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Chapter 3
Extension's Role in Adapting and Evaluating New Technology for Farmers

S. H. Johnson III and E. D. Kellogg

One of the most important means of accelerating national development in economies with large agricultural sectors is the development, adaptation and evaluation of new agricultural technology that can be adopted by small farmers. This adoption can result in higher incomes for small farmers, lower real prices of agricultural products for consumers, and greater economic efficiency and growth in the national economy. Therefore, the identification, development, adaptation, verification and farmer adoption of new agricultural technology has become an important part of the economic development strategies in many countries.

Extension services can play a substantial part in this process (Kellogg, et al., 1984), although the success of past efforts has often been limited. In order to overcome these limitations, new approaches to the adaptation and evaluation of technology have been developed. The purpose of this chapter is to specify extension's role in the new approaches. First, problems which inhibit successful technology adaptation and evaluation will be discussed. Then, a general approach will be outlined to alleviate many of these problems. Finally, specific extension activities to implement the approach will be identified.

PROBLEMS FACING TECHNOLOGY DEVELOPMENT, ADAPTATION AND TRANSFER

In many countries there are too few resources devoted to the technology development and transfer process. Additionally, there may be problems such as the lack of trained personnel, too little basic and/or component research, or agricultural policies that discourage farmers from adopting new technology. These problems are difficult to solve within the extension-research system. However, there are other important problems that have limited the development, adaptation, and adoption of agricultural technology by small farmers that can be addressed by extension personnel. For example, researchers do not fully understand that agricultural production in less developed countries takes place within a complex farming system that has evolved over a number of years, based on experience and sound reasoning. In many cases, researchers have limited knowledge about important problems confronting farmers. In addition, there is often little information about the physical, economic, and socio-cultural factors which create the environments within which farmers work. Because these environments are spatially different and change over time, agricultural technology development and transfer activities must deal with these differences to be effective. Also, new technology, as adopted and managed by farmers, often does not perform as well as expected, and additional adaptation may be necessary. Many of these problems can be alleviated by developing and/or strengthening extension activities in their inter-action with researchers and farmers.

These problems fall into four major groups (a) lack of knowledge and understanding of farming systems, (b) insufficient feedback from farmers to research programmes, (c) insufficient understanding of the environment within which farmers work, and (d) lack of mechanisms for testing and adapting technology on farmers' fields (Gilbert, Norman and Winch, 1980).

The first problem area entails having insufficient knowledge and understanding of the farming systems. These farming systems are often characterized by activities related to crop and animal production, family and household consumption, production, labour and leisure time usage, and off-farm household tasks. Technology development and transfer activities that do not consider these farming systems might attempt to extend inappropriate technology which will not be accepted by the farmer. For example, new crop varieties

often have higher yields than traditional varieties but require a longer or different growing season; therefore, they may not be readily adopted in well-developed cropping sequences. Another example is the rejection of new crops which need attention during seasons where off-farm labour demands are high.

A second problem area is the lack of communication and information feedback from farmers to research programmes. In some cases, there are few, if any, mechanisms established to facilitate this process. In other cases, researchers and extension personnel do not appreciate the need for eliciting information and evaluation from farmers. Technological developments, adaptation and transfer based on problems identified by farmers themselves will be more effective in producing new technology acceptable to farmers. In adapting and transferring new technology, it is important to understand farmers' own evaluations of its performance during early adoption. Farmers' evaluations can also assist research personnel in their efforts to adapt technologies to fit a greater number of situations.

A third problem area involves the need to identify the environments farmers must operate within more precisely so that technological development and transfer can be tailored to specific situations. Agricultural and family activities are greatly influenced by physical, economic, and socio-cultural factors which tend to change with time, and are different among geographic areas within the country. Technological development and transfer must accommodate these different environments. For example, topography, climate, and water availability in different zones where crops exhibit roughly the same biological expression (agro-climatic zones) dictate options for the adaptation of relevant technology. Off-farm labour opportunities, input and output market accessibility and government price policy also determine the environment, as do family structure, kinship ties and habits of consumption.

The fourth problem area is the lack of well-developed mechanisms for testing and adapting technology on the farmers' fields. It is clear that adaptation of technology cannot be accomplished entirely on experimental fields or by tightly-controlled experiments on farmers' fields. For successful technology transfer, farm-level testing, adaptation and verification must be done in co-operation with farmers and extension personnel.

A NEW APPROACH TO ADAPTING AND EXTENDING NEW TECHNOLOGY TO FARMERS

Over the past decade, new approaches have evolved for technological development and transfer that are oriented to alleviating many of the problems discussed above. Although specific approaches vary among locations, the general approach involves the following steps (see Figure 3.1) (Kellogg, 1977a).

