe the use of "criollo," largely because they don't think that the initial investment cost will be well spent. In August, 1978, Tuxpeñito seed was selling for $12.50 per kg in local input stores. Farmers need about 20 kg per hectare of this seed to attain a density of around 50,000 plants per hectare. Therefore, an initial investment of $250 per hectare is required. Given the poor reputation of the variety among the numerous "ex-users," "non-users" may well be concerned with this use of their scarce capital.

7.3 Changes in Research and Policy Related to Variety Choice

Results of on-farm experiments lead to a recommendation for the use of the "Tuxpeñito" maize variety, at a target density of 50,000 plants per hectare, instead of "criollo," the local variety. This short, early variety was tried by almost half of the farmers in the study area but was dropped by most of them. The major reason for dropping the use of this variety is its inability to be stored under farmer conditions.

The major suggestion for change in research is directed towards breeders: They should be aware that storability is as important to target farmers as earliness or shortness.

In the meantime (until a storable improved variety is developed) other changes in agricultural research may be suggested. Non-variety experiments conducted for the purpose of making recommendations for farmers should use "criollo" and not Tuxpeñito as base or blanket practice. Experiments on harvesting dates may be conducted, to see if insect attack is due to late harvest of this early variety. Likewise, agronomic and economic research should be undertaken on the use of insecticides to enhance the storability of Tuxpeñito.

Finally, in the light of the above information, the extension service and the official bank should re-consider their policy of including Tuxpeñito as a recommended input in their program of production credit for small farmers.

CHAPTER 8

INSECT CONTROL PRACTICES: RECOMMENDATIONS AND FARMER ASSESSMENT

8.1 Results of Insect Control Experiments

Over the years, nineteen insect control experiments have been conducted that make comparisons among no insect control, granular applications of Birlane insecticide in the world and applications of Furadan, a systematic insecticide, in the hole with the seed at planting.

Within the nineteen experiments mentioned, a variety of treatments was used: no insect control, a single application of Birlane, two applications of Birlane, one application each of Birlane and Furadan, a single application of Furadan only, and two applications of Furadan. In an effort to use common practices from the same experiments, eleven experiments were identified that each contained the following treatments: no control, a single application of Birlane and a double application of Birlane. These treatments were chosen to avoid the inclusion of Furadan in the analysis, for the following reason: Neither Birlane nor Furadan is commercially available in Mexico, but Birlane use more closely represents the current farmer practice of insect control. This current practice is the application of parathion one or more times, especially when the plant is small. Farmers do not use systematic insecticides on maize and no good substitute for Furadan is available.

When the data are combined over cycles and over RD's, pooled economic analysis indicates that a single application of Birlane is, indeed, profitable. The second application of Birlane, however, seems to be unnecessary. (See Table 8-1.) A "t" test using paired comparisons indicates that there is significant difference (.20 level) between yields associated with the "no insecticide" treatment and those associated with the "Birlane once" treatment ($t = 1.55$).

8.2 Farmer Assessment of Insect Control Practices

A single application of the insecticide Birlane was more profitable than no insect control. The date of this application varied in the experiments between 30 and 45 days after planting.

The data used in farmer assessment of insect control practices were obtained in the April 1979 random survey. All respondents could be classified as "users." Although only 80% of respondents used insecticides in the 1978 B (wet) cycle and only 64% used them in the 1979 A (dry) cycle, all farmers had used them in the past. Of farmers not using insecticides, most (82%) decided not to use them simply because they noticed no infestation in their fields. It seems that this is not an infrequent occurrence. More than half of the respondents noted that they did not automatically spray their maize each cycle, but rather waited for signs of insect attack before doing so. Thus, "users" follow a practice of "insect control whenever merited by infestation."

Table 8-1

Economic Analysis of Eleven Insect Control Experiments
Combined Cycles and RD's

Variable	NO Insecticide	Birlane Once	Birlane Twice
Yield (MT/ha)[1]	3.05 (.23)	3.32 (.35)	3.38 (.34)
Adjusted yield[2] (MT/ha)	2.4	2.7	2.7
Gross benefit[3] (pesos/ha)	5319	5790	5894
(Labor man-days/ha)	0	2	4
Labor value[4] (pesos/ha)	0	100	200
Insecticide quantity (kg/ha)	0	8	16
Insecticide value[5] (pesos/ha)	0	92	184
Varying costs (pesos/ha)	0	192	384
Net Benefit (pesos/ha)	5319	5598	5510
	x $\xrightarrow{\text{MRR = 145\%}}$		

[1]Numbers in parentheses are standard errors.

[2]20% reduction, MT/ha.

[3]Field price of maize = \$2.18/kg.

[4]Wage = \$50/day.

[5]Birlane = \$11.5/kg.

8.2.1 Positive Information -- Farmer Use of Insecticides

Surprisingly, insecticide use is a relatively new practice. Although a few hardy innovators have used insecticides since the 1950s, most farmers (83%) only began using them since 1970. Informal conversations with farmers indicate that they have only noted an insect problem for the last 7-9 years--that before 1970, insects caused negligible losses. The sudden increase in perceived damage, however, seems to have caused them to spontaneously and consciously seek a remedy. This movement does not seem to have been due to extension activities.

A wide variety of insect pests is reported as troublesome. The fall armyworm ("gusano cogollero"), the white grub ("gallina ciega") and a species of leafhopper ("mosca pinta") were noted as especially common problems. (See Table 8-2 for details on the distribution of problem insects.) There seems to be little variation across recommendation domains regarding insect incidence.

The distribution of problem insects by period in the growing cycle is reported as being of importance, however. In the first few weeks of plant growth, fall armyworms and leafhoppers are seen as pests but subsequently (knee-high to flowering) fall armyworms, stem borers and measuring worms are the prevalent problem. This may be seen in Table 8-3.

To combat these insects, 64% of respondents applied insecticides at least once to their maize during the 1979 A (dry) cycle, while 34% applied them twice and only 3% applied them three times. Regarding the first application, RD1 farmers (alluvial soils) preferred

Table 8-2

Percent of Farmers Reporting Given Insects as Serious Pests

Insect	Percent of Farmers Who Consider it a Serious Pest
Cogollero[1]	93
Mosquita blanca[2]	27
Mosca pinta[2]	42
Palomilla[2]	37
Lorillo[2]	31
Gallina ciega[3]	55
Lenguilla[4]	5
Barrenador[5]	24
Medidor[6]	37

[1]Fall armyworm

[2]Leafhoppers

[3]White grub

[4]Slug

[5]Stem borer

[6]Measuring worm

Table 8-3

Percent of Farmers Reporting Given Insects as Serious Pests, by Plant Growth Stage

Insect	Percent of Farmers Reporting As a Serious Pest: In the First Few Weeks of Growth	Percent of Farmers Reporting As a Serious Pest: Knee-high to Flowering
Fall Armyworm	47	79
Leafhoppers[1]	34	0
Stem Borer	0	24
Measuring Worm	0	37

[1]Mosquita blanca, mosca pinta, palomilla, lorillo.

the use of DDT whereas farmers from RD's 2 and 3 (flat and sloped vertisols, respectively) preferred Foley (methyl parathion, 50% a.i.). There was little difference between RD's on application dates, however. The first application was made, on the average, 3.1 weeks after planting. The less common second application was made 6.8 weeks after planting. Those farmers applying Foley reported (almost unanimously) a dose of 0.25 lt/hectare of commercial product. DDT users reported applying 6-8 kg/hectare, of the commercial product Dragon.

Application labor is low. Farmers report using 1.7 man-days per hectare in the first application and 2.6 man-days in the second. These estimates include the labor required for hauling water and sprayer preparation. Details on insecticide use for both cycles may be found in Table 8-4.

8.2.2 Normative Information -- Farmer Perceptions of Advantages and Disadvantages of Insecticide Use

The universally reported advantage of insecticide use is the reduction in yield loss due to insect pests. Farmers perceive insect damage as potentially serious. When asked what would be a likely production loss in the face of a normal infestation if spraying were not undertaken, 73% reported that they would expect to lose more than half of their crop, while only 6% thought that losses would be small.

However, almost half of the respondents (41%) also reported that foliar damage by the fall armyworm or other insects during the period

Table 8-4

Information on Insecticide Use, by RD and Cycle

Variable	1978 B (wet) Cycle				1979 A (dry) Cycle			
	RD1	RD2	RD3	All RD's	RD1	RD2	RD3	All RD's
% farmers using Foley	23	59	72	57	8	76	71	58
% farmers using Aldrin	54	6	6	17	NA	NA	NA	NA
% farmers using DDT	8	10	18	14	69	8	13	24
% farmers using other	15	25	4	12	24	16	13	16
% farmers applying once	62	86	82	80	NA	NA	NA	64
% farmers applying twice	8	47	28	32	NA	NA	NA	34
Timing - first application[1]	NA	NA	NA	2.7	NA	NA	NA	3.1
Timing - second application[1]	NA	NA	NA	4.6	NA	NA	NA	6.5
Labor - first application (man-days/ha)[2]	NA	NA	NA	NA	1.7	1.6	1.7	1.7
Labor - second application (man-days/ha)[2]	NA	NA	NA	NA	2.5	2.2	2.4	2.4

[1]Timing of first or second application (weeks after planting).

