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AIMING AGRICULTURAL RESEARCH AT THE NEEDS OF FARMERS

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The Problem

Few farmers in developing countries are following the recommendations of researchers and extension workers. Explanations for this difference between practice and recommendations abound.

Some claim that farmers are at fault, arguing that preferences based on traditionalism lead farmers to reject unfamiliar technologies. Some point to extension, arguing that the utility of improved technologies has not been demonstrated to farmers. Others claim that inadequate credit limits farmers' ability to adopt improved technologies. Some emphasize that inputs are not available in a timely way and at appropriate prices. Finally, but less frequently encountered, some contend that recommended technologies are often not appropriate for farmers.

Certainly each of these explanations has been valid for some time and place. However, a number of recent experiences have shown even the poorest farmers—presumably among the most tradition-bound and usually among those with least access to inputs, information, and markets—taking up certain technologies while rejecting others. These experiences suggest that more attention should be given to the adequacy of recommended technologies. This, in turn, implies that more attention be given to the research systems which develop technologies.

In 1974 CIMMYT's Economics Program initiated its work to identify effective procedures for developing technologies. That effort involved collaboration with professionals in national programs and with CIMMYT staff assigned to regional and to national programs. At headquarters economics joined with the maize and wheat training programs in pursuing work in procedures. The following discusssion is based on our interpretation of those experiences.

The procedures which have emerged are now being tried in several national maize and wheat programs. They emphasize identifying the production problems of representative farmers and integrating the critical dimensions of their decision-making into research on new technologies.

This concentration on research does not imply that the other issues mentioned earlier are not important; they are. The intention here is to add emphasis to the importance of the research system, to its procedures and its product.

CIMMYT's interest in such procedures relates directly to the Center's association with national programs. The Center is a producer of intermediate goods—elements of new technology, training, and procedures—which national programs apply in forging improved technologies. The procedures in this case related precisely to the process from which improved technologies emerge.

Characteristics of Useful Technologies

The utility of technologies can be judged from two related perspectives, that of the farmers and that of the larger society. In most cases, to be satisfactory from society's standpoint technologies must be judged useful by farmers.

In most developing countries choices among alternative technologies are left to farmers. By now two related impressions about farmers are widely held: 1) Farmers are purposive in their behavior,

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seeking to obtain incomes and to avoid risks; they are sensitive to the nuances of their environment; and they are reasonably efficient in managing the resources at their disposal. 2) While farmers' choices among alternative technologies are influenced by a host of variables, physical, biological, and economic forces dominate those choices.

This last impression warrants some amplification. Based on a series of CIMMYT sponsored country studies examining factors influencing the adoption of new maize and wheat technologies (essentially improved varieties and higher rates of fertilizer) it was concluded that:

> "the most persuasive explanation of why some farmers don't adopt new varieties and fertilizer while others do is that the expected increase in yield for some farmers is small or nil, while for others it is significant, due to differences (sometimes subtle) in soils, climate, water availability or other biological factors." (Perrin, et.al. 1976).

These studies and a reading of the earlier impressions of others (e.g. Foster 1962 and Schultz 1964) led to the conclusion that, while other variables might have a limited influence on choices among alternative technologies, income and risk are prominent farmer concerns and these variables are strongly influenced by the natural and economic circumstances of the farmers making the choices. Hence, our emphasis is on these physical, biological, and economic factors.

With this view of farmers, technologies which will be widely used must be consistent with farmers' natural and economic circumstances and must promise improved incomes while keeping risks within reasonable bounds. Technologies which do not meet these standards will not be widely taken up.

The utility of technologies can also be judged from the standpoint of a nation's goals. National decision makers will want patterns of adoption to have consequences, e.g. for income distribution among producers or for the distribution of benefits among consumers, which are in accord with national goals. Given this concern; those responsible for national policy will rarely be indifferent among alternative technologies and, consequently, among alternative lines of research aimed at forging improved technologies.