I. Diagnosis of farmers' circumstances and actions in target area.

II. Planning and design of technological adaptation.

III. On-farm testing and verification.

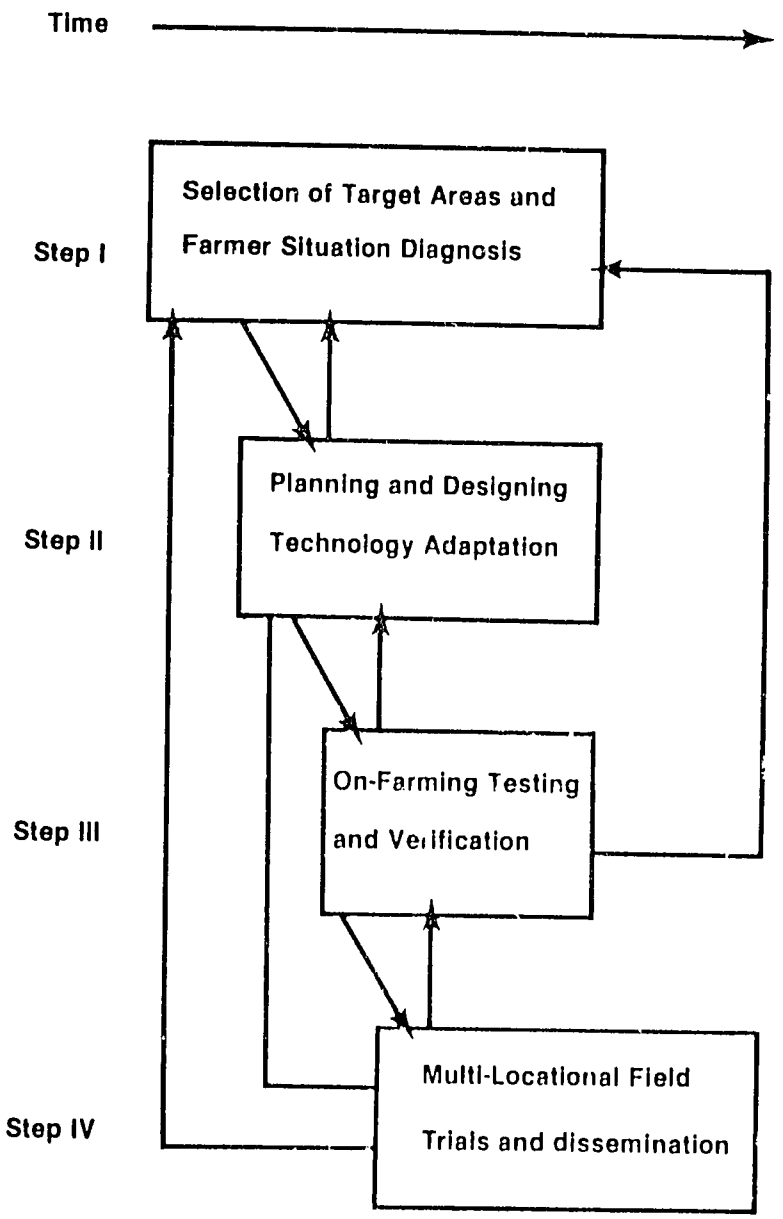
IV. Multi-locational field trials and dissemination.

Step I

This new approach is usually initiated by defining target geographical areas which have similar characteristics. These similar characteristics define a relatively homogeneous set of agricultural activities throughout a particular agroclimatic zone; it is distinguishable from other zones. Extension personnel can contribute to this identification of target areas because they often know conditions at the farm level better than research personnel. While physical data, such as topography, soil type, temperature and rainfall can usually be developed from secondary sources, extension personnel can be useful in helping to define other environmental variables which help to define homogeneous farming areas such as off-farm labour opportunities, market accessibility, actual water availability, and kinship or tribal ties. Agricultural economics extension specialists, if available, can be particularly helpful in determining these variables (Kellogg, 1977a).

Once these target areas are defined, the next task is to diagnose the situation farmers must work within and important problems that need attention. Extension person-

Figure 3.1 Steps in a general approach to adapting and extending new agricultural technology



Note: The arrows indicate that steps overlap in time and results in later steps may require going back to previous steps for further analysis.

Note: From Role of social scientists in cropping systems research, by E. Kellogg, 1977, in Proceedings of the first national conference on cropping systems research in Thailand, pp. 500-547, Chiang Mai, Thailand: Department of Agriculture Economics, Chiang Mai University.

nel are particularly suited to helping researchers understand farmers' problems and existing farming systems with which new technology must fit. This information is usually developed through informal target area assessment surveys by observing farmers' fields and actions and discussing farming with farmers. In many cases, major impressions gained

from these quick assessment surveys are further analysed through implementation of formal surveys of farmers and members of farm households. Again, extension personnel can take a leadership role in these activities. General extension field workers are probably more suited to contribute to this activity because they know farmers and general agricultural conditions better than other extension personnel.

Step II

By using information developed in Step I planning and design of technological adaptation can begin (Byerlee, et al., 1982). Because of their knowledge of research techniques and farmers' situations, the subject matter specialists play a critical role in determining how productive the research directions chosen by the researcher may be. Certain research projects may need to be implemented on experimental stations before being moved to farm locations, while other projects can be started directly on farmers' fields.

Step III

Once these research directions are chosen and preliminary results of experiments obtained, on-farm field testing and verification can be begun. In general, this involves planning on-farm trials, choosing method(s) for implementing these trials, and adjusting trials as results occur (Kellogg, 1977b). The role of extension personnel can be significant in this step.

Step IV

During the on-farm testing and verification process, certain trials will yield results that indicate that the technological options can be managed by farmers and are a significant improvement over current farming practices. Then, similar trials should be implemented in a number of locations within the target area for further verification. These multi-locational field trials can be primarily operated by extension personnel and utilized in the dissemination process.

The steps, as illustrated in Figure 3.1, overlap in time. This means that as sufficient information is gained in one step, the next step can be initiated without waiting for the completion of the previous step. For example, planning and designing technological adaptation may be initiated as soon as certain problems confronting farmers are identified. These steps are also iterative, in that results from one step may require reworking parts of the previous step. If, for example, on-farm trials are not producing results superior to current farming practices, new planning and design of technological adaptation must occur.