[2]Labor requirement per hectare for first and second applications assuming sprayer use and including hauling water.

of rapid plant growth (knee-high to flowering) would have only a negligible effect on yields -- an opinion also held by agronomists in the study area.[1] The implication (which in turn is supported by informal conversations with farmers in the study area) is that it is the insect damage incurred in the first weeks of plant growth that causes yield reduction. This is likely to be due to the reduction of plant stand, in turn due to the killing of the growing point (fall armyworms) or to the spreading of virus diseases (leafhoppers). It is instructive that, in visits with farmers to their fields, farmers were found to attribute to "insects" damage that was really caused by virus.

Farmers were, on the whole, unwilling to acknowledge disadvantages to insecticide use. One may assume, then, that the main disadvantage is the cost of the treatment. Using the farmer practice of Foley application as a base, treatment cost per application would include the following: $30 per hectare for Foley, $100 per hectare for application labor (including the carrying of water), and $57 of sprayer cost on a per cycle and per hectare basis. Total increased costs that are due to insecticide use, then, are $187 per hectare. If one adds on 40% for cost of capital (i.e., the minimum desired return to expenses incurred, including the opportunity cost of family labor), the costs to be recovered are $261.80 per hectare. Pricing maize at $2.18 per kg (the field price of maize) a yield increase of only 120 kg/hectare would be sufficient to pay this.

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[1] CIMMYT agronomists, personal communication.

8.2.3 Farmer Prescriptions Regarding Insecticide Use

Farmers almost universally prescribe the use of insecticides, whenever infestations are "high enough" to warrant such use. In a given cycle, the majority of farmers perceive an infestation that is, indeed, "high enough."

8.3 Suggestions for Changes in Research and Policy Relative to Insect Control

Farmers agree with the results of on-farm experiments that the use of insecticides is profitable. Farmers believe that application of insecticides is even more profitable than indicated by the experiments; their perceived yield loss due to insect pests is higher than that observed in experiments.

One possible reason for this has already been advanced: Herbicide use (a blanket practice in insect control trials) may reduce the insect population and, hence, make insecticides less profitable. Farmer assessment of insect control under conditions of chemical weed control is clearly a necessary next step in research. A new experiment to detect the hypothesized substitute relation between insecticides and herbicides would be helpful. (See Section 6.3.)

Farmer assessment indicates that farmers are concerned primarily with insect attack (fall armyworm and leafhoppers) during the very early stages of plant growth. In this light, treatments included in future insect control experiments should reflect this interest in very early control.

Another suggestion for the re-design of insect control experiments refers to the insecticide alternatives included in experimental treatments. Insofar as trials have as their purpose the making of recommendations to farmers, either insecticides commercially available to farmers should be used in place of Birlane and Furadan or these two insecticides should be made available.

One final suggestion for changes in insect control experiments may be made. The "farmer practice" detected in farmer assessment is to apply insecticides when "merited" by infestation. On-farm experiments should be designed to determine just what is the level of infestation (as measured by some easily-applied criterion) that makes insecticide use profitable.

The only change in policy that is apparent in the case of insect control is to make Birlane available to farmer: Agronomists report that it is less toxic than parathion and hence less dangerous to users.

CHAPTER 9

CONCLUSIONS

The primary objectives of the study were to develop procedures for farmer assessment of new technology and to use these procedures to assess maize technology developed for farmers in N. Veracruz by CIMMYT's Maize Training Program.

Farmer assessment of new technology is seen as an extension of current procedures for on-farm research. Such research, whose purpose is the design of new agricultural technology useful to farmers, has become increasingly important both at international research centers and in national research programs. Recently, a new role for the economist in on-farm research has been identified: the study of farmer problems and circumstances in order to help plan agronomic experiments. On-farm research, including the economist in this _ex-ante_ role, has gradually become integrated in several national research programs during the last several years.

As experience in on-farm research accumulates, a need is arising to evaluate the results of such research before moving into extension. To be useful, such evaluation must provide timely feedback to researchers and must be sufficiently inexpensive that national research programs may implement it without straining resources. In an effort to develop such evaluation procedures, the current study on "farmer assessment" was undertaken.

Farmer assessment of new technology may be distinguished from other kinds of evaluation research. It is different from adoption studies in two respects. First, it is characterized by speedy acquisition and analysis of data, to insure timely feedback to researchers. Second, it necessarily has a problem-solving focus. Adoption studies, in comparison, are frequently conducted several years after a new technology has been released and are often examples of subject-matter research. Farmer assessment of technology may also be distinguished from monitoring and evaluation of research programs in that the former focuses on the technology itself while the latter focuses on the program that develops the technology.

Farmer assessment has several specific goals. They are listed below, with corresponding examples from the case of farmer assessment of maize technology in N. Veracruz, Mexico.

(1) Identification of unexpected problems with the new technology: As problems with a technology are identified, feedback may be directed towards breeders, agronomists, and policy-makers. In the current study, maize breeders were made aware of the poor storability of the recommended Tuxpeñito variety, and of the high value placed by farmers on storability. Agronomists were made aware of the need to re-design on-farm trials in light of problems of input availability and inadequate variety performance. Information useful to policy-makers was generated regarding the need to change availability patterns for fertilizers and insecticides.

(2) Identification of farmer innovations: Farmer suggestions on the importance of machete chopping before herbicide application, on the timing of insecticide application and on the possibility of a substitute relation between insecticides and herbicides all lead to new avenues of inquiry for researchers.

(3) Research versus extension priorities: Fertilizer recommendation (if the proper fertilizer may be made available) were found to be especially ready for extension. Weed control recommendations should be subjected to further research (multiple-cycle private effects and social effects) before

being extended, although their single-cycle private effects were found to be acceptable to farmers. Regarding variety, emphasis should be placed on research, not extension.

9.1 Empirical Conclusions

In general, farmer assessment of maize technology in the study area uncovered various ways in which recommendations were not suitable for farmers. Assessment also provided clear guidelines for the direction of future research. Results of assessment are presented below, practice by practice:

Whether tillage was conventional (tractor or horse) or "tillage" was performed by herbicides, results of agronomic experiments indicated that chemical weed control should be profitable for farmers. The exact recommendations were as follows: (1) Under conditions of conventional tillage, apply a pre-emergence application of 2.5 kg/ha of Gesaprim Combi (40% atrazine + 40% igran), or (2) Under conditions of "zero tillage," an application of 2.25 lt/hectare of Gramoxone (18% paraquat) to kill off weed cover, followed by a pre-emergence application of 2.0 kg/hectare Gesaprim 50 (50% atrazine).

In the study area, only one "user" and no "ex-users" of the practice were identified in an attempt to conduct a purposive survey. Indeed, a random survey found no farmers to be familiar with this practice. Therefore, farmer trials were conducted. After farmer trials, seven "users" and one "ex-user" were identified. Thus, all but one of the farmers trying chemical weed control adopted the practice, i.e., they became "users." Their decision was based on their concept that the advantages (savings of operator labor, savings of expense for hired labor) outweighed disadvantages (herbicide expense, occasional problems of availability). It appears that this practice is often cost-reducing as well as yield-increasing.

"Users" suggested several modifications in the recommendations. For example, if "chuchuyate" is a problem weed, they suggested that one add "Tordon" to the herbicide mix. They viewed machete chopping before herbicide application as a must, with labor input proportional to weed cover. They furthermore observed that after using zero tillage on the same field for several cycles, the Gramoxone component of the recommendation may become unnecessary.

Based on the above, the following suggestions were made for changes in agricultural and policy research: (1) Divide chemical weed control trials into trials that examine effects of herbicide use in the first cycles of adoption and those that examine long-term effects; long term effects could include reductions in herbicide requirements, residual herbicide effects on bean and squash crops, and shifts in the weed population. (2) Conduct experiments on the hypothesized substitute relation between herbicides and insecticides, followed by farmer assessment of insect control practices by "users" of chemical weed control. (3) Conduct an analysis of the likely displacement of hired labor if herbicides were introduced on a larger scale in maize production; and (4) If labor displacement is deemed "sufficiently low" given alternative opportunities to use it, consider a change in the policy of the official bank and the extension service toward an emphasis on herbicides instead of (or in addition to) tractor tillage.

Fertilizer recommendations obtained from experimental data were different for each recommendation domain: RD1 farmers (on flat alluvial soils) were advised to use 50 kg/hectare of nitrogen and 40 kg/hectare of phosphorous; RD2 farmers (on flat vertisols) were advised to use 50 kg/hectare of N but no P, RD3 farmers (on sloped vertisols) were advised to apply 40 kg/hectare of P, but no N. It was also found that cycle A (dry cycle) maize, should receive somewhat less nitrogen than cycle B (wet cycle) maize. Fertilizer use did not appear riskier than non-use.

A combination of random and purposive surveys was employed to identify "users" and "ex-users" of fertilizers for RD's 1 and 2. No "users" or "ex-users" could be found for RD3, so farmer assessment for that RD was not performed. In RD1, both "users" and "ex-users" applied only N at a mean dose of 46 kg/hectare, to the "criollo" variety. Perceptions of "users" and "ex-users" of the advantages and disadvantages of fertilizer use were similar: The major advantages were the expected yield increase of around 450 kg/hectare of dry maize, while disadvantages included increased lodging, fertilizer expense and drought risk. In the end, it was found that "ex-users" were distinguished by their decision to drop maize cultivation altogether or to only grow maize in rotation with (heavily-fertilized) tobacco. Furthermore, it was noted that almost all "users" were from a different ejido than that in which fertilizer trials were conducted; in fact, trials were only conducted in collaboration with a single farmer. Therefore, two suggestions were made for changes in research: (1) Broaden the geographical base of RD1 fertilizer experiments, and (2) Further stratify experiments by crop rotation (e.g., the maize-maize rotation vs. the maize-tobacco rotation).

