ON-FARM RESEARCH TO DEVELOP TECHNOLOGIES APPROPRIATE TO FARMERS

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It is now widely accepted that technological change is a necessary although by no means sufficient condition for agricultural development. It is clear that despite the widespread diffusion of new wheat and rice varieties, many new technologies are not being widely used by farmers because they do not fit the particular circumstances of farmers for whom they are intended. This is despite the fact that considerable public expenditures are often made to provide the infrastructure such as credit and markets to enable the farmer to adopt these technologies.

This paper attempts to synthesize our experiences with national research programmes and with the International Wheat and Maize Improvement Center's (CIMMYT) wheat and maize programmes in deveolping research methodologies to ensure that agricultural technologies generated by scarce research resources are consistent with the circumstances of target farmers. It emphasizes collaboration of technical and social scientists in on-farm research--both in diagnosing farmers' problems and demands for technology and in developing and testing in farmers' fields those technologies which appear to meet these problems.

Traditional Approaches to Agricultural Research

Agricultural research is generally characterized by the gap between the researcher and the farmer. That assertion arises from our experience in many countries. There are many exceptions to that and the other generalizations in this section. On the one hand, much research has been guided by disciplinary interests. Although the importance of the problem to the farmer is sometimes advocated in determining research priorities, no explicit means of identifying priorities is employed. On the other hand, even research aimed at farmer problems has traditionally used a top down approach; that is, it is conducted on research stations under conditions quite different from those of farmers and then passed to extension for promotion to farmers. Although the problems of extrapolating these results to farmers have been recognized (see for example, Swanson), the movement of research to farmers' fields has been slow. An exception is experimentation on fertilizers which has long been conducted on farmers' fields in many countries, but practices under which these experiments are conducted (for example, weed control and land preparation) are often quite different from those of local farmers.

The economist in this process has usually been a late actor. Large scale involvement began with production function analysis of agronomic (usually fertilizer) experiments. In some cases this led to the collaboration of agronomists and agricultural economists in the design of fertilizer experiments (see, for example, Hoffnar and Johnson). More recently, in developing countries, economists and other social scientists have been even later participants through studies, after the fact, of technology adoption. Increasingly these studies reflect the fact that recommended technologies are not appropriate to particular farmer circumstances. (See, for example, the Perrin and Winkelmann review of several such adoption studies.) However, these adoption studies have largely been conducted by economists outside of agricultural research institutions, and, as a result, there has been little immediate feedback to decisionmaking on research priorities for developing improved tehnologies.

There is now increasing emphasis on collaboration of technical and social scientists in on-farm research to bridge the gap between researchers and farmers. The general approach embraced in various degrees by various institutions (see, for example, Norman; CIMMYT; Dillon and others; Hildebrand; and Navarro) has three important components:

1. The approach emphasizes solving farmer problems which are specific in time and location. It begins with an identification of current farmer problems and possible technological solutions to these problems that are feasible under the natural and socioeconomic circumstances faced by farmers and that are consistent with national policy goals.

2. Technologies appropriate to farmers are then developed and evaluated by experimentation in farmers' fields under farmers' conditions.

3. Farmers' experiences with the new technology are monitored and this information fed back to research decisionmaking.

There is now growing support for the central role of on-farm research in national agricultural research programmes. However, the actual methodologies for implementing this type of research vary quite widely. In searching for such a methodology, we have been conscious of the need for several basic criteria:

1. The research should be well focused to enable quick payoffs to relatively limited research resources. This means research should be highly location specific and should focus on technology for an important or potentially important crop or crop mixture (in our case wheat or maize) rather than considering all crops and crop technologies in the system as variables. However, the identification and evaluation of potential technologies for a single crop must be made in the context of the farming system. Often small farmers operating in imperfect factor markets in an uncertain environment will use highly complex systems to meet an overriding food security objective. While yield increasing technologies are important, technologies for the target crop which have total system benefits are also necessary (for example, an earlier variety to allow two crops per season).

