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The Farming Systems Perspective and Farmer Participation in the Development of Appropriate Technology

CIMMYT ECONOMICS STAFF

It is now widely accepted that technological change is the basis for increasing agricultural productivity and promoting agricultural development. Improved agricultural technologies are, for the most part, the product of formal agricultural research systems. In recent years, significant advances have been made in developing the capacity of agricultural research systems to deliver technologies appropriate to the needs of the major client of agricultural research systems, the farmer.

In this paper we describe research methods conducted with a farming systems perspective that emphasize farmer participation in the research process. First we treat conceptual and definitional issues related to this approach. Then we present research methods that are consistent with the resources of national agricultural research programs and that, we argue, should receive high priority in efforts to improve the effectiveness of these programs.

CONCEPTS AND DEFINITIONS

ON-FARM RESEARCH WITH A FARMING SYSTEMS PERSPECTIVE

Since 1978, when several publications (for example, CGIAR; Norman) drew attention to Farming Systems Research (FSR), interest in FSR has increased dramatically. This is reflected in a growing number of publications and workshops on the theme (such as Byerlee, Collinson, et al. 1981; Zandstra et al. 1981; and Shaner, Philipp, and Schmehl 1982) and a sharp increase in the commitment of resources to its implementation in developing countries.

The term "farming systems research" has been applied to a wide variety of activities, leading to confusion about its objectives and methodology. In its broadest sense, FSR is any research that views the farm in a holistic manner and considers interactions in the system (CGIAR 1978). We will define this explicit recognition of the importance of interactions in the farming system as the *farming systems perspective* (FSP).

Research with a farming systems perspective can have various objectives. The major objective, however, is to increase the productivity of farming systems by generating appropriate new technologies. This, in turn, is often further divided into location-specific research, having a short-term objective of developing improved technologies for a target group of farmers, and research conducted with a longer time perspective to overcome major, widespread limitations in farming systems.[1] Location-specific research is best implemented through *on-farm research methods* (OFR), where farmers are involved in identifying potential technological improvements, which are then tested under their conditions.

In this paper, we discuss a subset of FSR, referred to as *on-farm research with a farming systems perspective* (OFR/FSP), which has the following characteristics: (1) it aims to generate technology to increase resource productivity for an identified group of farmers, especially in the short term; (2) it is conceptually based on a farming systems perspective; and (3) it uses on-farm research methods.

THE NEED FOR A FARMING SYSTEMS PERSPECTIVE

The farming systems perspective is especially important when conducting research for small farmers in subtropical and tropical environments of developing countries. Several characteristics of the small farmers' environment lead to complex farming systems and add to the importance of interactions in farmer decision making.[2] Some of the most important elements leading to this complexity are: (1) a long growing season, which increases the range of potential crops and the possibilities of multiple cropping, including intercropping; (2) unreliable input and output markets, uncertain climate, and low farm incomes, which increase the importance of risk in farmer decisions; (3) high marketing margins and price variability, which encourage farm households to produce what they consume, contributing several additional elements to the farm household's objective function, such as production of preferred foods and a balanced seasonal distribution of food supplies; (4) low average productivity of family labor, the major factor of production, often combined with seasonal labor shortages, which encourage such practices as intercropping; and (5) heterogeneity of resources employed by the farm household (for example, land may be differentiated by quality, or labor may be provided by men, women, and children).

CIMMYT is the International Maize and Wheat Improvement Center in El Batan, Mexico.

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* Book chapter

These considerations make for complex farming systems with a wide range of enterprises and even a range of production practices for a given enterprise, such as the use of more than one variety or planting date for a given crop. Complexity in most cases results from (1) direct physical interactions between production activities, generated by intercropping and crop rotation practices; (2) interactions due to competition and complementarity in resource use between different production activities; and (3) interactions due to trade-offs among the multiple objectives of the farm household. These interactions, from both biological and socioeconomic sources, underlie the need for a farming systems perspective and a multidisciplinary approach to research on improved technology.