In RD2, "users" were found to apply about 69 kg/hectare of nitrogen with no phosphorous, to the "criollo" variety. Fertilizer was obtained by "users" in Papantla on cash terms. "Ex-users," on the other hand, applied 18-46-0 at an N dose of 22 kg/hectare to the Tuxpeñito variety. It was obtained from the official bank in Poza Rica on credit terms. "Users" expected yields to increase by about 500 kg/ha but were concerned about fertilizer expense and possible losses due to drought. "Ex-users" in turn, only expected yields to increase by about 250 kg/ha and were concerned with fertilizer expense, possible losses due to drought, and the perceived necessity of collaboration with the official bank. Budgets indicated that the use of the bank's fertilizer recommendations (18-46-0) at the bank's prices is not profitable. Based on the above, the obvious suggestion for change in policy was that the official bank and the extension service consider the promotion of urea (or some other inexpensive source of nitrogen) in place of 18-46-0.

Results of agronomic on-farm experiments indicated that it should be profitable for farmers to shift from the "criollo" variety, at 25,000 plants/hectare, to the Tuxpeñito short variety, at 50,000 plants/hectare. Although almost half of the farmers in the study area had tried Tuxpeñito themselves, very few of them continue to use it. "Users" and "ex-users" alike praised the variety's resistance to lodging and its earliness; "users" also perceived a yield increase. The commonly perceived disadvantage is Tuxpeñito's susceptibility to insect damage in storage. Indeed, even "users" sold their Tuxpeñito maize immediately after harvest.

Several suggestions for changes in agricultural and policy research were as follows: (1) Breeders should be aware that target farmers consider storability to be as important as shortness and earliness; (2) Until a storable improved variety is available, non-variety experiments on farmers' fields should use "criollo" as a blanket practice; (3) The official bank and the extension service should re-consider their promotion of Tuxpeñito in the bank's package, and (4) Research should be initiated on alternative methods of storing Tuxpeñito under farmer conditions; possible solutions include earlier harvest dates and use of insecticides on husked ears.

Regarding insect control, economic analysis of pooled experimental data indicated that a single application of Birlane (8 kg/ha commercial) is profitable. Birlane, however, is not commercially available to target farmers. A random survey found that virtually all target farmers are "users" of an insect control practice of "insecticide use when infestation merits such use." The most popular farmer practice is the use of 0.25 lt/hectare of Foley (50% methyl parathion) in the very early stages of plant growth to control fall armyworms and leafhoppers. Farmers perceive much greater probable yield loss due to insects than is observed in experiments. Herbicides were used in insect control experiments, but were not used by farmers.

Based on the above, several suggestions were made for changes in agricultural research: (1) Conduct experiments to see if herbicides and insecticides are substitutes, and farmer assessment of insecticide use under conditions of chemical weed control, (2) In future experiments, emphasize insect control in the very early stage of plant growth, and (3) Use commercially available insecticides instead of Birlane and Furadan, or make these insecticides available.

As a result of farmer assessment, information was made available to breeders, agronomists and policy-makers that will be useful in the re-design of agricultural research and the adjustment of policy. Furthermore, the information obtained from farmers enabled extensionists to avoid the mistake of promoting an inappropriate package.

9.2 Methodological Conclusions

Farmer assessment of new technology has received relatively little attention in the past. CIMMYT scientists, for example, have recognized a need for a monitoring of farmers' experience with new technology but have done little to develop the corresponding procedures. ICTA (through its Socio-Economic Division) and IRRI (through its Cropping Systems Program) have each implemented a kind of farmer assessment of new technology, heavily based on the use of farmer trials. The current study indicates that the use of time-consuming farmer trials is not always necessary. Furthermore, these institutions paid inadequate attention to stratification of farmer into use classes, and stratification of the data to be gathered into knowledge classes. Both concepts proved useful in the current study.

Some of the results of farmer assessment could have been obtained through a proper *ex-ante* survey, i.e., a farm survey conducted before experiments were initiated. Fertilizer availability is an example. As expected, farmer assessment and *ex-ante* surveys are to a degree substitutes for one another. Much of the information would have been difficult to obtain ex-ante, however, because a knowledge of recommendations was needed in order to properly focus the survey. The fact that the only readily available fertilizer is 18-46-0 could have been ascertained ex-ante; this only gains importance, however, in light of experimental evidence indicating lack of response to P. Similarly, the close focus in farmer assessment on the Tuxpeñito maize variety was due to that variety's having been recommended over alternatives. Finally, only farmer assessment could have affirmed the usefulness of weed control recommendations as no farmers were familiar with the practice ex-ante.

The questions of "which farmers" should assess new technology was discussed in the study and led to an important contribution to assessment procedures. Since prescriptive information is important in farmer assessment, only "knowledgeable" farmers should participate. "Knowledgeable" implies that they have made a decision for or against use of the recommended practice based on, for them, sufficient information. It is not fair to include in assessment activities farmers who have not made up their minds. This, in effect, will at times restrict participation in assessment to ex-collaborators and early adopters. A useful stratification of "knowledgeable" farmers is that used in the study:

1) Users: Farmers who have decided to use an input or practice.

2) Ex-Users: Farmers who have decided to drop an input or practice after having tried it.

3) Non-Users: Farmers who have decided not to use the input or practice without having tried it. These should not be confused with farmers who do not use the input or practice because of insufficient information. In practice, it was not difficult to distinguish "non-users" from "farmers with insufficient information."

The present study's stratification of knowledge classes should also be viewed as a contribution to assessment procedures. Prescriptive information was needed to stratify farmers into the use classes mentioned above. It also reflected the farmer's judgment on the performance of the technology under his conditions, using his own criteria for success. Normative information led to the uncovering of unknown attributes of inputs and practices (e.g., poor storage quality of Tuxpeñito, use of herbicides to maintain low levels of insect damage, etc.). Positive information, frequently the only kind of information collected in farm surveys, allowed inferences to made regarding the performance of the technology under farmer conditions, using the researcher's criteria for success. For example, input-output relations observed by farmers were compared with those observed in experiments, in the case of fertilizer. All three kinds of information were needed for assessment activity.

Random and purposive surveys of farmers, and farmer trials were all found useful in conducting farmer assessment. Positive, normative and prescriptive information obtained from a random survey of farmers was sufficient to assess insect control recommendations, and variety-density recommendations. The assessment of fertilizer recommendations required the use of a purposive survey because a random sample identified only a few farmers who had taken a decision for or against fertilizer use based on, for them, sufficient information. The assessment of weed control recommendations required the use of farmer trials, as virtually no farmers familiar with the recommended practice could be found in the study area.

Farmer assessment of new technology has limitations, of course. A chief limitation is that it often relies on purposive surveys and/or purposively chosen collaborators for farmer trials. Researchers must be aware of the potential hazards of bias associated with purposive sampling. Researchers must also be especially on their guard against non-sampling errors; farmers who realize that the researchers conducting the assessment of a technology were intimately involved in its development may not be frank in their criticism of that technology. Finally, it should be noted that stratification of farmers into use classes, a key step in the advocated procedures, may not always be simple. This is especially true regarding the distinction between "knowledgeable" farmers and "non-knowledgeable," i.e., the distinction between those farmers with versus those without sufficient information on which to base an adoption decision.

9.3 Suggestions for Further Research

A number of questions related to procedures for farmer assessment of new technology merit further study.

1) What is a cost-effective mix of ex-ante survey work and ex-post farmer assessment? Under what conditions should one be emphasized at the expense of the other?

2) Farmer assessment of technology was conducted in the present study as a "one-shot" activity. What are the implications for farmer assessment procedures when assessment becomes an on-going activity? For example, can farmer panels replace one-shot surveys?

3) Farmer assessment in the current study was conducted for a single crop (in the context of the farming system), regarding a technology whose component parts demonstrated few strong interactions. Should farmer assessment procedures be adjusted when intercropping is present, or when many strong interactions among inputs are present? For example, how useful are one-shot surveys when major cropping system

changes are introduced? What is the most cost-effective way of conducting farmer trials of complicated new technology?

4) How well do the results of farmer assessment predict adoption rates of inputs and practices by farmers? How often do recommendations "cleared" by farmer assessment fail to be generally adopted by farmers?

5) How is farmer assessment best institutionalized? Should researchers in charge of assessment be the same ones responsible for the development of the new technology? How may results of farmer assessment be brought most effectively to the attention of policy-makers?

Farmer assessment was found in the present study to be a useful part of on-farm research procedures. Whether this result is generally true for different crops in different locations, under different institutional arrangements, will only be answered by future research.