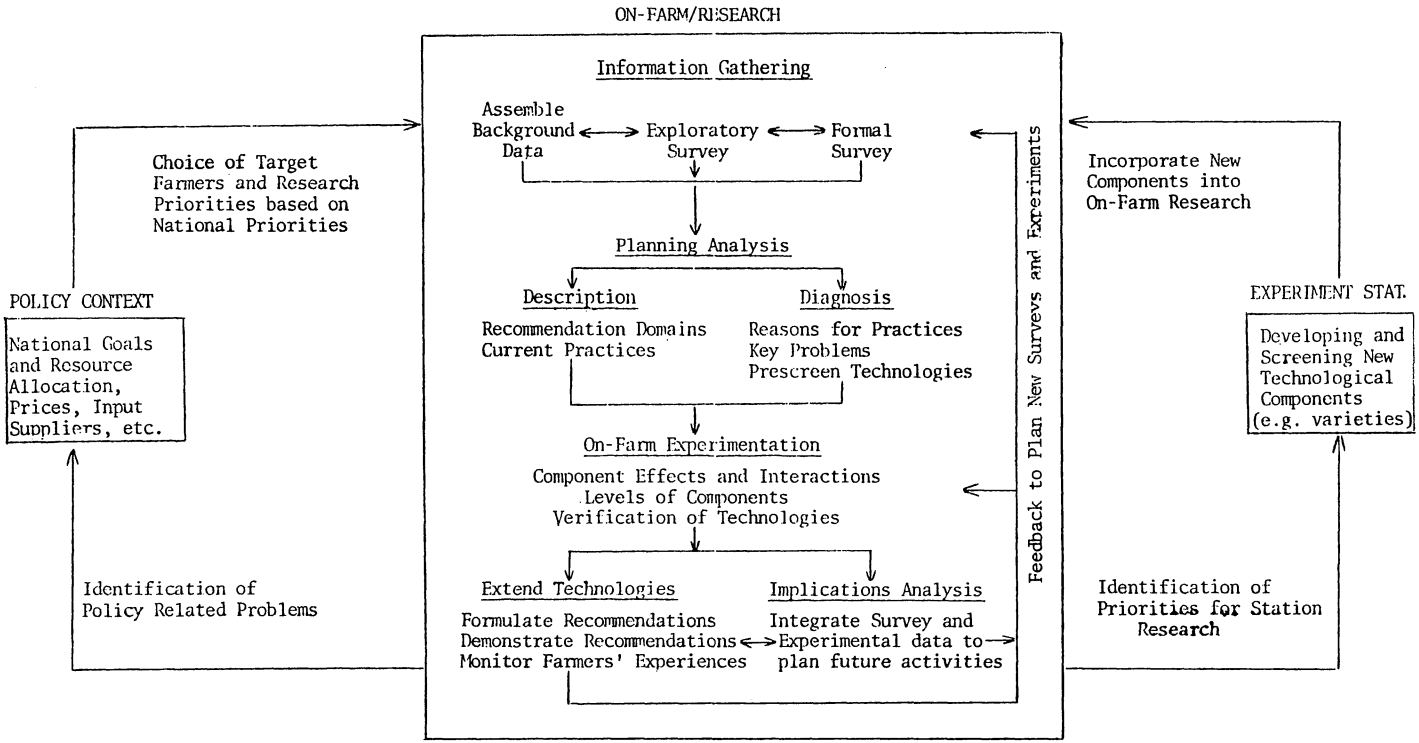
2. The farmer's decisionmaking with respect to technology is conditioned by natural circumstances, such as soils and climate, and by economic circumstances such as resource endowments and access to markets. To understand this complex of factors, a multidisciplinary research team usually consisting of an agronomist and an economist is needed to plan research with farmers.

3. Technological adoption by farmers is a learning-by-doing process that proceeds in small steps. The on-farm research should therefore set as an objective the generation of a few best-bet technological components. Furthermore, it is not possible to provide precise recommendations to each farmer, but recommendations can be made which are generally relevant to representative groups of farmers.

4. On-farm research should be part of a broader programme to improve crop production and farmers' incomes, and must therefore be closely linked to experiment station research, policymaking, and extension.

5. The methodology of on-farm research should be practical and replicable in

FIGURE 1. OVERVIEW OF AN INTEGRATED RESEARCH PROGRAMME



the context of scarce research resources of developing countries. It should be relatively cheap in implementation and make possible a fast turnaround in results.

The remainder of this paper summarizes the methodology we have found to meet these criteria. Figure 1 shows the specific steps in the methodology, which is described in detail in CIMMYT.

Choice of Target Region and Crop

Initially, the choice of the crop and region for an on-farm research programme must be justified in relation to the objectives of national policy and the resources and logistics available for the research. If national policy dictates that low income farmers should be priority beneficiaries of research expenditures, then the on-farm research will focus on a region where low income farmers are concentrated and where technologies are available with potential to increase production of a crop which is important in the farming system of these low income farmers. In this process, researchers will want also to consider the future perspective as well as the present; for example, whether there will be an adequate market for the increased production. This initial matching of the likely outcome of the research with national development priorities helps in the allocation of scarce research resources.