THE NEED FOR EFFICIENT ON-FARM RESEARCH METHODS

On-farm research methods provide a means for introducing a farming systems perspective to research. Agricultural research has traditionally been organized along disciplinary or commodity lines without involvement of social scientists. It has typically been conducted on research stations under conditions not representative of farmers' fields and has had little or no farmer involvement. In on-farm research, direct communication of a multidisciplinary research team with farmers increases understanding of the farmers' decision-making environment and enables identification of technological alternatives that are more consistent with that environment. Experiments under farmers' conditions lead to estimates of yield and cost changes that better reflect what farmers can expect from using these alternatives.

The reorientation of an agricultural research system so that it is firmly based on on-farm research methods requires changes in research structures, organization, and incentives (see, for example, Moscardi et al. 1983). Moreover, methods used in OFR/FSP must be efficient in terms of resources, especially human resources but also financial resources and data processing facilities.[3] Because these programs initially tend to have only the partial support of research administrators, convincing results are needed early in the research program to ensure continuation and full integration into the research system.

There is an apparent anomaly between our advocacy of a farming systems perspective as a holistic view of an often complex farming system and the use of research methods that are cost-effective and emphasize rapid results. However, small farmers with scarce capital and with risk-avoidance objectives tend to favor a cautious learning process and, as a consequence, rarely make drastic changes in their farming system. Rather they proceed in a stepwise manner to adopt one and sometimes two new inputs or practices at a time.[4] Hence, a research strategy should focus on a very few—perhaps two to four—research opportunities that offer potential to increase resource productivity in a way acceptable to farmers. This narrow focus on a few priority research themes also enables national programs to use OFR/FSP despite shortages of skilled manpower and other resources. The identification of research opportunities and their development into technologies acceptable to farmers can and should be done using a farming systems perspective. However, since farmers rarely adopt farming systems as such (Collinson 1981), an OFR/FSP program should not seek as an immediate objective the development of completely new farming systems.[5] Rather, in the long run, a new farming system may evolve as the result of a series of discrete changes to the existing system.

RESEARCH PROCEDURES FOR NATIONAL AGRICULTURAL RESEARCH PROGRAMS

In this section we present the elements of an integrated agricultural research system based on on-farm research methods applied with a farming systems perspective. We assume that researchers are interested in developing a technology for a target crop in the system. In many cases the need to focus research on high-priority research opportunities will result in research on one crop, usually a major resource user. Many programs also have mandates for research on a specific crop, so researchers can select regions in which it is highly probable that research on that crop will increase system productivity. In any event, even research on a target crop requires a farming systems perspective that considers interactions with other crops in the system.

OVERVIEW OF PROCEDURES TO DEVELOP TECHNOLOGIES FOR FARMERS

A research process involving collaboration among scientists as well as between scientists and farmers is essential for rapid development of technologies that are appropriate to farmers' circumstances and that help to meet national goals.

A *technology* is a combination of all the management *practices* for producing or storing a crop or crop mixture. Each practice is defined by the timing, amount, and type of various *technological components,* such as varieties, land preparation, fertilizer, or weeding. A subsistence farmer who purchases no inputs is nevertheless using a technology—sometimes quite a complex one. Agricultural researchers should be particularly concerned that technologies developed are appropriate to the circumstances of target groups of farmers. *Farmers' circumstances* are all the factors that influence farmers' decisions about a crop technology—the natural environment (such as rainfall), the economic environment (such as product markets), and the farmers' goals, preferences, and resource constraints. If technologies are *appropriate* to farmers' circumstances, they will, by definition, be rapidly adopted by farmers.

Agricultural researchers should also seek a technology that helps meet *national policy goals.* Most governments want increases in food production; therefore any technology that increases production and is rapidly adopted by farmers will help meet this goal. Most governments also hope to reduce income inequalities among their citizens. This might require technologies that are adapted to small farmers or poorer regions or that provide cheap food to low-income urban consumers.[6]

The main participants in on-farm research are applied scientists—scientists of different disciplines who work together to solve immediate, high-priority problems—*and* farmers. Typically, the scientific team will include a biological scientist, usually an agronomist, to assemble information and analyze the physical and biological aspects of crop production, and a social scientist, usually an agricultural economist, to assemble information and analyze farmers' resource endowments, economic goals, and market environment. For specific problems, the scientific team may call on other specialists, such as entomologists or anthropologists, to supplement its skills. Fundamentally, however, it is essential that the agronomist and the agricultural economist *collaborate* in all phases of the research and jointly make decisions on such major topics as the content of on-farm experiments.