Procedures for Developing Useful Technologies

Orientation—Four points should be made before initiating a brief description of our procedures for developing useful technologies.

First, we are concentrating on that research whose results are intended for near or intermediate term application, e.g. fertilizer research or plant breeding. We are less concerned with basic or exploratory research destined to be applicable in the long run. This theme is treated by others at this conference.

Second, the entire process features collaborative research among biological scientists and economists. With farmers sensitive to both natural and economic forces the formulation of technologies requires the same sensitivity. This is not commonly found in a single scientific discipline and even less in a single individual. In the partnership we envision the biological scientist contributes his know ledge of the interaction among plants, insects, and diseases and their environment while the economist brings an awareness of the influence on farmer decision making of other opportunities for employing his resources and of markets for products and inputs. Beyond this, for issues relevant to policy makers, biological scientists have clearer perceptions of what is feasible through research while economists have the advantage in sorting out the implications of the adoption of alternative technologies. Each, then, contributes elements which are crucial in the formulation of technologies consistent with the needs of representative farmers and with national goals. This collaboration is a hallmark of the procedures being described.

The third point is that we are concerned here with formulating technologies for a single crop or for that crop as part of a mixture. We are not discussing full scale farming systems research.

Finally, the procedures aim at useful but not necessarily "optimal" technologies. After all, if each farmer responds to his own natural and economic circumstances then, as these differ among farmers, each could need a different "optimum" technology. Satisfying such demands is clearly beyond the capacity of any national research system. In place of "optimums" we seek to forge good approximations, technologies which promise more incomes with acceptable risks to representative farmers. We expect that, after adoption, each farmer will adjust the recommended practices to fit his own particular circumstances. This expectation is entirely consistent with experience, e.g. the increasing use of fertilizer on HYV wheats in India's Punjab and in Mexico's Yaqui Valley. Moreover, this stance relieves the researcher of the costly impression that he must be precise in framing recommendations. The researcher must be precise in his research, of course, but his recommendations are most useful when formulated as good approximations for a large number of potential users.

In brief, then, the procedures rest on collaborative research destined for early application, treat a single crop or mixture, and promise useful but not necessarily "optimal" technologies.

And one additional caveat. We recognize that the effectiveness of agricultural research is limited by shortages of physical and human capital, by nettlesome work rules, and by other constraints as well as by the limitations mentioned in our introduction. Even so, research is being done, technologies are being recommended, and farmers are following some recommendations but rejecting most. Hence, it is appropriate to question the paradigms which now organize applied research and potentially useful to explore new formats for its undertaking.

Integrating Entities—A distinguishing feature of the process described in the following paragraphs is its emphasis on representative farmers as its primary clients. In our view, for many countries this represents a significant shift in the orientation of agricultural research. And what are the dimensions of this shift?

We believe that much agricultural research in developing countries is concentrated on problems emphasized by professional disciplines and guided by their standards. This is entirely consistent with the training of most active agricultural researchers and with the incentives which orient their efforts. It is also consistent with the paradigms followed in developed countries where technological change has contributed to rapid increases in yields and reductions in production costs.

Why, then, with the system featuring professional peers as primary clients apparently working so well in developed countries, a shift in emphasis to farmers as primary clients?

Said briefly we believe such a change will make agricultural research in developing countries even more effective. This conviction emerges from our interpretation of the process which links research to practice in developed countries. What is most emphasized in this process is the research of the publically supported research systems. What is too little emphasized is the important role of entities which mediate between this research and the farmer, which integrate research results into effective technologies for farmers.

These mediating entities, e.g. the agri-business complex in some countries, are not well established in developing countries. Moreover, unhappily, the incentives of developing country public institutions do not encourage the researcher to play an integrative role. On the contrary, incentives tend to accent professional contributions—measured by the timely and lucid publication of research results, the contribution to professional organizations, and the training of others in the litany of the discipline. Furthermore, work rules seemingly conspire against anything done off experiment stations. The result is that research is often more attuned to the problems of the profession than to those of representative farmers and the resulting recommendations are often irrelevant of their needs. It is the absence of this critical integrating activity which underlies our belief that there is scope for making research systems more effective.