Collecting Information on Farmer Circumstances

The research then focuses on an understanding of farmer circumstances in the target region. This phase has both diagnostic and descriptive objectives. The primary objective is to diagnose the problems and constraints to crop production in the area in order to prescreen from a wide range of possible technological components a few best-bet components for experimentation in farmers' fields. Information from this diagnostic stage can also be used to guide experiment station research such as the development of new technological components, particularly varieties. The diagnostic effort also uncovers particular constraints at the farm level which are the result of policy decisions or problems in policy implementation (for example, problems of input availability, product marketing, and credit). Second, a description of farmer circumstances enables farmers in the target region to be tentatively classified into relatively homogeneous groups or recommendation domains for which the same recommended technology will be generally applicable. Also, this description of current farmers' practices and fields is important to establish representative farmers' practices and sites for on-farm experiments.

In the context of this paper, farmer circumstances are all those factors which bear on farmers' decisions with respect to technology for the target crop. These include natural factors such as climate, soils, and pests, and socioeconomic factors including marketing institutions, infrastructure, land tenure, and the farmers' own goals and resource constraints. Often these factors influence the farmers' choice of a crop technology through interactions within the farming system; that is, resource competition, crop rotations and multiple cropping, risk management, and food preferences. To the extent that these interactions are important, information must be obtained on other activities of the farming system.

Three sources of information on farmer circumstances are used: (1) background information on the farmers' environment, usually from secondary sources; (2) interviews with farmers; and (3) observations in farmers' fields. Typically available background agroclimatic and socioeconomic data are the first collected and analyzed. For example, in dryland areas, rainfall data from several sites are checked for important differences across the region and for periods of major rainfall uncertainty. A team--usually an agronomist and economist--will then spend one to four weeks touring the region in an exploratory survey of farmers and other persons linked to the farming community such as merchants, input suppliers, and extension agents. At this stage, information interviews of farmers and visits to farmers' fields are conducted. A questionnaire is not used, although the data are collected in a systematic manner against a mental checklist of issues and problems. Efforts are made to talk to traditional leaders who can often explain traditional practices, to innovative farmers who may or may not be working closely with the extension service, and to farmers encountered by chance on the tour. The researchers begin by trying to obtain a broad perspective on the farming system. As the exploratory survey proceeds, the interviews become more focused on specific problems and hypotheses to explain farmers' practices for the target crop within the context of the larger farming system. Also, at this stage, tentative definitions of recommendation domains are formulated and potential technological components are identified.

The primary role of this exploratory survey is to place the researcher in the farmers' fields in direct communication with the farmer and to help design a sharply focused, formal, and one-contact survey of farmers in the region in order to quantify and verify what has been learned in the exploratory survey and investigate some critical problems in more depth. Because a random sample of farmers is interviewed, the use of certain practices can be quantified and hypotheses on the reasons for these practices formally tested. Furthermore, relatively little emphasis is placed on quantifying farmers' resource use and allocation in order to infer technological needs. Rather, the questions aim to exploit the farmers' own intimate knowledge and experience of their environment in order to identify these needs. As a result, many questions (again based on exploratory survey information) elicit subjective types of information such as preferences about specific varietal characteristics.

The implementation of the formal survey--the training of enumerators, sampling, and field work--generally follows standard procedures for this type of work (see, for example, Collinson, 1972). Farmers are stratified as far as possible by the tentatively defined recommendation domain, and about 30-60 farmers are interviewed in each recommendation domain. The questionnaire is designed to be completed in 45 to 90 minutes.

Data Analysis and Prescreening Technologies

Data are analyzed quickly after the survey (within a maximum of 3 months), usually using hand tabulation sometimes supplemented by computer analysis. Descriptive tabulations of farming systems and cultural practices with respect to factors such as rainfall and farm size are used to refine boundaries of recommendation domains. These recommendation domains are only broad classifications of farmers and much heterogeneity still remains within each domain. The descriptive tabulations also provide a profile of representative farmers' practices and fields in each domain for the design of on-farm experiments.

The diagnosis of research priorities is made in the following steps: (1) important reasons for farmers using current technologies are listed; (2) priority problems and constraints in the target crop are identified on the basis of these reasons, results of field observations, and farmers' opinions and perceptions; (3) possible solutions to these problems and constraints are noted on the basis of practices of innovative farmers, on-station research results, and agroeconomic expertise; (4) all changes in the farming system implied by each solution, including associated costs, labour needs, and risks are listed, and based on researchers' understanding of the current farming system, those changes which are subjectively felt to be inconsistent with farmers' circumstances are eliminated (for example, cash costs too high, unacceptable risks, or conflicts with present multiple cropping system); (5) partial budgets following Perrin and others are constructed assuming a priori best guestimates of yield responses for these technological components; and (6) in each recommendation domain, a few best-bet components arising from this prescreening exercise are chosen for on-farm experiments.

This prescreening process emphasizes identifying technologies which use resources and inputs available to farmers and have short run payoffs. However, experiments may be included with a longer run horizon. For example, such experiments may provide information on the desirability of making a new input available.