An overview of an integrated research program is shown in figure 1. At its heart is on-farm research, which is linked to two other important factors in developing technologies. On one side is experiment-station research, which emphasizes the development of new technological components, such as new varieties. On the other side is agricultural policy, which influences much of the economic environment—such as national goals, input prices and supply, product markets and infrastructure—in which researchers and farmers make decisions.

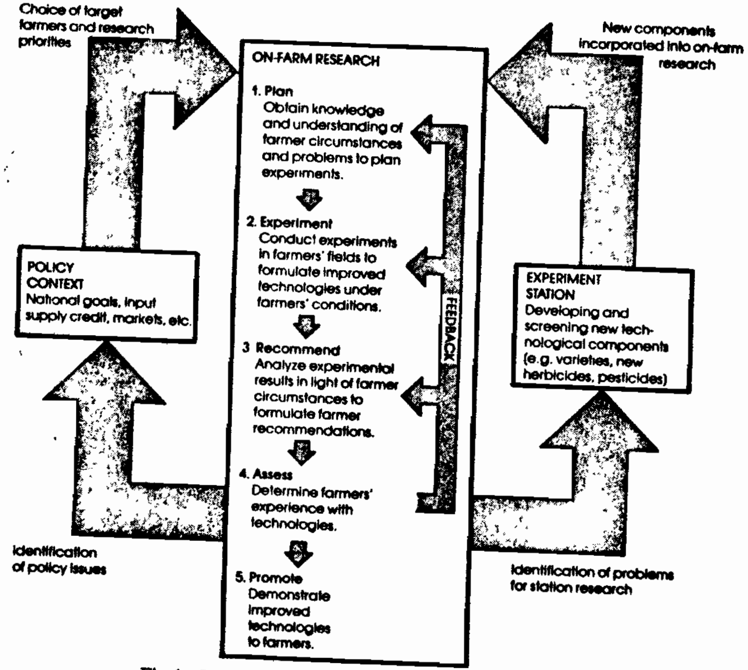

Fig.1. Overview of an Integrated Research Program

On-Farm Research

On-farm research is research conducted in farmers' fields with the participation of farmers. Frequent contact between researchers and farmers makes it more likely that the constraints and problems of farmers will be considered in the design of technologies. Experimentation in farmers' fields ensures that technologies are formulated under farmers' conditions. It also provides a check on experiment-station results; otherwise, the results may be uncritically used to make recommendations to farmers even when the stations are in sites unrepresentative of the surrounding area or are operated with highly intensive management practices.

Because of its farmer orientation, on-farm research must carefully identify the farmers for whom the research is intended. It is most efficient when focused on a specific group of farmers who have similar problems and potentials.

Various activities or stages of on-farm research are indicated in figure 1. In the planning stage, the research team tries to describe and understand farmer circumstances. This information is used to identify priority technological components that increase productivity and that are consistent with the circumstances of target groups of farmers.

The priority technological components are then further investigated in the experimental stage in order to formulate improved technologies, that is, to construct, from known technological components and known biological relationships, technologies that improve upon farmers' existing practices. These experiments are conducted in farmers' fields so that new technologies are formulated under conditions similar to those in which farmers will use them.

Technologies are then recommended to farmers after careful testing against farmers' technologies in several locations and after economic analysis of the results (procedures are described in Perrin et al. 1976).

The final phases of the on-farm research are assessing farmers' experiences with the recommendations and promoting the recommendations to farmers. Farmers' reactions to the recommended technologies when they themselves pay the cost of inputs and bear the risks constitute important information that should be fed into the research process. If farmers are accepting the recommendations, researchers can turn to other problems while extension workers focus on promoting the technologies. If farmers are rejecting or substantially modifying the recommendations, then learning why may suggest appropriate changes in the recommendations or even in the experiments.