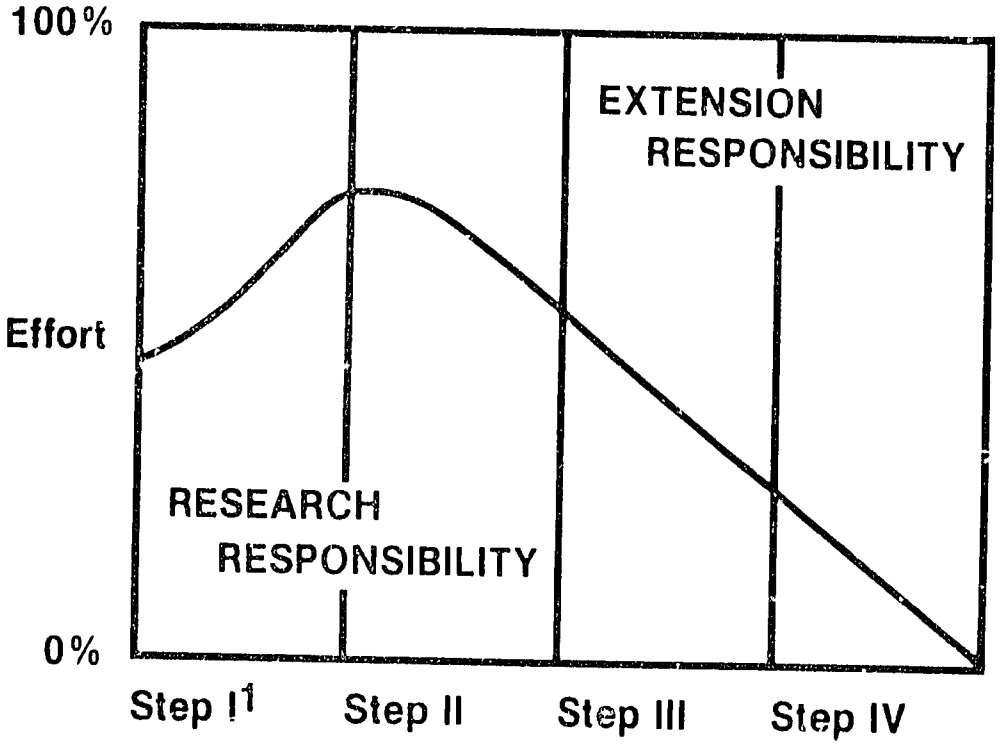
As illustrated in Figure 3.2, the role of extension personnel as intermediaries between farmers and researchers varies from step to step. The following section expands on these roles and provides a description of the tasks of extension personnel in ensuring that more appropriate technology is developed and extended to farmers.

Extension's Role in Selection of Target Areas and Farmer Situation Diagnosis

Effective selection of target geographical areas is a critical activity in the development and extension of new production technologies. Selection generally begins with high-level decision makers in government deciding on one or more areas needing increased attention. National and regional development goals are usually important criteria for selecting an area. For example, in one African country, decision makers selected an area that contained a large number of very poor families, while in another instance, an area that had a high potential for increased production of export crops was selected. These alternatives are illustrated in Table 3.1. In another example, decision makers in a different African country selected a sparsely populated region with improvement potential as a target area.

This target area selection decision was based on the national policy to alleviate land pressure on the fertile river plains. As another alternative, decision makers may select an area on the basis of specific physical limitations or problems such as flooding, soil salinity, steep slopes or inadequate rainfall. In Southeast Asia, decision makers in Thailand have selected target tracts based on criteria of poverty and erratic rainfall,

Figure 3.2 Division of effort in adapting and extending new technology



[1]See Figure 3.1 for definition of steps

Table 3.1
Comparison of Characteristics of Two Potential Target Areas

Characteristics	Target Area I	Target Area II
Total number of families	150,000	125,000
Number of families below poverty level	85,000	25,000
Production of export crops ($)	5,000	1,750,000
Average family's cash income as percent of national average	55%	135%

Note: From Understanding small farmers by M. C. Collinson, 1979, December, Paper presented at Conference on Rapid Rural Appraisal, University of Sussex, Brighton, England.

while in Sumatra areas that have large areas of land infested with Imperata have been chosen (Shaner, Philipp and Schmehl, 1982).

Once target areas are selected, it is necessary to subdivide them into recommendation domains that include a group of roughly homogenous farmers of similar circumstances. These similar circumstances define a relatively homogenous set of agricultural activities throughout the area that distinguishes it from other areas. These activities are usually

Table 3.2
Farm System Zoning Questionnaire, Central Province, Zambia

District_____ Ward No._____ Farmer Group_____

A. Animals kept by most farmers	1. Three main types of animals kept	1 2 3	_____ _____ _____
	2. If cattle, main purposes for keeping	1 2 3	_____ _____ _____
B. Foods Grown (G) or Bought (B) by Most Farmers	1. Starch Staples	1 2 3	_____ _____ _____
	2. Relish crops to flavour staples	1 2 3	_____ _____ _____
	3. Animal products for food	1 2	_____ _____
C. Main Cash Sources for Most Farmers	1. New cash crops and % growing	1 2	_____ _____
	2. Crop sales as a cash source	1 2	_____ _____
	3. Livestock as a cash source	1 2	_____ _____
	4. Off-farm cash source	1 2	_____ _____
D. Land Use and Preparation Methods of Most Farmers	1. Years cultivated	1	_____
	2. Typical area (ha.) preparation	1 2	_____ _____
	3. Main methods of land preparation	1	_____
	4. Main months of land preparation	1 2	_____ _____
E. Hire and Purchase of Resources by Most Farmers	1. Types of hired labour & payment	1 2	_____ _____
	2. Work done by hired labour	1 2	_____ _____
	3. Main inputs purchased and crops using	1 2 3	_____ _____ _____

Note: From Understanding small farmers by M. C. Collinson, 1979, December, Paper presented at Conference on Rapid Rural Appraisal, University of Sussex, Brighton, England.

defined by natural features, such as soil, climate and topography, and agro-economic features, such as access to resources and marketing opportunities. Site selection may also be concerned with certain subsets of the area, such as small farmers following a particular cropping rotation or those with mixed livestock farming systems (Tripp, 1982).