On-Farm Experimentation

On-farm experimentation serves three purposes. First, it enables technology to be developed and tested under farmers' conditions. Most experiment stations are managed in such a way that, over time, soil structure, fertility, weeds, pests, and diseases are quite different from those in farmers' fields. Second, the technology can be developed and tested over a variety of environments and cultural practices. Finally, the farmer and the extension agent can be actively involved in the process of developing and demonstrating technological components.

Several types of on-farm experiments are implemented by the same multidisciplinary team responsible for the surveys in order to test the three to four priority technological components arising out of the diagnostic studies (Violic and others; and Winkelmann and Moscardi). Exploratory experiments are 2^n factorials with levels of each factor set at the farmers' level and at substantially higher levels to look at the main effects and the first order interactions of each factor. On the basis of these experiments, experiments with one or two factors (depending on interactions noted in the exploratory experiments) are designed to find recommended levels of these factors in terms of income and risks. (Procedures for analyzing experimental data and making recommendations are described in Perrin and others.) Finally, factors are combined to verify tentatively recommended technologies in comparison to the farmers' technology. These verification experiments often serve as the basic design for extension demonstrations. To ensure relevance, all of these experiments are conducted under conditions determined by the formal survey to be representative of local farmers.

Dynamics of On-Farm Research

On-farm research is a continuous learning process. After each cycle of on-farm research, information from surveys and experiments are integrated and analyzed, and strategies for the following cycle formulated. Special purpose surveys may be organized, particularly to monitor how farmers use the recommended technologies when they themselves must pay all costs and accept the risks. This provides important feedback to the research programme. If cooperating farmers are accepting the technology, then it can be promoted through extension and demonstrations, and new technological components, previously of lower priority, can be incorporated into the research programme. On the other hand, where farmers reject or significantly change the recommended technology, an understanding of why this is so could influence the design of future experiments. Likewise, experimental results may help modify recommendation domains or identify new technological components not previously considered important.

Effectiveness of on-farm research can be greatly strengthened by maintaining close linkages with research at experiment stations. Experiment station research focuses on developing and screening new technological components; that is, research that usually requires greater control (for example, development of new varieties) or would be risky when done on farmers' fields (for example, screening new herbicides). Promising new technological components arising from station research are then submitted to experimental evaluation in farmers' fields. The results of on-farm research also help establish priorities for station research. For example, a knowledge of farmer circumstances can guide plant breeders in deciding between yield, earliness, specific disease resistance, grain type, and storability in varietal development.

On-farm research is also conducted in a specific policy context that might guide the selection of target farmers and technologies consistent with national goals. In addition, in most countries there is a shortage of micro level information for policy analysis. The detailed information on farmers' circumstances and technological responses under farmers' conditions generated by on-farm research can be important for identifying changes in policy and policy implementation that would complement the introduction of improved technologies (for example, increasing the availability of specific inputs).

Finally, the impact of on-farm research is increased if researchers responsible for on-farm research are institutionalized within the agricultural research establishments with appropriate incentives and logistics to work in a multidisciplinary team on priority problems. This will require agricultural research programmes to include economists as an integral part of the research staff. Our work initially focused on demonstrating to research administrators the value of these on-farm research procedures and the potential contribution of economists (for example, see Collinson, 1978). The emphasis has now shifted to assisting national research programmes to develop their own capacity for on-farm research. It has been shown that well trained four year agricultural graduates are capable of implementing these on-farm research procedures in a target region.

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RAPPORTEUR'S REPORT--Bernard H. Sonntag

Introduction of new farming systems requires a transitional or learning period in addition to resource base changes. Irrigation and new high yielding varieties were cited as examples. Agronomists are generally willing to participate in informal surveys. Problems in establishing multidisciplinary teams should not be attributed solely to physical scientists--economists should share the blame.

The proposed approach would supplant the traditional experiment station. Neither the links between on-farm research and the experiment station nor those between the proposed approach and the farm management work of other institutions appear to be very strong.

Similar work is under way in outreach programmes in some developing countries. This approach is also useful in developed countries; for example, the recent efforts toward establishment of a farm management field laboratory in Alberta, Canada. Physical scientists have been invited to participate in that programme.

How can the programme be made operational in areas where the available staff is not trained beyond the secondary school level?

There is a need for more research on adaptive behaviour of farmers before economists will be able satisfactorily to explain their diagnosis of farm problems. The authors expressed a need for more applied field work in undergraduate training programmes. They also reemphasized the iterative nature of the approach and the need to adapt it as further experience is obtained. There has been little emphasis to date on monitoring and followup efforts. Some recent results in Africa and Latin America are reported in the literature.

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