The on-farm research focus is continually changing as information is accumulated about farmers' circumstances, the performance of various technologies in experiments, and farmers' experiences with the technologies. Over time some problems may be solved (or set aside because of a lack of solution) and new problems added. The system provides for continual improvement in technologies as researchers apply results gained from past research to the planning of future research.

Experiment-Station Research

If a strong on-farm research program exists, research on experiment stations is primarily aimed at developing new technological components that require more closely controlled conditions, such as the development of new varieties. Also, experiment-station research can be used to screen technological components that might have undesirable effects on farmers' fields, such as herbicides that might leave residues. Promising technological components arising from experiment-station research are further refined and evaluated in on-farm experiments for their appropriateness for farmers.

A two-way flow of information should exist between on-farm research and experiment-station research. Information generated by on-farm research is important for guiding experiment-station research. For example, information about farmers' circumstances from on-farm experiments may indicate the type of variety that performs well under farmers' conditions and that meets farmers' preferences for varietal maturity, yield, storage quality, and cooking quality.

Information summarized from on-farm research in several regions can help in setting broad priorities for experiment-station work. It can provide a valuable base for assessing the impact of alternative breeding decisions—for example, the relative emphasis that should be placed on early maturity versus disease resistance. The information from assessments of farmers' circumstances and from experiments will help establish the production benefit of each technological component, the associated risks, and the types of farmers likely to realize the benefit.

Information fed back to the experiment station is often as important as the technologies recommended to farmers. Many experiment-station research programs lack mechanisms for relating research decisions to farmers' needs. In this situation, the on-farm research program should initially focus on screening the technologies developed at the station for relevance to farmers. The results can be extremely useful for evaluating the appropriateness of existing priorities in experiment-station research.

Policy Context of Agricultural Research

Government policies that shape the economic environment in which researchers and farmers make decisions are another important influence on agricultural research (fig. 1). Some policies directly influence the production decisions of farmers, such as a policy to make available compound fertilizers but not single-nutrient fertilizers. Most policies, however, influence farmers' behavior indirectly through their effects on input prices (for example, through subsidies) or product prices (for example, through marketing boards). The effects of policy on farmers' decision making in turn have implications for agricultural research. In countries where herbicides are expensive or difficult to obtain, researchers might orient research on weed-control problems differently than they would in a country where herbicides are cheap.

Policies may also directly influence research decisions. For example, many governments express the desire to make the distribution of real income more equal. This might influence the orientation of research programs toward poorer rural areas if most of the poor are in agriculture, or toward regions with high production potential if most of the poor are in urban areas. In fact, in most countries many geographical regions need assistance, but research resources are insufficient to initiate research programs in all regions. Measuring the characteristics of regions against national priorities such as increased food production and equalizing income distribution is one way to narrow the choice of target farmers for a research program.

Agricultural research, particularly on-farm research programs, can also provide valuable information to the policy maker that might encourage a change in policies to facilitate the adoption of improved technologies by farmers. For example, on-farm experiments may demonstrate the superiority of an input that is not available to farmers because of import restrictions. Or information on farmer circumstances might reveal important discrepancies between stated policy goals and policy implementation—for example, the late arrival of credit leading to untimely use of inputs.

Agricultural researchers must subjectively decide which elements of the policy environment to consider fixed and which to consider variable for the planning horizon of the research program. Researchers might justifiably experiment with inputs that are not currently available, under the assumption that if they can demonstrate a high payoff technology, they will be able to convince policy makers to make the inputs available. Other policies, such as price policies, might also vary as governments try to adjust to changing supply-and-demand conditions. However, there will be many other elements of the policy environment that reflect basic government strategy or that can only change slowly as agricultural development expenditures increase (for example, for infrastructure), and these policies must generally be taken as fixed when researchers are making decisions.