Table 3.2 illustrates a simple questionnaire that was developed and administered by agricultural extension staff to collect descriptive information about a target area in Zambia. The information was used to define specific recommendation domains within the target area. This exercise involved some 20-30 professional work days to survey 100 farmers. Using such a questionnaire, it is possible to develop tables, such as Table 3.3, which detail a tabulation of farmer practices by recommendation domain in a tropical maize-producing area.

Table 3.3

Tabulation of Farmer Practices by Recommendation Domain - Tropical Maize

General Farm Data	Recommendation Domain	
	Flat Land	Steep Land
Average Farm Size (ha.)	11.1	10.2
Area in Maize in August (ha.)	4.6	2.6
Area in Tree Crops (ha.)	3.5	2.7
Annual Cropping Pattern in Selected Field		
Percent Maize-Maize	31	37
Percent Maize-Maize-Beans	33	33
Percent Maize-Squash-Maize	12	10
Percent Other Systems	24	20
Land Prepration		
Percent Plough-Harrow (with tractor)	38	0
Percent Harrow Only (with tractor)	24	0
Percent Hand Hoe	34	68
Percent Chop Only or Chop and Burn	3	27
Planting		
Percent Plant "Improved" Variety	18	3
Distance Between Rows (cm.)	103	102
Distance Between Hills (cm.)	92	94
Average Seeds per Hill	3.7	3.9
Percent Replant	26	35
Weeding		
Percent Weed with Horse or Tractor	15	3
Percent Weed with Hoe	85	97
Percent Weed Twice	83	80
Average Time of First Weeding (weeks after planting)	4.5	3.8
Other Inputs		
Percent Apply Insecticides	86	82
Percent Use Fertilizer	2	0
Production		
Average Yield (ton/ha.)	1.2	1.1
Percent Maize Sold	63	56

Note: From Planning technologies appropriate to farmers concepts and procedures by D. Byerlee, M. P. Collinson, R. K. Perrin, D. L. Winkelmann, S. Briggs, F. R. Moscardi, J. C. Martinez, L. Harrington and A. Benjamin, 1980, Mexico City: International Maize and Wheat Improvement Center.

Assessment Survey

Once recommendation domains are defined, the next task is to analyse the situation of farmers in the area. Extension personnel are well qualified to help researchers understand (a) the problems farmers see as important, (b) existing farming systems within which new technology must fit, and (c) research areas that may yield potentially useful technologies. This kind of information is usually developed through assessment surveys by examining farmers' fields and discussing farming with them. In many cases major impressions gained from these quick assessment surveys are supplemented by working closely with key informants and by implementation of formal targeted surveys of farmers and members of farm households. These survey activities, which should be led by extension personnel, are critical in obtaining a complete understanding of farming practices and systems in the selected areas.

Initially, farmers are interviewed very informally at their farms, preferably in their fields. Farmers are asked about their agricultural production levels. As farmers respond, they are asked if they would like to increase their production. Assuming the answer is positive, the field staff then ask farmers questions such as, "What is limiting your production?" At the end of the day the responses are summarized to try to improve the structure of future interviews. This daily summary might look something like Table 3.4.

Table 3.4
Assessment Survey--Daily Summary

What Keeps Farmers From Obtaining Higher Rice Yields?

(rank 1 = most important 6 = least important)

Reason	Importance
Water supply	3
Lack of fertilizer	4
Poor drainage	2
Insects	6
Weeds	1
Other	5

By applying this approach to the informal survey, extension staff will have a better basis for developing a formal survey document.

Formal Targeted Surveys

Formal targeted surveys are used to gain a better understanding of farming systems in an area and to identify the most relevant problems and opportunities for improvement. Before developing the questionnaire, it is necessary to determine what information the survey is designed to produce. Depending upon the situation, a variety of information might be required. For example, information may be obtained about:

1. Farmers' practices with a particular crop,
2. Land preparation,
3. Post-harvest operations,
4. Harvest, including distribution of the produce and use of crop residue,
5. Farmers' knowledge of plants, soils, pests, weather and plant damage,

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6. Those factors of a total farming system that bear on a particular crop, for example, labour bottlenecks, crop sequences, family food preference, cash flows and water availability.

The length of the questionnaire is important. The longer the questionnaire, the more difficulty the interviewer will have holding the farmer's attention. Ideally, administering a questionnaire should take no more than an hour. This is important, because to provide timely information, it is necessary to process the data quickly. Early knowledge of analysis procedures significantly reduces the time required to process data. It must be emphasized that the purpose of the survey is to be able to diagnose more accurately existing farmer situations in the area and not to obtain information concerning all facets of rural life. Thus, the questionnaire can be shorter and more focused than a general census or rural survey (Bernsten, 1979). Appendix 1 (see Appendix at end of manual) contains a sample of such a questionnaire that was used to interview farmers in Turkey regarding their maize production and general farming system.