APPENDIX

Questionnaire for Baseline Survey for Three Recommendation Domains in N. Veracruz

CIMMYT, August, 1978

Background Data:

(1) Name of Farmer ______________________ (2) Ejido ______________

(3) Does the farmer grow maize (not with citrus) ________________

(4) Date _______________ (5) Name of enumerator __________________

Land Resources:

(6) Ejido parcel size ______(ha) (7) No. of fields ______________

(8) Ha in pasture ______ (9) Ha in permanent crops (citrus, bananas, sugar cane, mango, etc.) ____________________________

(10) Average ha in annual crops ______________________________

(11) What are the annual crops you plant on your annual crop land? ___

____

(12) Ha in forest______ (13) Ha in fallow_______ (14) Ha in maize (average) _______ (15) No. of fields in maize (average) _______

(16) Ha of maize on slopes (average) ____________________________

(17) Ha of maize on flats (average) _____________________________

(18) The fields where you do not sow maize are (a) sloped (b) flat ____

Other Resources:

(19) No. of members in family _________

(20) No. of men in the family more than 15 years old (include the farmer) ______________

(21) No. of members of the family that help full-time with agricultural work (include the farmer) ____________

(22) No. of members of the family that help part-time with agricultural work __________

(23) By part time, you mean _______ (a) days/month (b) months/year (c) ___________

(24) No. of full-time hired workers _______ (25) No. of horses _____

(26) How many horses are used for agricultural work? ______________

(27) No. of cattle ______ (28) No. of owned tractors _____________

(29) No. of owned tractors used for agricultural work on your own land _____ (30) No. of owned tractors used for custom work ___

(31) No. of owned tractors in running condition now ______________

(32) What equipment do you own for use with horses in agricultural work? ____

(33) What equipment do you own for use with tractors in agricultural work? ____

(34) What other machinery or equipment do you own that you use in agricultural work? ____________________________________

Cropping System:

A) Rotations:

(35) Do you plant dry cycle maize? ___ (36) Do you plant wet cycle maize? ____

(37) After you harvest dry cycle maize, do you generally use that same field for wet cycle maize? _______

(38) After you harvest wet cycle maize, do you generally use that same field for dry cycle maize? _______

(39) When do you usually plant beans? (month)

(a) first planting __________ (b) second planting ____________

(40) When do you usually harvest beans? (month)

(a) first planting __________ (b) second planting ____________

(41) When do you usually plant squash (month)? ____________________

(42) When do you usually harvest squash (month)? __________________

(43) Have you observed that your land "becomes tired" because of continuous maize cultivation? ________________________________

(44) (If YES) What have you done about this?

(a) continued with maize cultivation
(b) planted a permanent crop
(c) left the land fallow
(d) plant another annual crop
(e) planted pasture
(f) applied fertilizer
(g) other ________________________

(45) (The enumerator should select one maize field with the farmer. For this maize field, ask the following:) When did you begin continuous maize cultivation in this (selected) field? _________

(46) (For the same field mentioned in question 45:) List the crops, along with their respective dates of planting and harvesting, that you planted during the last 3 years in the (selected) field. Start with December, 1975.

Crop	Planted (month/year)	Harvested (month/year)

B) Intercropping

(47) Do you plant beans in the same field with maize, before that maize is harvested? ________

(48) Do you plant maize between the rows of bananas or citrus? ______

(49) Do you plant squash between the rows of bananas or citrus? _____

(50) Do you plant squash together with maize? ___________

(51) If you plant any annual crop together with another, please list the crops and their respective dates of planting and harvesting for a typical year:

Crop	Planted (month)	Harvested (Month)

Cultural Practices and Tillage (Maize, 1978 Wet Cycle):

(52) see next page

(52)

Practice	Yes/No	Tractor/ Horse/ Manual	When? (month/week)	Ha of area	If manual, No. of man-days including hired and family	If rented horse or tractor, cost per ha.
Chopping						
Burning						
Hoeing						
Plowing						
1st Harrow						
2nd Harrow						
Furrowing						
Planting						
Re-planting						
Thinning						
1st weed						
2nd weed						
3rd weed						
Doubling						
Harvesting						
Transport						
Other						
Other						

(53) In which practices did you employ hired laborers? ____________

____

(54) A hired laborer earns _____ pesos per day (without lunch) or _____ pesos per day (with lunch)

Input Use (Maize, 1978 Wet Cycle):

A) Seed:

(55) Variety planted (a) Tuxpeñito (b) local variety (c) hybrid (d) other _________________

(56) Where was it obtained? ___________________

(57) Price: pesos/kg __________________

(58) Distance between rows _________cm (59) Distance between hills __________cm

(60) Seeds per hill ____________

B) Other Purchased Inputs:

(61) The enumerator should obtain the following information:

see next page

(61)

Product	Name/ Formula	Where Purchased	Price/ Unit	Application Number	When? (month/week)	Dose/ ha	No. of ha
Insecticide				1			
				2			
				3			
Fertilizer				1			
				2			
				3			
Herbicide				1			
				2			
				3			
Other				1			
				2			

(62) Is it difficult to find the inputs you need for maize production? ___________

(63) (If YES), Which inputs are difficult to find? _________________

(64) Which inputs for maize production do you normally purchase on credit? ____

Production and Use of Production:

A) Total Production:

(65) How many ha of maize did you harvest in the last dry season? __________ha

(66) What was your total production of maize in that harvest? _______ (a) kg (b) bags

(67) (If the production was measured in bags,) How many kg of maize (shelled) does a "bag" contain? __________ kg

B) Use of Maize Production:

(68) Of your production from the last dry maize cycle, how much did you sell? __________ kg

(69) Who purchased the maize you sold? _________________

(70) What price was paid at this sale? ____________ pesos/kg

(71) Of your total maize production in the last dry cycle, how much was fed to animals? ___________kg

(72) How much was stored? ___________kg

(73) (If maize was stored,) How was this maize stored? (a) shelled (b) unshelled with the husk intact (c) husked but not shelled (d) other _________________

(74) Did you use an insecticide to protect stored maize? ___________

(75) (If YES) Which insecticide did you use? ______________________

(76) How much insecticide did you use? ___________ (kg) (lt) for

each _________(kg) of (grain) (ears)

(77) Where did you store this maize? ______________________________

(78) What did you do with the stover after the harvest?

(a) burned it (b) plowed it under

(c) left on top of the soil (d) fed it to the animals

(e) other ____

(79) After the weedings, what did you do with the weeds?

(a) left them on top of the soil (b) fed them to the animals

(c) other ____

(80) (If the weeds were fed to the animals) If no weeds were available to feed the animals, what would you feed them? _________________

(81) (Regarding the alternative feed mentioned in question 80) How much does this cost? ______________ pesos/kg

(82) Do you grind your maize at home or do you take it to the mill?

____

<u>Problems and Preferences</u>:

(83) The enumerator should obtain the following:

Potential Problem	Is it a Serious Problem? (yes/no)	When? (Dry/Wet)	How many maize plantings have you lost (less than 500 kg/ha yield) in the last 5 years?
Drought			
Flooding/Waterlogging			
Insects			
Disease			
Lodging			

(84) Which insects are serious pests of maize? ____________________

(85) If you already use an insecticide, what would happen to your maize if you were to stop using it? ____________________

(86) In which month do you have most problems with maize lodging? ____________________

(87) In cycles of plentiful rain, do you have difficulties in carying out tillage? __________

(88) (If YES) What do you do? ____________________

(89) In cycles of plentiful rain, do you have difficulties in weeding? __________

(90) (If YES) What do you do? ____________________

(91) (If the farmer mentioned that he has problems with diseases:)

Disease Name	Damage Caused to Maize Plant and Grain

(92) Do you prefer white maize or yellow maize? ____________________

Special Section: Tuxpeñito Variety:

(1A) Have you ever planted Tuxpeñito maize? __________

(If NO)

(2A) Are you familiar with Tuxpeñito maize? __________

(3A) Do you expect to plant Tuxpeñito maize in the future? __________

(4A) If you expect to plant it in the future, why? ____________________

(5A) If you do not expect to plant it in the future, why not? ____________________

(If YES, the farmer has planted Tuxpeñito:)

(6A) In which years did you plant Tuxpeñito?

Year	Dry Cycle	Own/Purchased	Wet Cycle	Own/Purchased
1973				
1974				
1975				
1976				
1977				
1978				

(7A) What planting distance did you use in your first and last plantings of Tuxpeñito?

Distance	First Planting	Last Planting
Distance between rows		
Distance between hills		
Seeds per hill		

(8A) What are the advantages of Tuxpeñito maize? (Mark if the farmer mentions one of the following:)

(a) Resistant to lodging (b) Matures early

(c) Yields better (d) Tastes better

(e) Other ________________________________

(9A) Which of the above advantages is most important? ____________

(10A) What are the problems with this maize? (That is, with the plant or the ear or the grain that the plant produces. Mark if the farmer mentions any of the following:)

(a) Low yields (b) Tastes bad

(c) Insect damage in storage (d) Thick cob

(e) Foliar insect damage (f) More weed problems

(g) Not drought tolerant (h) Other ____________

(11A) Which of the above problems is the most serious? ____________

(12A) Have you had problems with the Tuxpeñito seed that you purchase? ___________

(13A) (If YES) What problems have you had with Tuxpeñito seed? (Mark if the farmer notes any of the following:)

(a) the seed comes infested (b) the seed does not germinate well
(c) The seed is difficult to find (d) the seed comes broken
(e) The seed is expensive (f) other ________________

(14A) Which of the above problems is the most serious? ______________

(15A) Where did you purchase your Tuxpeñito seed? ___________________

(16A) (If purchased from the official bank:) If this seed were not included as part of the official bank's credit package, would you use it anyway? _____________

(17A) Which variety produces better under conditions of drought?

(a) Tuxpeñito (b) local variety (c) no difference

(18A) Which variety produces better under conditions of excess rain?

(a) Tuxpeñito (b) local variety (c) no difference

(19A) Which variety produces better under conditions of strong winds?

(a) Tuxpeñito (b) local variety (c) no difference

(20A) Which variety produces better on slopes, where you don't plow?

(a) Tuxpeñito (b) local variety (c) no difference

(21A) What do you do with your Tuxpeñito maize after harvest?