FARMERS' CIRCUMSTANCES AS A BASIS FOR PLANNING RESEARCH

Farmers' circumstances are those factors that affect farmers' decisions about what technologies to use in growing a crop. Expressed this way, farmers' circumstances explain both a farmer's current technology and his decisions about changes in that technology. Various farmers' circumstances are shown in figure 2. They include natural and economic circumstances. Economic circumstances

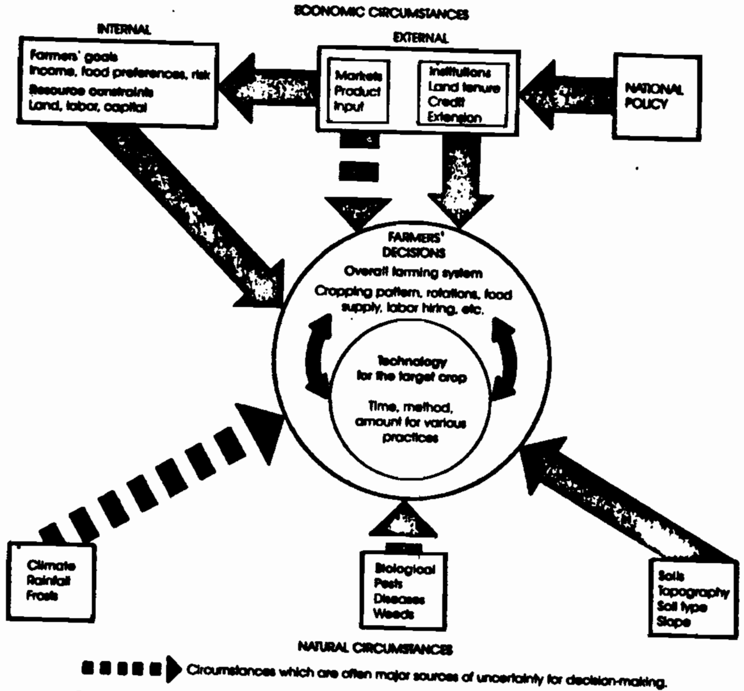

Fig.2. Circumstances Affecting Farmers' Choice of a Crop Technology

can be divided into those that are internal to the farmer, and over which he has some control (such as his goals and resources), and those that are external (such as markets).

Almost all farmers wish to increase their income—broadly defined to include production for home consumption. Generally, too, small farmers want security in meeting subsistence requirements of their preferred foods. Most also want to avoid taking risks that might endanger their subsistence supplies or sources of cash income.

Farmers have relatively fixed quantities of resources—land, family labor, and capital—that they can allocate to meet these goals. (Capital resources here include both durable equipment and cash.) Farmers may allocate these resources to different uses. Within limits, they may also adjust the amount of a resource available—for example, they may use some of their cash to rent more land or hire more labor.

Many circumstances also shape the economic environment in which farmers make decisions. These include the prices and price variability for inputs and products, access to inputs and product markets, land tenure systems, credit facilities, physical infrastructure (roads, dams, irrigation channels), and so on. This economic environment is largely outside of the farmer's control; it is influenced by policy decisions about distribution of inputs, price supports, infrastructure development, and so on. A large number of natural circumstances also condition the farmer's decision making, such as soil slope and depth, climate, weeds, and pests.

In making decisions, the farmer generally accepts as fixed external natural factors, such as rainfall, and economic factors, such as prices, though he may be able to modify their effects. A farmer may know, for example, that he has soils of different fertility, so he may decide to plant crops that meet his subsistence food preferences on the best soils to meet his goal of food security. Many external factors, particularly rainfall and prices, are variable and unknown to the farmer when he makes decisions. (In figure 2, factors that are major sources of uncertainty are marked with a broken line.) They provide an element of *risk*, which may have important effects on farmers' decision making. For example, although a farmer may not be able to predict rainfall, he is aware of its likely variability and therefore may plant a crop on several different dates to spread the risk of a dry period's striking at a critical stage in the crop cycle.

Most of these factors have *direct* effects on farmers' decisions about a technology for an individual crop. Late-season frosts might cause farmers to seek an early-maturing variety to reduce risks. Expensive labor encourages farmers to use a less labor-intensive weeding method, such as herbicides.

Many factors affect the choice of a technology for the target crop *indirectly* because of interactions in the farming system (fig. 2). The farming system is the totality of production and consumption activities of the farm household, including the choice of crop, livestock, and off-farm enterprises, as well as food consumed by the household. For example, a farmer may choose to plant maize late because he is planting beans early to avoid late-season disease problems in beans. Or he may plant an early variety of maize in order to have food early in the season before other crops mature. The point is that crop technologies often result from decisions made for the farming system as a whole. Consequently, planning technologies for one crop requires knowledge of important interactions in the farming system that potentially influence that crop.