We turn now to a brief description of the procedure we have been developing. Their function is to orient the competence of researchers towards the needs of farmers, bridging the gap between research and practice.

Identifying Relevant Farmers—Natural circumstances in most countries are usually sufficiently variable that several technologies will be needed for a given crop or crop mixture. Moreover, farmers operating under essentially uniform natural circumstances might well confront such differing economic circumstances as to need different technologies for a given crop. It is unlikely that the research resources of a country are sufficient to simultaneously meet all such demands, even for a single crop. The first step, then, in organizing research is to identify the farmers for whom technologies are to be formulated.

The process is expeditiously handled by forming environments with similar ecologies, insuring that the crop or mixture in question reacts in roughly the same way and confronts roughly the same challenges in all parts of a particular environment but behaves differently in important ways in other environments. A first grouping can usually be done on the basis of the experience of informed biological scientists and economists working with secondary data on area, yield, soils, weather, elevations, and demography, all complemented by the observations of merchants specializing in the crop.

The next step is to roughly characterize the environments in terms of information which may be important to agricultural policy, e.g. area in the crop, production, number of farmers, distribution of farm size, relative importance of the crop, exportable surpluses. Combining this information with researchers' impressions of the potential for improving technologies is usually sufficient to permit a first rough ordering of the environments in terms of national goals.

In Ecuador this procedure was followed to identify five invironments in which farmers produce maize. It was inferred from policy statements that Government was accenting the incomes of low income farmers. For each environment the area in maize, maize as a proportion of total cropland, average farm size, and yields were estimated. Happily, the zone with the smallest farms and the heaviest reliance on maize also had one of the largest areas in maize and biological scientists ranked it high in terms of the potential for forging improved technologies. This congruence will not always occur so the rankings will often have a degree of arbitrariness, becoming more so as Government goals are less clearly stated and as impressions about research potential are more probalistic.1/

Identifying Farmers' Circumstances—While secondary data are adequate to frame general impressions, they are rarely sufficiently detailed to orient research on improved technology. Such detail requires first hand knowledge of circumstances and problems. We advocate two related sets of activities for acquiring that first hand information. Again, given the scarcity of research resources, these are concentrated on the environments assigned the highest priorities.

The first of the activities is exploratory survey work in the environments for which technology is to be developed. This will include informal but organized discussions with farmers, with merchants, and with others familiar with the environment. The effort involves both discussion and observation and focuses on production practices and problems, markets for production and inputs, and important competing activities.

Secondary data, the knowledge of researchers, and the results of the exploratory survey are then used to describe tentative recommendation domains1/ (i.e. sets of farmers whose natural and economic circumstances are sufficiently similar that a given technology will be relevant to each farmer within a set).2/

1/ For the most part, examples are from Latin America. We could also have taken them from CIMMYT work in East Africa or South Asia.

2/ While some of our colleagues find other phrases more congenial we favor this one. Notice that adjacent farmers need not be in the same domain and that recommendation domains need not be contiguous in space.

The second activity starts with the same sources of information plus the insights derived from the exploratory survey and proceeds to a formal survey. The information and insights are integrated into questionnaires, which are then administered to a random sample of farmers from each tentative recommendation domain. While each questionnaire is focused on issues critical to the farmer, the farm, and to the crop or crop mixture of primary concern, it also attends other activities—other crops, livestock, non-agricultural activities or non-farm activities—which impinge in important ways on the crop or mixture under study.

These surveys, especially the formal survey, serve to identify characteristics of representative farmers, e.g. farm size, common implements, typical rotations, critical periods, and access to inputs. They permit description of practices currently employed—levels, types, and dates associated with each activity—by representative farmers. They provide information for establishing the representative farmer's perception of major problems affecting the crop or mixture under study. Finally, the survey data also allows for refinement of the description of recommendation domains.