(a) sell it green (b) sell it dry
(c) feed it to animals (d) save it for future sale
(e) save it for family consumption (f) other ________________

(22A) Which variety is best for planting in the dry cycle?

(a) Tuxpeñito (b) local variety (c) no difference

(23A) Which variety is best for planting in the wet cycle?

(a) Tuxpeñito (b) local variety (c) no difference

Special Section: Credit Use:

(1B) Do you use credit for purposes of agricultural production? _____

(2B) (If YES) From whom do you accept credit? ______________________

(3B) What quantity of credit do you use for one maize cycle?

__________ pesos/ha

(4B) What interest must you pay for use of this credit?

__________ pesos or ________%

(5B) Do you have to leave the ejido to arrange your loan? ___________

(6B) (If YES) How many times? _____________

(7B) Where must you go? ______________________

(8B) Do you accept loans from friends, family or patrons for purposes of agricultural production? __________________

(9B) What do you purchase with your agricultural loan? ______________

____

(ONLY if the farmer uses credit from the official bank:)

(10B) What maize variety do you use? ___________________

(11B) If you did not have credit from the official bank, would you still use this variety? ___________

(12B) Is this variety better or worse than the local variety? ________

(13B) (If considered different:) In what way? ______________________

(14B) Do you use fertilizer on maize? ______________________________

(15B) If you did not use credit from the official bank, would you still use fertilizer? ____________

(16B) Does fertilizer raise maize yields? ______________

(17B) What would you buy with credit from the official bank if it were delivered to you, completely in cash, before planting?

____

(18A) For how many years have you used credit from the official bank? ______________

<u>Special Section: Sprayers</u>:

(19B) Do you own a sprayer? __________

(20B) (If YES) Of what size? ________lt.

(21B) Where did you purchase it? ______________________________

(22B) How much did it cost? _____________pesos

(23B) When did you purchase it? ______________

(24B) (If the farmer uses both herbicides and insecticides:) Do you use different sprayers for herbicides and insecticides? _________

(25B) (If the farmer uses herbicides:) Do you use an adherent when you apply herbicides? _______________

(26B) From how far must you haul water to spray your maize in the dry season? ___________meters

(27B) From how far must you haul water to spray your maize in the wet season? ___________meters

(28B) Has your sprayer broken down? ______________

(29B) (If YES) Do you fix it yourself or send it out to be fixed?______

(30B) How much did you spend last year on sprayer repairs? _______pesos

<u>Special Section: Hired Workers</u>

(31B) In which months is there more agricultural work to be done? _____

____

(32B) What work must be done for which crops in these "busy months?"

Crop	Jobs

(33B) Is family labor sufficient to carry out these jobs? ________

(34B) (If NO) Do you hire labor during these busy months? ________

(35B) How much do you pay these hired workers, per day, during these busy months? __________pesos per day

(36B) From where are the hired workers that you employ?

(a) from a different state

(b) from the state of Veracruz but from a different county

(c) from your county, but from a different ejido

(d) from your ejido

(37B) What are the months of least agricultural work? __________

(38B) How much do you pay your hired workers during these months of little work? __________pesos/day

Questionnaire for Farmer Assessment of Recommendations

CIMMYT, April, 1979

IDENTIFICATION

(1) Name of Farmer ______________________ (2) Ejido ______________

(3) Date ______________________________ (4) Enumerator ____________

DATA ON MAIZE, WET CYCLE, 1978

(5) Let's talk about your maize crop that you just harvested. (The enumerator should obtain the following data about the 1978 wet cycle maize crop, for maize not intercropped with citrus:)

(5) see next page

(5) Job	Yes/No	Tractor/ Horse/ Manual	Rented/ Own	When? (Month/week)	Area (ha)	If tractor or horse (own), or manual, total mandays	If rented tractor or horse, cost/ha
2nd weeding							
3rd weeding							
Hilling up							
Doubling							
Harvest							
Transport							
Other							
Other							

(6) How many hectares of maize did you harvest, in total, in the last wet cycle? ___ ha

(7) What was your total production of maize for the last wet cycle? _________ (kg) (bags)

(8) (If the farmer answered in terms of "bags":) If you were to shell the ears contained in one bag, how many kg of maize would result? ___________ kg

(9) Did you sell a part of the maize you harvested from the last wet cycle? _______

(10) (If YES:)

see next page

(10)

No. of Sale	Quantity Sold (kg)	Purchaser (CONASUPO/merchant neighbor/other)	Price/kg	How sold? (green/dry unshelled/shelled)

(11) Of your total production from the last wet cycle, how much maize do you expect to use for animal feed (that is, that which you have already used for feed and that which you expect to use in the future for feed)? _____ kg

(12) How much did you store after harvest for both animal feed and family consumption, and future sales? ________ kg

(13) Of that maize stored after the last harvest, how much do you expect to sell in the future? _______ kg

DATA ON DRY CYCLE MAIZE, 1978-1979

(14) Now let's talk about the maize that you are cultivating right now. (The enumerator should obtain the following data on maize in the current dry cycle, for maize not intercropped with citrus.)

see next page

(14)

Job	Yes/No	Tractor/ Horse/ Manual	Own/ Hired	When? (month/week)	Area (ha)	If owned tractor or horse, or manual, total man-days	If rented horse or tractor, cost/ha
Chopping							
Burning							
Hoeing							
Plowing							
1st Harrow							
2nd Harrow							
Furrowing							
Planting							
Replanting							
1st weeding							
2nd weeding							
other							

(15) Are you cultivating dry cycle maize on the same field (i.e., on top of) where you cultivated wet cycle maize last cycle? ________

DATA ON INSECTICIDE USE

(16) Have you ever used insecticides on maize? _________

(If the farmer has NEVER used insecticides on maize:)

(17) Do you expect to use insecticides on maize in the future? ________

(18) (Only if YES, the farmer expects to use insecticides on maize in the future:)

Why do you expect to use insecticides on your maize? _____________

____

(19) Why didn't you spray your maize with insecticides in the past?

____

(20) (Only if NO, the farmer does not expect to use insecticides on maize in the future:)

Why don't you expect to use insecticides on your maize? __________

____

(Only if the farmer YES used insecticides on maize:)

(21) Did you apply insecticides to your maize in the current cycle? __________

(22) (If the farmer YES applied insecticides this cycle, the enumerator should obtain the following information:)

No. of Application	Name of Insecticide	Price/Unit	When (month/week)	Dose/ha (commercial)	Ha sprayed

(23) Which was the first year when you applied insecticides to maize? ________

(24) Since the first time you applied insecticides to maize, have you applied them on all succeeding cycles? __________

(25) (If NO) In the cycle(s) in which you did not apply insecticides, why did you decide not to apply them? ______________________________

(26) Do you apply insecticides to maize even when no insect damage is apparent? ________

(27) Which insects are serious pests for maize?

(a) White fly (leafhopper) (b) Painted fly (leafhopper)
(c) Moth (leafhopper) (d) Lorillo (leafhopper)
(e) Fall armyworm (f) Trozador (leafhopper)
(g) Slug (h) White grub
(i) other __________________________________

(28) Of the insects noted above, which are controlled by the insecticide you currently use? (note letter only) ________

(29) Of the insects noted above, which are unaffected by your insecticide? (letter only) ________

(30) Of the insects noted above, which are most serious pests for very small maize (first few weeks of growth)? (letter only) ______

(31) Of the insects noted above, which are most serious pests for larger maize (knee-high to flowering)? (letter only) ___________

(32) Do you believe that foliar insect damage on larger maize seriously affects yields? _________

(33) Do you believe that foliar insect damage by fall armyworms on larger maize seriously affects yields? _________

(34) If you were to not use insecticides on maize in a normal cycle, how much would your yield be reduced? (a) all or almost all would be lost (b) more than half would be lost (c) less than half would be lost (d) little loss

(35) How many man-days are needed to apply insecticides to maize when it is very small? (Include hauling of water.) _______ man-days

(36) How many man-days are needed to apply insecticides to maize when it is larger? (Include hauling of water.) ________ man-days

(37) In which maize cycle do you have more problems with insect pests? ___________

(38) Do you own a sprayer? _______

(39) (If YES) Besides applying insecticides to maize, what other uses do you have for your sprayer?