The environment in which farmers make decisions changes over time. In particular, the external economic environment is characterized by changes in the ratios of input prices to product prices, which affect farmers' decisions. Changes in the external economic environment may also directly affect farmers' goals and resources. For example, as the market for food staples expands, farmers usually become more willing to depend on it for food supplies,and hence the influence of farmers' food preferences on their production decisions declines.

In the same way that farmers' circumstances determine a current crop technology, they are also important in a farmer's decision to change his technology. If a change in a technology conflicts with any of the circumstances of farmers, that technology may be rejected. For example, new varieties may be rejected because they are not suited to the soil conditions or because they ripen too late for the planting of the next crop. Fertilizer recommendations that aim for maximum yields are usually rejected because they are not consistent with either the farmer's income-increasing objectives or his risk-avoiding objectives.

When farmers reject technologies, it is not because they are conservative or ignorant. Rather, they rationally weigh the likely changes in incomes and risks associated with the technologies under their natural and economic circumstances and decide that for them the technology does not pay. The researchers' task is to incorporate knowledge of these circumstances into the design of technologies.

DECISIONS IN PLANNING AN ON-FARM EXPERIMENTAL PROGRAM

Researchers must make a series of decisions in planning an on-farm experimental program. First, researchers must determine whether farmers in the region are sufficiently alike to allow a common set of experiments and a common recommendation. If there are significant differences among farmers, researchers must somehow divide farmers into more homogeneous groups and design experiments for each group. Second, they must decide which problems are going to be investigated and which technological components will be included in experiments for each group of farmers. For each technological component chosen, the levels, timing, and type of input or practice must be decided. Third, for each set of experiments, researchers must determine the level of nonexperimental variables, or those variables that are fixed for all treatments in the experiments. Finally, the researchers must choose farmers and sites on which to locate the experiments. The circumstances of the farmers for whom the technology is intended will be a key factor in all of these decisions.

Grouping Farmers into Recommendation Domains

Obviously, no two farmers have *identical* circumstances and therefore identical needs for technology. On the other hand, a research program cannot be established to provide recommendations for each farmer. It is therefore necessary to classify farmers with *similar* circumstances into *recommendation domains,* groups of farmers for whom more or less the same recommendations can be made. At least a tentative delineation of these recommendation domains is necessary for planning on-farm experiments, since the research priorities and consequent experiments might be different in each domain.

The proper number of recommendation domains depends on the amount of variation in farmers' circumstances (the more variation, the more domains needed) and on the amount of research resources (the more resources, the more domains that can be afforded). The final decision on the number of domains will be a trade-off between these two factors. However, it should be remembered that the researcher does not need to seek precise recommendations; general guidelines that the farmer can adjust to his own circumstances will be sufficient.

Recommendation domains can be defined on the basis of the various farmers' circumstances. They may be determined by variations in the natural circumstances of the farmer, such as rainfall, soils, or diseases. A region may contain many *agroclimatic environments.* In an agroclimatic environment a crop exhibits rather uniform biological expression, so that varietal or fertilizer responses would be similar, *everything else being equal.* Within an agroclimatic environment, however, there may be groups of farmers with differing socioeconomic circumstances that require different recommendation domains. For example, close to a large town, maize may be grown for sale as fresh ears, while further away it is grown as a subsistence grain. Such differences may impose modifications on varietal selection and planting date. More commonly, even among farmers who are in the same agroclimatic environment, differences in resource endowments may lead to different technological needs. For example, small farmers who have scarce capital relative to labor and who place more emphasis on food security may follow cropping patterns and practices quite different from those of large farmers in the same agroclimatic environment.

At times, a recommendation domain may result from a complex interaction of agroclimatic and socioeconomic factors. For example, within an agroclimatic environment for maize there may be different disease incidences for beans which cause farmers in one part of the agroclimatic environment to plant beans early, therefore delaying maize plantings. In this case recommendation domains result from natural circumstances, diseases, which affect bean production, and an economic circumstance, labor scarcity, which conveys this effect to maize practices.