Extension personnel can play a major role in the development of the formal survey document as their intimate knowledge of the area combined with their involvement in the informal surveys allows them to prepare well-focused, relevant questions. As a result of the survey process, new technology options that fit local requirements can be identified. In addition, participation in these surveys provides extension personnel with better insights into farmers' needs and problems. Again, extension personnel's knowledge and understanding of farmers' situations and actions can be invaluable in reviewing the direction of technological development proposed by research scientists.

Extension's Role in Planning and Design of Technology Adaptation

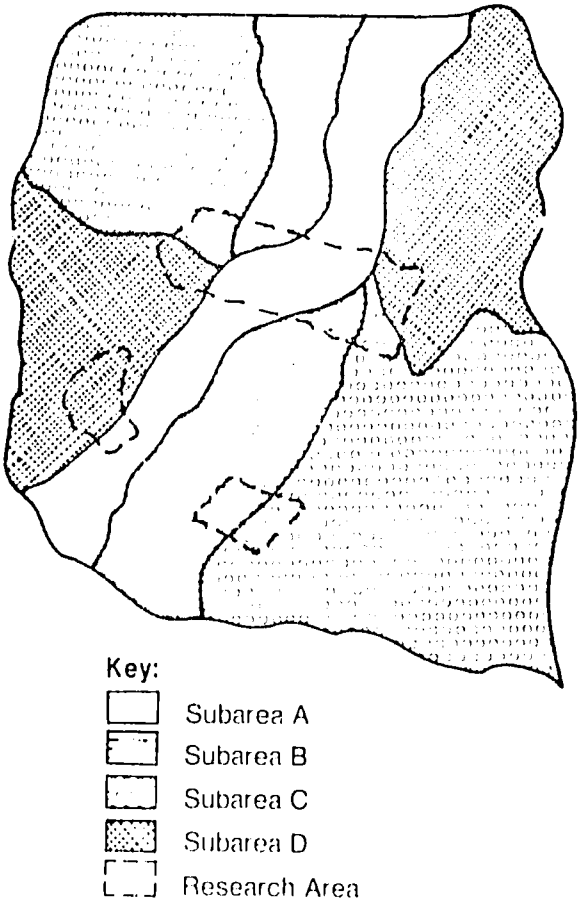
The planning effort is designed to produce a work plan for on-farm trials leading to improvements for an identified group of farmers within the target area. Potential for improvement becomes the basis for setting objectives, selecting field methods, co-ordinating the efforts of experimental stations and other supporting organizations, and outlining the tasks and responsibilities of field staff (Gilbert, et al., 1980). Planning activities involve

1. identifying the target group of farmers,
2. laying the groundwork for field activities,
3. considering alternative activities and methods,
4. finalizing plans for field trials.

In many instances, particularly in situations where there are weak links between research and extension organizations, planning for on-farm trials is viewed as the role of researchers. Yet, when these trials are to be located on a large number of sites, extension staff involvement is critical to the success of the project. In addition, when conditions within a target area are not homogeneous, it may be necessary to divide the target area into smaller sub-areas which eventually will be used as recommendation domains for more or less the same recommendations. Here again, extension staff with their intimate knowledge of the area can facilitate this process. Field and regional extension staff are familiar with local conditions and can work closely with researchers to select target area and sub-area locations. As the selection process requires a knowledge of physical, biological, and socio-economic conditions, extension staff are in a position to accelerate this process and to minimize the costs. Figure 3.3 illustrates the selection of recommendation domains and the identification of on-farm sites within these areas.

An analytical framework can aid in laying the groundwork for on-farm trials. This framework provides guidance in making preliminary estimates of overall feasibility and includes consideration of physical, biological, economic, financial and socio-cultural factors. While the first two factors are in the domain of biological researchers, the last three are clearly in the domain of the social scientists and extension staff. Thus, extension can contribute to the analytic framework. In designing trials, it is best to work towards technically viable designs rather than toward optimal designs. Optimality usually does not have much operational meaning within the complexity of farmers' circumstances, while technical viability implies designs that are responsive to conditions likely to prevail when the technologies are introduced to farmers (Harwood, 1979).

Figure 3.3 A hypothetical target area divided into four sub-areas showing trial locations



Note: From Planning technologies appropriate to farmers concepts and procedures by D. Byerlee, et al., 1980, Mexico City: International Maize and Wheat Improvement Center.

Before deciding on a particular approach, it is necessary to consider alternative crops, research trials, and design. Failure to consider alternatives will produce inferior results no matter how well the trial is designed. Searching for alternatives takes an open mind, imagination, and considerable judgement and experience. The field knowledge of extension staff members can be invaluable at this point. Often the substitution of traditional farming techniques for research station-oriented practices can mean the difference between success and failure (Rogers, 1971). Alternatives under consideration should always attempt to reduce farmers' risk and increase farmers' satisfaction.

In developing alternative designs, it is necessary to establish standards for on-farm trials. General standards include (a) setting up trials that will yield useful results, (b) avoiding unnecessary detail and complexity, and (c) gaining uniformity among trials across areas and over time. Other standards are specific to different countries and to the objectives of the programme. These standards are related to types of farmers, location and number of trials, design complexity and methods of evaluating results (Shaner, et al., 1982).

Before finalizing field trial design, it is necessary to determine the characteristics of farmers who are to be chosen as co-operators. It is important to decide whether to select more progressive farmers or farmers who are representative of the areas' average farmers. More progressive farmers are usually easier to work with and ensure a higher degree of success with trials. However, the results from such trials are probably not representative and may provide biased answers to the question of the appropriateness of the technology (Kirkby, Gallegos, and Cornick, 1981).