The procedure starts, then, by grouping farmers into essentially homogeneous natural environments, orders these environments in terms of national goals, assesses farmers' circumstances, establishes groups of farmers in terms of natural and economic characteristics and of national goals, and makes specific the circumstances of representative farmers for each important group.

Returning to the example of Ecuador, surveys there indicated that the environment assigned the highest priority contained three different sets of farmers based on natural factors. The three emerged from insect patterns and access to irrigation. The insect patterns, in turn, were closely related to altitude. Some differences in economic circumstances appeared, e.g. farm size and access to inputs; for virtually all farmers in each group these differences were slight. The remaining farmers were few in number and small in the proportion of total area given over to maize. So, no additional recommendation domains were formed because of economic circumstances. For each domain the survey data was used to characterize the circumstances of the representative farmer.

While data on farmer circumstances are gathered primarily to orient research, experience shows that an immediate sifting of the information for policy implications might also be profitable. For example, one maize study showed that a supposedly effective system for distributing inputs was falling far short of meeting farmer requirements for insecticides. The problem uncovered, policy makers could move to clear it up.

The perceptions of farmers and merchants, the knowledge of scientists, and the information derived from surveys is then combined to reveal factors significantly limiting the production of representative farmers. As with the earlier activities, data analysis requires the joint participation of biological scientists and economists. Each, again, brings specialized skills and sensitivities to the data, contributing to the identification of significant problems and to establishing the lines of work which might lead to their resolution. The research itself is undertaken on experiment stations and on the fields of representative farmers (see Figure 1).

Organizing Experimentation—Some of the limitations identified require research under carefully controlled conditions. This is usually best done on experiment stations. Its benefits often will not be realized in the near term and its results must be tested under the conditions of relevant representative farmers.

The surveys also orient on-farm experimentation. The first step involves examining existing solutions to the problems identified, carefully assessing the adequacy of such solutions, and modifying proposed solutions in the light of findings on the fields of representative farmers. This activity has a featured role in the process because the natural conditions of experiment staions often depart markedly from those of representative farmers.

Survey work in one Andean region of Peru showed the importance of leaf diseases in maize. The importance of the disease established, maize breeders began to screen their own material and sought promising materials from others to screen for resistance to this disease. In another Andean region survey work uncovered a farmer demand for a shorter season variety with good stalk strength. Maize breeders are now recombining shorter season material with material having good stalk strength and proper grain type. And why good stalk strength? Because surveys disclosed that the representative farmer grows climbing beans with his maize and on-farm experiments showed that existing short season varieties were unable to carry the weight of the beans. These problems and opportunities were uncovered through on-farm research involving surveys and experimentation.

On-Farm Experimentation—The on-farm trials are initiated with best-bet strategies based on the experience of researchers and farmers' perceptions. At each critical period in the life of the crop or mixture farmers and researchers come together around the crop to assess the adequacy of the strategies. Information from the trials flows to the experiment station, signaling new problems, and to trials in succeding years (see Figure 2). Each year information from experiment stations trials is assessed for its relevance to the problems judged most critical.

Three classes of on-farm trials are advocated—yes-no trials, how much trials, and verification trials. The yes-no trials are designed to look at major effects and first order interactions of the factors thought to be most critical in limiting production. Factorial designs are the mainstay of these trials and these feature two levels of the inputs or practices being examined, one at current farmer levels and the other at a significantly higher level. The how-much trials are designed to identify levels at which income seeking, risk averting farmers might want to employ inputs or practices detected as limiting in the yes-no trials.

In developing improved technologies there are always questions regarding how many factors can be changed at one time, to what degree input use can be changed, and at what level those factors not being changed should be set. For on-farm experiments, we advocate that attention be concentrated on only three or four factors at a time. Most evidence is that farmers tend to make but a few changes at a time, concentrating on those with the highest payoffs, so research can be concentrated on a limited number of factors rather than aiming at all potential changes in one fell swope. Regarding the levels of input use, profit and risk considerations require that rates of return on purchased inputs be quite high, i.e. probably higher than the apparent cost of capital, and this could suggest less intensive use than might be thought desirable by yield maximizing biologists or profit maximizing economists. How much less can be approximated with farmers during research and verification trials.