(a) bathe cattle (b) apply insecticides to other crops
(c) apply herbicides (d) other ________________________

DATA ON FERTILIZER USE AND PLANTED DENSITY

(40) Have you ever used chemical fertilizer on maize? (Don't count organic fertilizer or foliar fertilizer.) ____________________

(If NEVER has used chemical fertilizer on maize:)

(41) Do you use fertilizer on other crops? ____________

(42) (Only if the farmer uses fertilizer on other crops:)

Crop	Name of Fertilizer	Where Purchased?	Credit/Cash	Price/kg

(43) Are you familiar with fertilizer? ___________

(44) Which are the fertilizers with which you are familiar? _____________

(45) Do you expect to use fertilizer on maize in the future? ____________

(46) (Only if YES, the farmer expects to use fertilizer on maize:) Why do you expect to use fertilizer on maize in the future? ____________

____

(47) (Only if YES, the farmer expects to use fertilizer on maize:) Why did you not use fertilizer on maize in the past? ______________

____

(48) (Only if NO, the farmer does not expect to use fertilizer on maize:) Why don't you want to use fertilizer on maize? ____________

____

(49) (ALL farmers who have never used fertilizer:) Have you ever tried to buy fertilizer with the purpose of applying to maize? ____________

(50) (If YES, the farmer has tried to buy fertilizer:) Where did you try to buy fertilizer for maize? __________________________________

(51) (If YES, the farmer has tried to buy fertilizer:) Were you able to acquire fertilizer for maize? _________

(52) (If NO, the farmer could not acquire fertilizer:) For what reason were you unable to acquire fertilizer for maize? _________________

(53) If you were to buy fertilizer for maize in the future, which fertilizer would you wish to buy? ____________________________

(54) Where would you purchase this fertilizer? ______________________

(55) How much do you think that this fertilizer costs now? _______ pesos/kg

(56) If you were to apply fertilizer to maize, do you think that production would increase or would it stay about the same? _________

(57) (Only if the farmer expects a yield increase due to fertilizer:) By how much do you think that fertilizer application would increase yields? __________kg/ha

(58) What is the difference between 18-46-0 and urea? _________________

____

(59) What is the distance that you used in planting your current dry cycle maize crop? ______cm between rows; ______between hills; ______seeds/hill

(60) Why don't you plant maize more closely? ____________________

(61) Have you ever tried to plant maize more closely than your maize is planted in the present cycle? ________

(62) (If the farmer tried a closer density:) When did you try a closer planting? ___________

(63) (If the farmer tried a closer density:) What was the result of this closer planting? ____________________

(64) You will recall that I work with CIMMYT. Now, CIMMYT has conducted many experiments in this region and has found that, usually, when you apply about 300 pesos worth of urea (that is, about 100 kg) per hectare, then you harvest 300 to 400 kg/ha more maize than you would have without urea. That is, what yield do you usually obtain now? _______ kg/ha. If you were to apply urea, then, your yield should rise to around ______ kg/ha. Of course, nothing in life is sure. In the experiments we have seen that in 10 harvests, there will be three or four in which there is no yield increase (because of drought or some other problem) and you lose the money you spent on urea. It is in the other six or seven of the 10 harvests that your yields would increase as indicated. Based on the above, do you think that urea use is the right thing to do? ____________________

(65) Why? ____________________

____

(Only if the farmer YES has used fertilizer on maize:)

(66) Did you apply fertilizer to maize during the present cycle?________

(67) (If YES, the farmer applied fertilizer to maize this cycle:)

(a) Name of fertilizer_______ (b) Where purchased?____________
(c) Cash/credit_________ (d) Price/kg____________
(e) Quantity/ha applied______kg (f) Date of application__________
(g) Date of planting__________ (h) No. of hectares___________
(i) Form of application: (broadcast) (banded) (in a hole) (other____)
(j) Variety of maize used: (local variety) (Tuxpenito) (hybrid)
(k) Freight cost from place of purchase to farmer's field: $____/kg

(68) (If NO, the farmer did not apply fertilizer to maize during the present cycle, obtain the following information for the last cycle in which he used fertilizer:)

(a) Year/cycle______________ (b) Name of fertilizer__________
(c) Where purchased? ___________ (d) Credit/cash______________
(e) Quantity/ha applied_________kg
(f) Time of application: (at planting) (with first weeding) (other___)
(g) Form of application: (broadcast) (banded) (in a hole) (other____)
(h) Variety of maize used: (local variety) (Tuxpenito) (hybrid)
(i) Freight cost from place of purchase to farmer's field: $____/kg
(j) You used fertilizer on maize before, but you didn't use it during the current cycle. Why not? ____________________________
____

(69) Do you use fertilizer on other crops?________

(70) (If YES, the farmer uses fertilizer on other crops:)

Crop	Name of Fertilizer	Where Purchased?	Cash/Credit	Price/kg

(71) What are the advantages of using fertilizer on maize?

(a) yield increase (b) plant turns green
(c) other____

(72) Do you feel that maize yields increase with fertilizer use?________

(73) (If the farmer feels that YES fertilizer use increases maize yields:) By how much do yields of maize increase due to fertilizer use? __________kg/ha

(74) What are the disadvantages or problems in the use of fertilizer on maize?

(a) expensive (b) increased lodging
(c) not available (d) other______________________

(75) Have you encountered difficulties in obtaining fertilizer for maize? _______

(76) (If YES, the farmer has encountered problems of fertilizer availability:)
What are the difficulties you encountered in obtaining fertilizer for maize?____

(77) What is the difference between urea and 18-46-0?__________________

(78) What planting distances did you use for maize in the present dry cycle? ______cm between rows; ______cm between hills; ______seeds/hill

(79) What is the normal distance you use for maize when you use fertilizer? ______cm between rows; ______cm between hills; ______seeds/hill

(79a) Have you ever tried a closer planting for maize than what you used for the current dry cycle? ________

(80) (If YES, the farmer has tried a closer planting, obtain the following data:)

(a) When did you try this closer planting (year/cycle)?____________
(b) Did you use fertilizer when you planted closer?________________
(c) What result did you obtain from this closer planting?__________

(81) (If NO, the farmer has never tried a closer planting:) Why don't you like to plant maize more closely than you did in the current dry cycle?________________________________

(82) Does fertilizer work better in the wet cycle or the dry cycle, or is there no difference?

(a) wet cycle (b) dry cycle

(c) no difference

(83) From whom did you learn to apply fertilizer to maize?____________

(84) You will recall that I work with CIMMYT. Now, CIMMYT has conducted many experiments in this region and has found that, usually, when you apply about 300 pesos worth of urea (that is, about 100 kg) per hectare, then you harvest 300 to 400 kg/ha more maize than you would have without urea. That is, what yield do you usually obtain now? __________ kg/ha. If you were to apply urea, then your yield should rise to around _______kg/ha. Of course, nothing in life is sure. In the experiments we have seen that in 10 harvests, there will be three or four harvests in which there is no yield increase (because of drought or some other problem) and you lose the money you spent on urea. It is in the other six or seven harvests of the 10 harvests that your yields would increase as indicated. Based on the above, do you think that urea use is the right thing to do? ____________________

____

(85) Why? ____

DATA ON HERBICIDE USE

(86) Have you ever applied a herbicide to maize?____________

(Only if NO, the farmer has never applied a herbicide to maize:)

(87) Are you familiar with herbicides?______

(88) What are the herbicides with which you are familiar?______________

(89) Do you expect to use herbicides in the future for maize cultivation?________

(90) (If YES, the farmer expects to use herbicides:) Why do you expect to use herbicides on maize?

(a) less use of hired labor (b) less use of operator labor
(c) keeps a clean field when you can't perform physical cultivation
(d) other ____

(91) (If NO, the farmer does not expect to use herbicides:) Why don't you like to apply herbicides to maize?

(a) I am not familiar with them (b) damage the sprayer
(c) expensive (d) other______________________

(92) Do you use herbicides on some other crop?___________________

(93) Do you own your own sprayer?________________

(93a) There exists a herbicide that does not allow weed emergence for a considerable time after its application. If you were to apply this herbicide, immediately after planting, you would not have to carry out any weedings. If you were to use this herbicide, what jobs or tasks would you perform in place of the now unnecessary weedings of maize?________________________________

____

(Only if YES, the farmer has used herbicides in maize cultivation:)

(94) Did you apply herbicides to maize in the current cycle?________

(95) (If YES, the farmer applied herbicides this cycle:)

No. of Application	Name of Herbicide	Price/Unit	Dose/ha	When (month/week	No. ha

(96) How many man-days are necessary to apply herbicides to a hectare of land planted in maize? (Include the hauling of water.)

________ man-days/ha

(97) (If NO, the farmer did not use herbicides on maize this cycle, obtain the following information for the last cycle in which the farmer used herbicides:)

(a) Year/cycle____________ (b) Name of herbicide__________

(c) Dose/ha (commercial)_________

(d) When applied? (before planting) (at planting) (after planting)

(98) What are the advantages of using herbicides in maize cultivation?

(a) saves time of operator (b) saves hired labor expense

(c) keeps a clean field when physical weeding is impossible

(d) other____

(99) What are the disadvantages or problems associated with herbicide use in maize cultivation?

(a) expensive (b) damage the sprayer

(c) other____

(100) What is Gesaprim?____

(101) Do you think that herbicides work better in the wet cycle or the dry cycle, or is there no difference?

(a) wet cycle (b) dry cycle

(c) no difference

(102) Do you think that herbicides work better when:

(a) there is drought (b) there is excess water

(c) there is normal weather (d) no difference

(103) There exists a herbicide that does not allow weed emergence for a considerable time after its application. If you were to apply this herbicide, immediately after planting, you would not have to carry out any weedings. If you were to use this herbicide, what jobs or tasks would you perform in place of the now unnecessary weedings of maize? ______________________________

____

DATA ON CASH FLOWS

(104) We would like to talk about your income and expenses for the last year. (The enumerator should obtain the following: If the farmer recalls the quantity of cash corresponding to a given situation, he should note that quantity in the corresponding box. Otherwise, he should mark with an "x" a box in which expenses or income (cash) occurred.)

see next page

(104)

Thousands of Pesos

Cash Movement Category	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Maize sales												
Citrus sales												
Milk sales												
Tobacco sales												
Banana sales												
Bean sales												
Squash sales												
Other sales												
Non-farm income												
Received credit												
Maquila maize*												
Maquila citrus												
Maquila other												
Hired labor maize												
Hired labor citrus												
Hired labor other												
Buy maize												
Repay credit												
Buy insecticides												
Education exp.												
Other expense												
Other income												

*Maquila = custom tractor service payments

DATA ON MAIZE STORAGE

(Enumerator: This section should only be filled out if the farmer reported storing maize in question 12.)