Recommendation domains are not necessarily continuous geographical areas. For example, two neighboring farmers may be in different recommendation domains because of large differences in available resources. Even within a farm there may be different recommendation domains due to variation in soil type or topography.

It is clear, then, that knowledge of farmers' circumstances and how they affect crop technologies will be necessary in defining recommendation domains.

Identifying Farmers' Problems and Prescreening Technological Components

Many things directly limit farmers' production and incomes, such as weeds, pests, diseases, inferior varieties, and drought. Few research programs can investigate all of these constraints simultaneously. Priorities must be set by selecting those few most important problems limiting farmers' production and incomes for which there are technological components that promise speedy solutions.

For each important problem, there may be several technological components that could contribute to its solution. A weed problem, for instance, might be alleviated by instituting a crop rotation, by altering the time and method of land preparation, by raising the crop seeding rate, by improving manual weeding techniques, or by using a herbicide. In planning experiments, it is necessary to *prescreen* the various components to select those few "*best-bet*" components that have a high probability of success. Since the components finally picked for on-farm experiments must be compatible with farmers' circumstances, knowledge of those circumstances is essential not only to identify problems but also to prescreen technological components. Information on farmers' circumstances also helps the researcher define the range over which to test the technological component. When fertilizer is expensive, rainfall is variable, and farmers have little cash, the relevant range of levels for on-farm fertilizer trials will be lower than when conditions are more favorable for fertilizer use.

Establishing Representative Practices and Sites

An important reason for conducting experiments in farmers' fields is to be able to formulate technologies under farmers' conditions. Information on farmers' practices helps researchers design experiments in which nonexperimental variables reflect farmers' conditions. For example, in a research program emphasizing variety, fertilizer, and weed control, nonexperimental variables such as time and method of land preparation, planting method, and pest control should be maintained at farmers' levels. If farmers interplant maize and beans and researchers do not, weed control recommendations arising from research may be inappropriate for farmers, and without effective weed control, the profitability of fertilizer recommendations can be markedly altered.

It is likewise important that sites selected for on-farm experiments be representative of the recommendation domain with respect to soils, crop rotations, topography, location, and farm size. If maize is grown on a particular soil type, then fertilizer experiments on maize should be conducted on fields of this soil type. While it is convenient to choose sites that are easy to reach or are identified by cooperating extension personnel, these sites may not be representative of farmers' fields in the area.

Identifying Problems for Station Research and Policy Making

Because on-farm research is closely linked to experiment-station research and to policy decisions, knowledge of farmers' circumstances obtained in on-farm research plays another role in guiding these two activities. A major activity of experiment stations is the development of new varieties. Knowledge of farmers' circumstances is important for setting priorities among various breeding objectives. Do farmers need earlier varieties to increase cropping intensity or to reduce late-season weather risks? Do they need varieties with resistance to an insect or lodging resistance? Or do they need varieties with improved storage characteristics because of difficulties in the marketing system? The answers to these questions depend on the circumstances of farmers for whom the varieties are intended.

Sometimes information on farmers' circumstances will have to be quite detailed. In Egypt farmers regularly strip the lower leaves from their growing maize to feed animals. Experiments by researchers had demonstrated that leaf stripping sharply reduces yields, and they recommended against the practice. The researchers had been working on new, high-yielding, short varieties of maize. When experiments were conducted using the *farmers'* time and method of leaf stripping, it was found that farmers' varieties, which tend to be taller and more leafy than the new varieties, permit leaf stripping with little effect on yields. With information on the value of leaves and the real yield loss when the leaves of existing varieties are stripped, researchers now have a measure of the amount by which yields of grain must be increased if farmers are to adopt new varieties that do not tolerate stripping.