Finally, we believe that the non-experimental factors, those not part of the yes-no trials, are best set to match practices followed by representative farmers. By definition these variables are not important in determining yields or costs—else they would be among the experimental variables—so they can be set at low cost rather than at high cost levels. 3/

Each year best-bet strategies are reformulated in terms of the on-farm trials of the previous year and the impressions of all participants in the trials (see Figures 1 and 2). They are also modified to incorporate findings from experiment station research. Once farmers and researchers are convinced that an appropriate strategy is available, i.e. one consistent with farmers' circumstances and promising significant improvement in income at acceptable risk, the strategy is verified on a larger number of representative sites. Once verified, recommendations are made.

Notice that the process accents immediacy with improved technologies available in the near or immediate term. If all goes well—if the proper elements have been integrated in the research—the recommended technologies will be widely and rapidly diffused. This occurs precisely because they have been deliberately tailored to fit the needs of representative farmers.

3/ Some CIMMYT staff members hold a different view on this point. Largely because of their contention that anything done on farmers' fields is regarded by farmers as a demonstration, they advocate setting non-experimental variables at levels sufficiently high that the expression of experimental variables is not limited.

Best Available Document

Over time, individual farmers will adjust the recommendations in the light of their particular circumstances. Experiment station results, e.g. new varieties, will be available for testing under farmers' circumstances and incorporated in new best-bet strategies. In the longer run researchers will turn their attention to other environments or to other problems of lesser importance in the same environment. The process, then, provides for continuing improvement in recommended technologies as both farmers and researchers—from on-farm trials and from experiment stations—apply new experience and information to farmer problems.

Incentives and Structure—The process described here rests squarely on bringing publically sponsored researchers together around the problems of representative farmers. By basing research on representative natural and economic circumstances, researchers will play that important integrative role. In many cases implementing such research will require changes in incentives and in work rules. For at least some researchers, incentives must favor contributions to representative farmers and to production; work rules must facilitate on-farm efforts.

Before making these changes, of course, the utility of the procedures themselves must be demonstrated. We believe that favorable evidence is accumulating rapidly. Already several national programs are recasting research in terms of the earlier discussion and their on-farm activities are showing new solutions for the problems of representative farmers. These solutions are moving towards verification. We have yet to see whether they give rise to recommendations suitable for the target groups of farmers but we are optimistic about developments.

Sumary

The preceeding paragraphs describe a procedure for developing improved technologies. Farmers are at its core as its primary clients. The procedure focuses on ascertaining relevant farmer circumstances and integrating these into research aimed at developing improved technologies. It rests on collaboration among farmers, biological scientists, and economists so that the special experience and skill of each can influence the orientation of research. On-farm research, under the circumstances of representative farmers and with feed-back from year to year and with experiment station research, play a featured role. The process itself is non-perfectabilitarian; it does not envision developing "perfect" technologies. Rather it systematically focuses on major constraints to production, integrates natural and economic circumstances of representative farmers, provides for continuing and immediate improvement through research, and counts on individual farmers to make adjustments in terms of their own special circumstances.