Farmers wl meet the requirements must be approached to see if they are willing to participate in a ial. Some small farmers are themselves experimenters, and the concept

of trying a different variety of seed or a new technique is acceptable to them. Nevertheless, in many places, farmers have limited experience in working with government agencies and none at all in cooperative on-farm trials. Therefore, a careful explanation of the farmer's duties and expectations must be made prior to initiating the trial. Extension personnel can help select and contact co-operating farmers, unless it is felt their choice is biased. Collaboration between on-farm researchers and extension workers is important at this stage if a good set of representative farmers is to be selected (Tripp, 1982).

Another consideration in choosing sites is a logistic one. The ideal distribution of sites would have on-farm trials scattered throughout the recommendation domain. Problems of transportation, resources and time often make this impracticable. If trials are placed too far from one another, it is not possible to visit all of them frequently enough. One compromise is to choose several areas within a domain to concentrate on during a given crop season and cluster trials in this area. Trial areas can, of course, be shifted from year to year. As will be emphasized later, the more responsibility is shifted to extension personnel the less any scatter of trial areas is a major problem (Moscardi, 1982).

Selection of trial sites requires a great deal of thought and effort and cannot be left to chance. The planners must have definite criteria for site selection. Some of the more important criteria include the degree to which the

1. site conforms to the basic characteristics of the target area and target group;

2. trial site fulfills the requirements for the type of on-farm trial that is proposed;

3. trial sites can be visited and managed throughout the year, and can provide opportunities for farmer participation;

4. trials are frequently seen by non-participating farmers, if they are to be used as demonstrations;

5. site selection is reviewed to correct previous biases or to reflect changes in emphasis;

6. sites are spread within the target area.

Once locations and farmers have been selected, it is necessary to decide how to choose among alternative fields, and locations within fields. Replicated experiments conducted within the same farmers' fields provide the greatest uniformity of conditions, but where farmers' fields are small, it is often necessary to spread the trials throughout the target area. In general, if trials are managed by research staff, the number must be limited to less than 20. Farmer-managed, extension-supervised trials allow for a much larger number of sites, perhaps double the number supervised by research staff alone.

The level of complexity of on-farm trials is critical. If trials are very complex and involve a large number of treatments, they are difficult to manage under actual farm conditions. In general it is better to have less complex trials in order to meet the limited resources of co-operating farmers and to facilitate eventual diffusion by extension field staff (Zandstra, et al., 1981).

Finally, it is critical to identify a methodology for evaluating the degree of success or failure of a trial. Where possible, it is best to use some type of total-farm budget analysis to determine the success of the trial within the context of the entire farm operation. It is particularly important to learn why trials fail and to be alert to the implications of this failure for design of future trials (Perrin, et al., 1976).

Extension's Role in On-Farm Testing and Verification

Once on-farm trials have been planned and designed, they are ready to be implemented. The most critical question at this stage is that of management. Which group shall actually be responsible for management of the trial sites? Often research staff attempt to manage all trials, but due to their limited numbers in rural areas, the number of trial sites is severely curtailed. Management by extension staff, or even by farmers themselves, offers the opportunity for a greater number of sites. Of course, this does not allow for the same level of research sophistication. Real-world illustrations of these

various field trial management techniques can be found in Limpinuntana, et al., (1982) and Kellogg (1977b).

Researcher-Managed Trials

Researchers manage trials on farmers' fields to develop appropriate technologies for specific groups of farmers. These trials tend to use more sophisticated methods, as used on experimental stations, although non-experimental variables are generally set to represent farmers' conditions. Researchers will often pay farmers for their labour and the use of their land, so that farmers do not suffer losses from poor experimental results. Because researchers manage the trials the designs can be more complex. Small plots are generally chosen, although larger plots may be needed to study constraints on water or soil resources. Replications can be contiguous or dispersed on different farms, depending on the experiment and field sizes. The necessity of researchers to visit the trials at least on a weekly basis severely restricts the number of trials managed by any individual researcher.

Extension-Managed Trials

Extension staff manage trials on farmers' fields to identify and verify appropriate technologies for target groups of farmers. In contrast to researcher-managed trials, extension-managed trials do not use experimental techniques typical of the experimental station, nor do they generally pay farmers for their labour or the use of their land. Extension-managed trials attempt only to control a limited number of experimental variables, although their level of control is usually higher than that of farmer-managed trials. By focusing on farmer conditions, the results of extension-managed trials provide a much better indicator about how farmers will respond to new technologies than do researcher-managed trials. Even though the trials are usually less complex than researcher-managed trials, extension-managed trials can be operated at a level of complexity higher than farmer-managed trials. As the extension worker is stationed and working in the area, it is possible for extension staff to manage a larger number of trials than can be managed by researchers alone.

Farmer-Managed Trials

Farmer-managed trials are particularly important because they allow farmers to participate in testing new technologies. In doing so, farmers reveal their reactions to these technologies. Selection of farmer co-operators requires knowledge, not only of individual abilities, but also about circumstances of the entire farm household. This is important, as field-level staff have often found that the limitations of farmers to manage on-farm trials properly are related directly to the household's resources and the uncertainties of the farmer's environment. Usually, farmers are not provided with financial encouragement, such as outright payments, subsidies for input costs or reimbursement for losses. The reason for this policy is that on-farm, farmer-managed trials are intended to show how farmers will react to the new technologies when applied to their actual conditions.

A critical factor in farmer-managed trials is the relationship between outside staff and farmer's. This relationship hinges on the degree to which staff attempt to direct a farmers activities. Fundamental to the effectiveness of farmer-managed trials is recognition that these tests belong to the farmers. Farmers must be allowed freedom so that the trials reflect their responses to the new technologies.