(105) How did you store the maize that you did not sell, from the last harvest?

(a) shelled (b) unhusked
(c) husked but not shelled (d) other______________________

(106) What are the most serious problems you face in maize storage?

(a) insect infestations (b) rat damage
(c) rotting--excess humidity (d) other______________________

(107) How do you prepare your maize so that it is not spoiled by humidity?

(a) toast it well in the field (late harvest)
(b) dry it in the patio before storage
(c) take it from storage occasionally to dry it
(d) other__________________________________

(108) How do you avoid damage to your maize by insects?

(a) apply lime (b) apply insecticides
(c) store only non-infested maize (d) other______________________

(109) For how many months do you usually store maize? ____________________

(110) What is the maximum period of time that you can store criollo maize without damage (less than 10 percent damage)? _____months

(111) What is the maximum period of time that you can store criollo maize without serious damage (less than 30 percent damage)? ______months

(112) Why do you store maize?

(a) family consumption (b) animal feed
(c) to sell when the price goes up (d) other______________________

(113) Do you use lime to protect stored maize from insects? ______

(114) (If YES)

(a) Amount of lime applied to store maize, last dry cycle_______kg
(b) How do you apply it?______________________________________
(c) How often do you apply it? ________________________________
(d) When do you apply the first application? ____________________

(115) Do you use insecticides to protect stored maize from insects?______

(116) (If YES)

(a) Name of insecticide
(b) Price/Unit______________
(c) Quantity applied to stored maize, last dry cycle_________
(d) How often do you apply it? ___________
(e) When did you apply the first application? ___________

(117) How much maize does your family need, for human and animal consumption, for a whole year? _________kg

(118) How much maize does your family consume, including animal consumption, in a single week? ______kg

DATA ON CHANGES IN LAND USE

(119) How much annual cropland do you have? _______ha

(120) How much annual cropland did you have five years ago? ________ha

(121) (Only if the farmer has less annual cropland now than he did five years ago:) Which crops did you plant on land that used to be reserved for annual crops?

(a) citrus
(b) pasture
(c) bananas
(d) other ___________________

(122) Do you expect to reduce the amount of annual cropland that you now have?_____________

(123) Do you expect to drop maize cultivation completely?__________

(124) (If YES, the farmer expects to drop maize cultivation completely:)

Do you expect to have any difficulty in obtaining maize for family consumption?_______

(125) What are the advantages of continuing to cultivate maize, instead of planting maize land to other crops?

(a) food security (b) income more than once a year

(c) non-maize prices rise and fall rapidly (price risk of alternatives)

(d) do not have to buy food (e) other____________________

(126) What are the disadvantages of continuing to cultivate maize?

(a) you lose money by cultivation of maize

(b) maize wears out the soil

(c) other____

(127) If you cultivate maize in two cycles a year per field, how many hectares of land in maize per cycle do you need to insure the family food supply? _________ha per cycle

DATA ON NON-AGRICULTURAL WORK

(128) Do you have another occupation (besides agriculture) to earn money, without having to work for another person? _______

(129) (If YES) What is this occupation? _________________________________

(130) How much of your working time do you spend on this occupation?_____%

(131) How much of your total income is gained from this occupation?______%

(132) Do you leave your farm to work for someone else? _________

(133) What job do you perform when you leave your farm for this purpose? ____

____

(134) During which months do you perform this work? _____________________

(135) How much do you earn in this work, as a percentage of total income? _________%

Questionnaire for the Purposive Survey of Fertilizer Users

CIMMYT, May, 1979

(1) Name of Farmer________________________ (2) Ejido _______________

(3) Enumerator __________________________ (4) Date ________________

(EX-COLLABORATORS ONLY)

(5) Period of Collaboration (cycle/year)

(6) We represent CIMMYT. Do you recall that you collaborated with us in some experiments on maize production? ________

(7) Did you see in your field the results of the experiments? _______

(8) Did you see in your field the results of the fertilizer experiments? _________

(9) What did you learn about fertilizer use from the experiments? ______

____

____

(ALL RESPONDENTS)

(10) Have you ever used chemical fertilizer on maize? ________

(IF NO, THE FARMER HAS NEVER USED FERTILIZER ON MAIZE:)

(11) Are you familiar with fertilizers? ______

(12) Which are the fertilizers with which you are familiar? _____________

(13) Do you expect to use fertilizers on maize in the future? ___________

(14) (If YES, the farmer expects to use fertilizers on maize:) Why do you expect to use fertilizer on maize in the future? _______________

(15) (If YES, the farmer expects to use fertilizers on maize:) Why haven't you applied fertilizer to maize in the past? _______________

(16) If NO, the farmer does not expect to use fertilizer on maize:) Why don't you like to apply fertilizer to maize? ______________________

(17) Do you use fertilizers on other crops? ____________

(18) (Only if YES, the farmer uses fertilizers on other crops:)

Crop	Name of Fertilizer	Where Purchased?	Credit/Cash	Price/kg

(19) Have you ever tried to purchase fertilizer for application to maize? _______

(20) (If YES) Where did you try to purchase fertilizer? ______________

(21) Did you obtain the fertilizer you sought? ___________________

(22) If you wished to purchase fertilizer in the future, which fertilizer would you select for maize? _________________________

(23) If you wished to purchase fertilizer for maize in the future, where would you seek to obtain it? ____________________________

(24) How much do you think this fertilizer costs now? __________

(25) If you were to apply fertilizer to maize, do you think that maize yields would increase or stay about the same? _____________

(26) (If the farmer thinks that fertilizers would cause maize yields to increase:) By how much do you think that maize yields would increase due to fertilizer use? _________kg/ha

(27) What is the difference between 18-46-0 and urea? __________

(28) What is the planting distance used in the present dry cycle, for maize? ________cm between rows; ________cm between hills; ________ seeds/hill

(29) Why don't you plant more closely? ____________________________

(30) Have you ever tried to plant maize more closely than you planted it this dry cycle? ____

(31) (If YES) When did you try this close planting? (cycle/year) _______

(32) (If YES) What were the results? ______________________________

(33) Recall that I work for CIMMYT. Now, CIMMYT has conducted many experiments in this region and has found that, usually, when you apply about 300 pesos worth of urea (that is, about 100 kg of urea) per hectare, then you harvest 300 to 400 kg/ha more maize than you would have without urea. That is, what yield do you usually obtain now? _______kg/ha. If you were to apply urea, then your yield should rise to around _______kg/ha. Of course, nothing in life is sure. In the experiments we have seen that in 10 harvests, there will be three or four harvests in which there is no yield increase (because of drought or some other problem) and you lose the money you spent on urea. It is in the other six or seven harvests of the 10 harvests that your yields would increase as indicated. Based on the above, do you think that urea use is the right thing to do? _______________

(34) Why? ____

(IF THE FARMER HAS APPLIED FERTILIZER TO MAIZE IN THE PAST)

(35) The enumerator should obtain the following data for the last three uses of fertilizer:

Cycle/Year	Weather (drought/ normal/waterlogging)	Estimated Yield

(36) (If the farmer used fertilizer on maize in the current dry cycle:)

(a) Name of fertilizer____________ (b) Where purchased? _______
(c) Cash/credit (d) Price/kg ______________
(e) Quantity/ha applied ______kg/ha (f) Application date________
(g) Planting date _______________ (h) No. of ha fertilized___ha
(i) Form of application (broadcast) (banded) (in hole) (other______)
(j) Distance of fertilizer from plant _________cm
(k) Variety of maize used: (local variety) (Tuxpenito) (hybrid)
(l) Planting distance: _____cm between rows; _______cm between hills; ______seed/hill
(m) Freight cost from purchase place to farmer's field: _____pesos/kg

(37) (If the farmer did not use fertilizer on maize in the current dry cycle, obtain the data as follows for the last time he applied fertilizer to maize:)

(a) Cycle/year ______ (b) Name of fertilizer______
(c) Where purchased: ______________ (d) Cash/credit ___________
(e) Quantity applied _______kg/ha
(f) Time of application: (at planting) (at the first weeding) (other _____)
(g) Form of application: (broadcast) (banded) (in hole) (other_____)
(h) Distance of fertilizer from plant _______cm
(i) Planting distance: _____cm between rows; _______cm between hills; _____seeds/hill
(j) Maize variety used: (local variety) (Tuxpenito) (hybrid)
(k) Freight cost from place of purchase to farmer's field ____pesos/kg
(l) Why didn't you apply fertilizer in the current dry cycle?_______
____

(38) Do you expect to use chemical fertilizer in the future? ________

(39) (If NO, the farmer does not expect to use fertilizer on maize:) Why don't you like to use fertilizer on maize? ____________________

(40) (If YES, the farmer does expect to use fertilizer in the future:) Why do you expect to use fertilizer on maize in the future? ________
____

(41) Do you use fertilizer on other crops besides maize? ________

(42) (If YES)

Crop	Name of Fertilizer	Where Purchased?	Credit/Cash	Price/kg

(43) What are the advantages of applying fertilizer to maize? __________

____

(44) Does fertilizer application cause maize yields to increase or do they stay about the same? ________

(45) (If the farmer thinks that fertilizers cause maize yields do increase:) By how much do you think that fertilizers cause maize yields to increase? ______kg/ha

(46) What are the problems or disadvantages of fertilizer use on maize? ____

(47) Have you had any difficulties in obtaining fertilizer for maize?____

____

(48) (If the farmer reports difficulties in obtaining fertilizer for maize:) What were the difficulties you encountered in obtaining fertilizer for maize? ____________________________________