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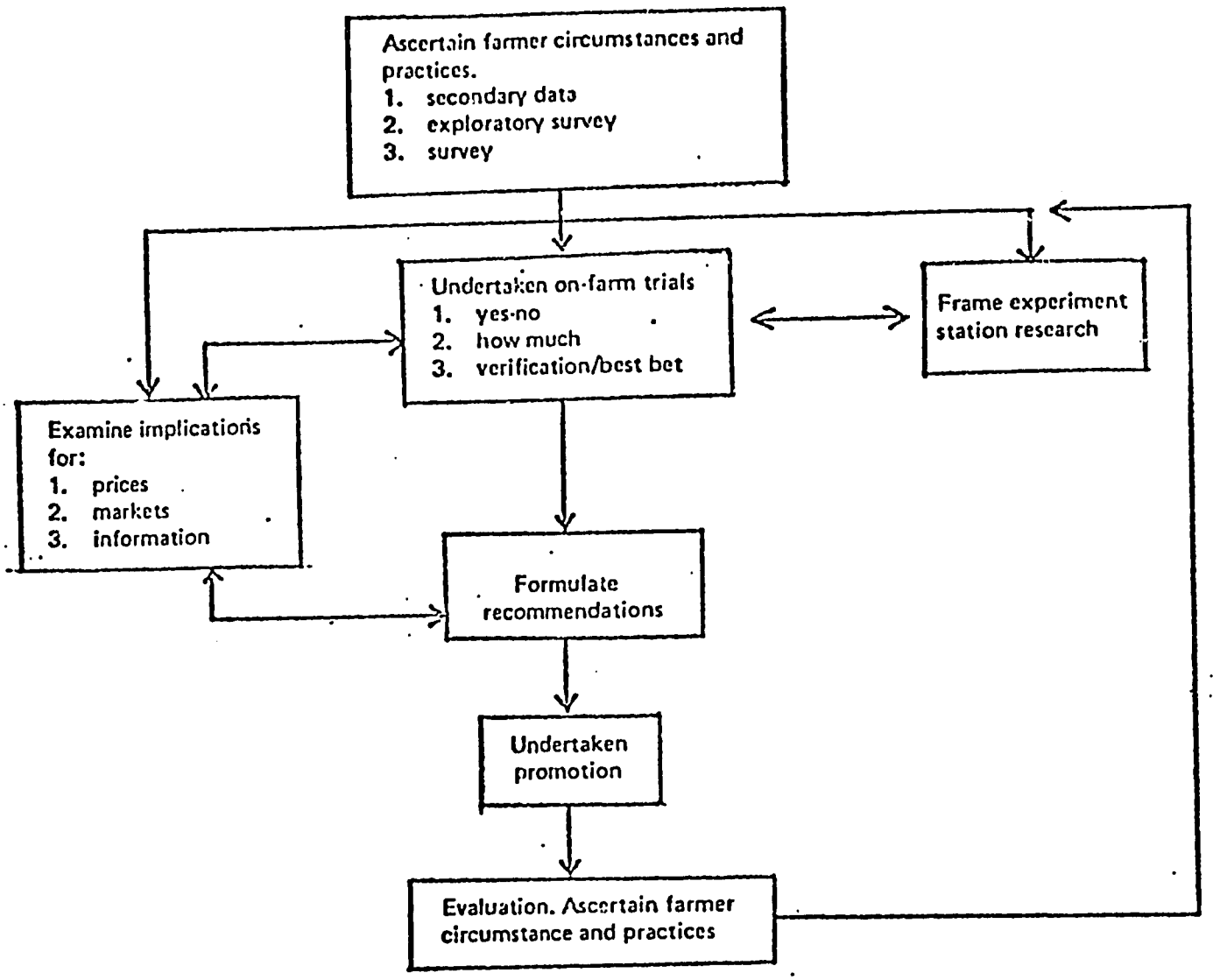
Figure 1: Overview of an integrated on-farm research program.



In the first phase the farmer (F) and the research team (A) come together in the farmer's environment, ascertain important problems, and identify potential solutions. These are tried out as "Best Bets" in a first set of on-farm experiments. The trials are monitored by (F) and (A). (A) and (F) use information to adjust sebsequent trials. Information goes also to station researchers (R) and to policy makers (P), who organize their work to alter the farmers' environment. (This is exemplified by a change in the economic circumstances after Year Two, e.g. different prices, giving rise to a new environment in Year 3). Interaction continues until a technology judged suitable for verification is identified.