Staff must realize that the results of farmer-managed trials will be different from those of researcher- and extension-managed trials. Because farmers carry out their activities to fit their available time, they may omit some operations. These adjustments allow the trials to become fully integrated into the farmers' systems. These adjustments are important as they provide the means for identifying and measuring farmers' constraints in adapting the technology to their conditions, and they help to identify problems and opportunities for additional trials.

While it may be possible for researchers to supervise farmer-managed trials, given the shortage of research staff and the necessity of having a large number of location-specific sites, it is usually best to have extension staff responsible for these trials. This can be done in conjunction with other farmer-oriented activities and fits well with the role of an extension worker as an educator. Although extension workers are usually not well-trained in field plot layout and design, the planning exercise and the simplicity of the trial design developed during this exercise should overcome this problem. Extension workers are exceptionally well prepared to determine acceptability of farmer-managed

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trials, as this is usually based on farmers' own actions and comments. Farmers will accept a new practice or technology when they perceive that the benefits are great enough to outweigh the costs.

It is easy to plant a trial, make observations, harvest the crop, and take yield data, all without talking to the farmer. This is a great loss and defeats the purpose of on-farm trials. Some of the most valuable information obtained by on-farm research are the observations and opinions of the farmer. Recommendation domains are defined as "groups of farmers." Collecting data from fields fulfills only a part of the goals of on-farm trials. As the season progresses, and as the research or extension personnel and the farmer participate in agricultural activities together, they come to know each other. This development of mutual respect is important as it facilitates honest exchange and encourages the farmer to provide a frank opinion of what he observes in the trial. It is a good idea to visit farmers with specific questions in mind, although farmers should be encouraged to talk about whatever is of particular importance (Tripp, 1982).

Every on-farm trial has to be closely monitored in order to provide the maximum amount of information concerning that production technology. Data collection is separated into data sets that include information on climate, field characteristics, crop performance, field operations and management, farmer characteristics and harvest data. An example of a field book used for on-farm research is provided in Appendix 2.

Analysis of production practices covering the agronomic and economic performance of the practice should be collected at the end of every season. Because of year-to-year differences in weather, input costs, and product prices, it may be necessary to evaluate the practice over a number of seasons. By working closely with extension staff familiar with the area, it is possible to weight the evaluation of test results to obtain a better estimate of the performance of the practice under the more common conditions of the different test sites. Important criteria for evaluation of performance of the trial technologies are the size of variation in yield and economic measures of the returns from the new practices. An experimental practice that offers returns above variable costs (RAVC) more than 30 percent greater than that of prevalent farmers' practices may be recommended for introduction to farmers (Zandstra, et al., 1981).

Once a new technology has proved itself in the field verification phase, it must be tested in a wider variety of locations. This is done by implementing a larger series of multi-locational trials in other areas that appear to have soil and climatic characteristics similar to those of the original trial area.

Extension's Role in Multi-Locational Field Trials and Dissemination

The target area and sub-areas contain some variability in farmers' conditions. In multi-locational testing, successful technologies identified within specific test areas are evaluated at many sites representative of the conditions for which the patterns were designed. Specification of the land type is an important aspect of multi-locational testing because it allows for a clearer delineation of the domain of adaption of the recommended practice. Procedures for multi-locational testing include

1. identification of extrapolation area by using rainfall records and soil, irrigation and land-use classification maps, where they exist. Extrapolation areas must be sufficiently large to merit future production programmes;

2. within the selected extrapolation area, identify the location and approximate extent of the area that coincides with the land types that were identified at the original site;

3. develop a set of designs for the extrapolation area that allow comparison of the technology's performance with that in the original sites;

4. establish and manage trials;

5. evaluate performance of the technology from production data.

Based on the results of the multi-locational trials, staff should plot the results of the trials on a map and attempt to associate performance with environmental and/or social factors. Through this process it is possible to determine how much, if any, adaptation is

required to adapt the technology to the varying conditions in the extrapolation areas. In the process of multi-conditional trials, staff are able to

1. associate differences in performance of new technologies with the factors causing the differences;

2. discover what adjustments are needed to adapt the new technologies to conditions somewhat different from those encountered in the original on-farm sites;

3. verify, or revise if necessary, boundaries for various recommendations associated with each new technology.

As a result of knowledge developed from multi-locational trials, it is possible to define the conditions for which the technologies are suitable and to formulate recommendations for their extension. This requires defining the domain of adaptation in site specific terms (soil types, rainfall patterns, or drainage characteristics) that are easily identified by extension workers on the basis of simple field observations.

Multi-locational trials should be done by extension or production agencies with the majority of the management provided by farmers. However, in order to ensure timely application of critical inputs such as fertilizer, pesticides and irrigation water, a limited number of trials are usually managed by extension staff. Management and supervision of farmer-managed trials by extension personnel serves to familiarize a large number of extension staff with the new technologies, which helps to facilitate broad-spread extension and to generate the interest and support of local and regional supervisors (Haws and Dilag, 1980).