(49) What is the difference between urea and 18-46-0? ________________

(50) How many times do you normally weed your maize? _________________

(51) How many weeks after planting do you normally carry out the first weeding? _____weeks

(52) Do you think that fertilizer use makes weed problems worse? _______

(53) (If the farmer didn't use fertilizer in the present dry cycle:) What is the distance of planting you used in the current dry cycle? ______cm between rows; _______cm between hills; ______seeds/hill

(54) Have you ever tried to plant maize more closely than you did this dry cycle? _______

(56) (If YES, the farmer has tried a closer planting:)

(a) When did you try this closer planting? (year/cycle) __________

(b) Did you use fertilizer when you tried close planting? _________

(c) What variety of maize did you use? _________________________

(d) What planting distance did you use?
______cm between hills; _____cm between rows; _____seeds/hill

(e) What result did you observe when you tried close planting?_____
____

(57) Does fertilizer work better in the dry cycle or the wet cycle?_____
____

(58) Does fertilizer work better with drought or with normal weather?____
____

(59) Recall that I work with CIMMYT. Now, CIMMYT has conducted many experiments in this region and has found that, usually, when you apply about 300 pesos worth of urea (that is, about 100 kg of urea) per hectare, then you harvest 300 to 400 kg/ha more maize than you would have without urea. That is, what yield do you usually obtain now? _______kg/ha. If you were to apply urea, then your yield would rise to around ______kg/ha. Of course, nothing in life is sure. In the experiments we have

(59) seen that in 10 harvests, there will be three or four harvests in which there is no yield increase (because of drought or some other problem) and you lose the money you spent on urea. It is in the other six or seven harvests of the 10 harvests that your yields would increase as indicated. Based on the above, do you think that urea use is the right thing to do? ____________________

(60) Why? ____

(61) How many hectares of maize did you plant this cycle? ______ha

(62) Of this maize, how many hectares are planted after tractor plowing and how many after hoeing? ______ha after tractor; ______ha after hoeing

(63) How many hectares of bananas do you have? ________ha

(64) How many hectares of citrus do you have? ________ha

(65) How many hectares of pasture do you have? _______ha

(66) How many hectares do you have in your farm, in total? _______ha

(67) Do you collaborate with the official bank this cycle? _________

(68) (If YES) If you could tell the official bank in what form you desire your credit, that is, with fertilizer or without fertilizer, which would you choose?

(a) with fertilizer (b) without fertilizer

(69) Why? ____

____

(70) (The enumerator should conduct an informal conversation with the farmer regarding his relations with the official bank, the problems he has faced, the reasons for continuing with using the bank's services, etc. After having left the farmer, a summary of this conversation should be reported below:)

Follow Up Questionnaire for Users
of Chemical Weed Control

CIMMYT, September, 1979

(1) Farmer__________________ (2) Date___________ (3) Ejido__________

(4) In how many maize cycles have you used Gramoxone or Gesaprim in maize? ____________ cycles

(5) When was the last cycle in which you used these herbicides? _______

(6) Now, let's talk about the last time you used these herbicides:

see next page

(6)

Job	Yes/No	Tractor/ Horse/ Manual	Owned/ Rented	Total Man-days	Total Man-days (Hired only)	When? (month/week)
Chopping						
Hoeing						
Plowing						
1st Harrow						
2nd Harrow						
Furrowing						
Planting						
Herb App.						
1st Weed						
2nd Weed						
Ins. Appl.						
Ins. Appl.						
Doubling						

(7) How large was the planting you made of maize with chemical weed control? ______ha

(8) In the same cycle in which you used the herbicides noted above (most recent use), did you also plant maize in a conventional manner (i.e., without herbicides)? __________

(9) (If YES) How many fields did you plant in conventional manner?

(a) field a has ______ha (b) field b has ______ha

(c) field c has ______ha (d) field d has ______ha

(10) Now let's talk about field ______, regarding this conventional maize planting:

see next page

(10)

Job	Yes/No	Tractor/ Horse/ Manual	Owned/ Rented	Total Man-days	Total Hired	When? (month/week)
Chopping						
Hoeing						
Plowing						
1st Harrow						
2nd Harrow						
Furrowing						
Planting						
1st Weed						
2nd Weed						
Ins. Appl.						
Doubling						

(11) Now we want to know, for the field in which you used Gramoxone and/or Gesaprim, which were the purchased inputs that you applied to this field:

Input	Dose/Ha	Price/Unit	Date	Where Purchased?	Hard to Find?

(12) Likewise, for the field ______, in which you planted maize in conventional manner, which were the inputs you used for the planting in question?

Input	Dose/Ha	Price/Unit	Date	Where Purchased?	Hard to Find?

(13) Do you expect to continue to use Gramoxone and/or Gesaprim in the future for maize cultivation? _________

(14) (If YES) Why do you expect to continue to use these herbicides? ____

____

(15) (If NO) Why don't you like to use these herbicides? _______________

____

(16) What are the advantages of using these herbicides? _______________

____

(17) Among the advantages listed, which is the most important? ________

____

(18) What are the problems or disadvantages with these herbicides? ______

____

(19) Among the listed disadvantages, which is the most important? ______

____

(20) How many weeds were there in the field in which you used herbicides, before herbicide application?

(a) thick brush (b) many green weeds

(c) few weeds (d) clean field

(21) Were you happy with the weed control gained as a result of herbicide use? _______

(22) Which are the weeds that are serious problems in your maize fields? ____

(23) Which of these weeds was not well controlled by Gesaprim? ________

____

(24) In your last use of herbicides, how many times did you have to apply Gramoxone? ________ Gesaprim? __________

(25) (If more than once:) Why did you have to apply ________(herbicide) more than once? ____

____

(26) (If the farmer reported having to make a manual or other weeding in his chemical weed control field:) Why did you have to undertake a weeding in your herbicide maize field? ____________________

____

(27) Do you think it is necessary to carry out a machete chopping in your maize field before applying herbicides? _________

(28) (If YES) What kind of chopping is necessary before applying herbicides?

(a) very light (b) normal
(c) very intensive (d) leave a clean field

(29) (If YES) In a field with many weeds (but not with thick brush), how many man-days of labor should be used in machete chopping before applying herbicides? ________man-days

(30) (If YES) In a field with few weeds, how many man-days of labor should be used in machete chopping before applying herbicides? ________man-days

(31) In the cycle in question, in which field did you note more insect pests in maize: (check one)

(a) field with herbicides ______ (b) field without herbicides____________

(32) In the cycle in question, which were the insect pests that attacked the respective fields:

(a) with herbicides ____
(b) without herbicides ____

(33) In the cycle in question, could you plant on time or was planting delayed in:

(a) the field without herbicides ________________________________
(b) the field with herbicides ___________________________________

(34) In which is it easier to plant on time?

(a) with herbicides _______ (b) without herbicides______

(35) In the field in which you used herbicides, for the last cycle in which these were used and which has already been harvested, how much maize did you produce? _______kg in ________ha

(36) What do you estimate as the yield of the field mentioned above? _______kg/ha

(37) In a field in which you did not use herbicides, for the same cycle noted in question (35), how much maize did you produce?

_______kg in ________ha

(38) What do you estimate as the yield of this field? _______kg/ha

(39) Which way of maize cultivation leads to higher yields?

(a) with herbicides_________ (b) without herbicides______

(c) no difference_______

(40) (If the farmer notes a yield difference:) To what do you attribute this yield difference? ________________________________

(41) Which way of maize cultivation is best under drought conditions?

(a) with herbicides________ (b) without herbicides_____

(c) no difference__________

(42) (If the farmer notes a difference) Why is _____best? _____________

____

(43) Which way of maize cultivation is best under conditions of excess moisture?

(a) with herbicides________ (b) without herbicides_____

(c) no difference________

(44) (If the farmer notes a difference:) Why? _________________________

____

(45) Which way of maize cultivation is best under conditions of normal weather?

(a) with herbicides______ (b) without herbicides_____

(c) no difference______

(46) (If the farmer notes a difference) Why? __________________________

____

(47) Which way of maize cultivation uses less hired labor?

(a) with herbicides_______ (b) without herbicides_____

(c) no difference_________

(48) Which way of maize cultivation uses less family labor?

(a) with herbicides_______ (b) without herbicides_____

(c) no difference________

(49) (If YES, the farmer thinks that herbicides use leads to less needs for family labor:) When you planted maize with herbicides, how did you and your family spend your newly acquired free time, now that you did not have to physically weed your maize? __________

____

(50) If you were to sow ALL of your maize with herbicides, and therefore would not have to physically weed your maize fields, what would you and your family do with your newly acquired free time? ____________

____

(51) If you were to sow ALL of your maize with herbicides, what would you and your family do in the months of June and July? ____________

____

(52) Do you own a horse or tractor for agricultural purposes? __________

(53) If you were to sow ALL of your maize with herbicides, and therefore would not need to use this horse or tractor in tillage or weeding, what would you do with it? ________________________________

(54) Do you sow beans or squash after a maize crop? ________

(55) Have you seen the effect of herbicides on these crops, i.e., do herbicide residues:

(a) help these crops_______ (b) harm these crops_______

(c) have no effect on these crops_____ (d) don't know_______

(56) Have you had to drop bean and squash cultivation on your maize fields where you used herbicides? _______

(57) (Other data gained in informal conversation after the formal interview:)

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