Information on farmers' circumstances also helps researchers identify policy problems that may impede successful introduction of new technologies. In one country, decision makers believed that insecticides were easily available to farmers. However, information obtained from farmers demonstrated that this was not true. Some insecticides were available in one place, some in another, and the distribution of insecticides did not at all coincide with the distribution of insects. This information convinced administrators to reexamine the input distribution system. Often information from research will show policy makers the potential benefits from changing policies. For example, if fertilizer is in short supply, researchers may want to conduct some experiments to provide information to policy makers on fertilizer response. In effect, these become experiments for recommendations to policy makers, rather than for recommendations to farmers, because farmers do not yet have access to fertilizer.

OVERVIEW OF THE PROCEDURES FOR OBTAINING AN UNDERSTANDING OF FARMER CIRCUMSTANCES

The planning of experiments as described above clearly requires an in-depth understanding of farmer circumstances. With experience in many countries, we have found that an efficient approach to obtaining this knowledge begins with collection of secondary data (such as rainfall statistics), followed by an exploratory survey and a verification survey. This is a sequential process in which information becomes more detailed and focused at each subsequent step in the process.

The exploratory survey is a useful technique for rapidly understanding the farming system and indentifying key research priorities. The essential characteristics of this technique are its relatively unstructured approach and the high degree of researcher participation in field interviews and observations (see Collinson 1981; and Hildebrand 1976). A multidisciplinary team of researchers interviews farmers in an informal and iterative manner, guided by a systems perspective of farmer decision making and oriented by a list of topics. Meanwhile, the biological dimensions of crop or livestock production are observed in farmers' fields. The whole survey is usually completed in two to three weeks in a given recommendation domain.

The exploratory survey is a sequential data-collection technique. The research team analyzes and evaluates information on a *daily* basis in order to make a decision on what further data need to be collected. Initially, researchers try to obtain a broad description and understanding of the farming system. They then focus on research opportunities for increasing productivity and, finally, the assessment of possible technological alternatives to be included in on-farm experiments.

The exploratory survey is followed by a well-focused "verification" survey using a short, structured questionnaire (sometimes only one to two pages long) and a random sample. This information allows formal testing of hypotheses and provides greater confidence in the conclusions reached in the exploratory survey. Note that even in the verification survey the emphasis is on a low-cost method that provides information in a few weeks.

SUMMARY

On-farm research with a farming systems perspective is a subset of FSR that can be used by national agricultural research programs to generate new technology appropriate for representative farmers. OFR/FSP is characterized by two-way linkages with the national policy framework and with experiment-station research. It also emphasizes the need to understand farmers' circumstances when planning the various stages of research, including forming recommendation domains, setting research priorities, and selecting representative sites and farmer-collaborators for on-farm experiments.

Although international agricultural research centers such as CIMMYT can make important contributions to the development of new agricultural technologies, the location-specific nature of most technologies means that much of the research and development work in agriculture must take place in national research systems.[7] The procedures for on-farm research discussed above were designed for use by national agricultural research programs that have limited resources because these programs must take the lead in developing technologies for farmers around the world.

NOTES

1. These are referred to as "downstream" and "upstream" FSR by some authors (e.g., CGIAR 1978). We disagree with this terminology—"downstream" is hardly consistent with the "bottom-up" philosophy of FSR. We are also confused by the definition of "upstream" research. Gilbert, Norman, and Winch (1980) limit it to research to overcome major *resource* constraints, such as soil moisture conservation or fertility maintenance.

2. Although we emphasize small farmers in this paper, we feel that OFR also has substantial value in commercial agriculture. Payoffs may, however, be less because of less complex farming systems and because commercial farmers may already have considerable influence on research decisions.

3. To some extent the increasing availability of microcomputers will help overcome the constraint on data processing.

4. It is sometimes assumed that OFR can make significant gains by a reallocation of existing resources, such as changing plant spacing or extra weeding, without introducing new inputs to the system. We believe that this is an exceptional case and in fact is contrary to the systems perspective of a rational farmer. For more on the stepwise adoption behavior of farmers see Mann 1978; and Byerlee and Hesse de Planco 1982.

5. Development of new farming systems may be appropriate where there is a drastic change in the farmers' external environment, such as the introduction of irrigation or a colonization program.

6. See Timmer, chapter 8 in this volume, for a discussion of other common goals governments establish for their food systems.—Ed.

7. See Schultz, chapter 23, and Evenson, chapter 24, in this volume.—Ed.

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