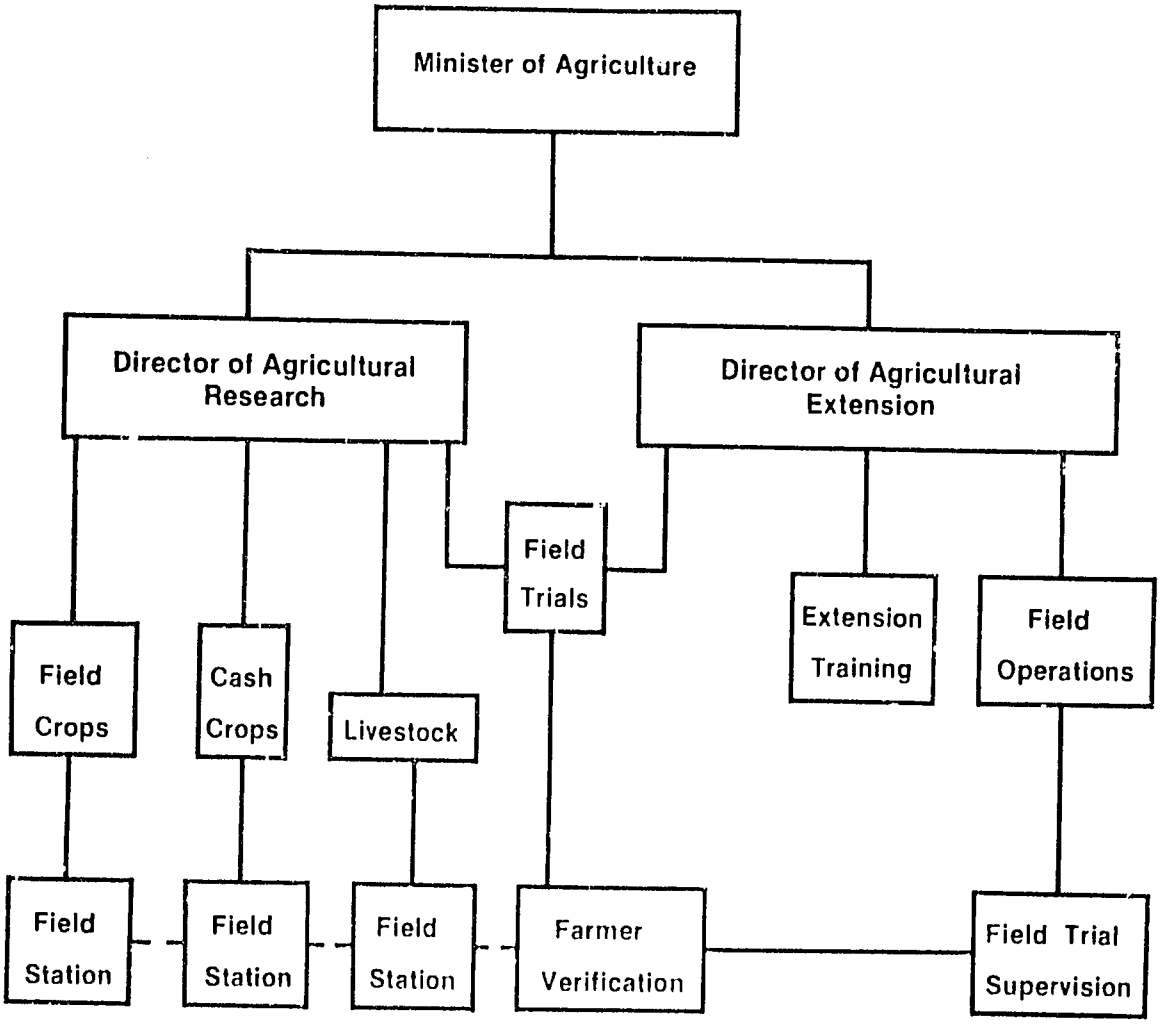
Once a technology has been proposed, tested, retested at a variety of sites, and proven acceptable, it is ready for regional diffusion. At this stage diffusion responsibilities for education and promotion at the farm level become that of the extension organization. The appropriate approach to use depends upon a number of factors which are discussed further in Chapters 9 and 10. Often it is felt that a pilot production programme is required in order to test how support systems--suppliers of inputs and markets react when the new technologies are introduced on a relatively large scale. Such a pilot programme provides valuable information about local factors like commodity markets, credit labour, agricultural chemicals, transportation and information systems.

ORGANIZING FOR ADAPTING AND EVALUATING NEW TECHNOLOGIES

As indicated in the previous section, on-farm trials can be organized and supervised in a number of different ways. Partly this is a function of the purpose of the trial, but it is also dependent upon the mandate and organizational structure of agricultural research and extension agencies implementing the trials. When trials are designed and supervised by researchers, it is important to make certain that trials are not simply research plots transplanted from experimental stations. There may also be problems feeding the results into the broader extension system in order to diffuse them to as many farmers as possible. Where trials are extension organized and supervised, there may be problems gaining access to new technologies from research institutions or stations. In addition, there are usually problems with the general lack of training in plot design for most extension personnel. The best organizational arrangement is one that mobilizes the specialized skills of the various entities. These skills should be focused on the problems of on-farm trials and should be organized in such a manner that they meet and come together in farmers' fields.

For the transition from research to extension to be effective, it is imperitive that both extension and research play an active role during the on-farm trial stage. Unfortunately, this is rarely the case. Too often extension is only involved at the point of diffusion. Field trials must be a shared responsibility of both agencies with joint budgetary, staffing and operational responsibility. In order to operate in this manner, an organizational structure such as that illustrated in Figure 3.4 is recommended. This organizational arrangement effectively links research and extension by creating a joint office responsible for field trials. This office, by having staff from both research and extension, especially subject matter specialists, creates the equivalent of a joint research-extension appointment and ensures that both research and extension are represented in on-farm field trials. Responsibility, and credit, for successful farm trials can be shared equally by the two organizations.

Figure 3.4 Proposed organizational arrangement linking research and extension for adaptation of on-farm technology



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