HENRY A. WALLACE INSTITUTE
FOR ALTERNATIVE AGRICULTURE

On-Farm Research Techniques

Report on a Workshop,
St. Paul, Minnesota, November 15-16, 1990

Molly D. Anderson and William Lockeretz,
School of Nutrition, Tufts University, Medford, Massachusetts 02155

March 1991

Acknowledgments

This workshop was organized in conjunction with a project on research policy at the School of Nutrition, Tufts University, funded by the Northwest Area Foundation and the Ford Foundation. Funds for workshop expenses and preparation of this report were provided by the Farm Foundation. We want to thank participants for their comments both during the workshop and on the draft of this report. We also thank Sr. Esther Nickel for her thorough workshop notes.

Purpose and Scope of the Workshop

In the last two decades, there has been increased interest in research on agricultural systems that reduce environmental damage and better serve the full range of society's needs, including those of farmers. Often, programs supporting research on such systems also encourage placing the research on commercial farms, although the connection between where research is conducted and what it can achieve is not always clear. Two funding sources for research with these objectives, the United States Department of Agriculture's Low-input Sustainable Agriculture Program and the Northwest Area Foundation, have explicitly encouraged collaboration between university researchers and non-academic grass-roots organizations. As researchers attempt to investigate problems and farming systems they have not studied before, and as people from institutions that do not have a long history of working together try to mesh their goals, disparate ideas are emerging about what on-farm research can accomplish, when it is appropriate, and how to do it properly.

This workshop was organized to provide a forum for discussing how on-farm research can contribute to minimizing farming-related environmental and social problems. It dealt both with research techniques and with the place of on-farm research in agricultural research generally. All participants were researchers who have been conducting such projects for several years. Many issues they faced in designing and carrying out their projects are common to all on-farm research. We hope that this report, drawn from their experiences, will be helpful to university teams and grass-roots organizations planning to do similar work.

Kinds of Research that the Workshop Covered

The term "on-farm research" has different connotations for different people. We used the term broadly, in planning the program and selecting participants, to mean any kind of agricultural research conducted on working farms, with three limitations.

First, we did not include a class of studies typified by traditional variety tests or fertilizer yield response trials. Here, researchers use a farmer's field to investigate a routine and very specific question of the type often studied on experiment stations, with involvement by the farmer limited to giving permission and perhaps performing the usual field operations. Such work has a long history, and does not need to be discussed in a workshop concerned with more unfamiliar kinds of research. Second, although on-farm research can study any kind of farming method, currently it is especially popular for research on "sustainable," "low-input," or "alternative" systems. All our participants' research could properly be described by these terms; however, much of this report applies equally to research on conventional farming practices. Finally, our participants' research deals with specific production methods, although on-farm research also can study general processes applicable to many different methods.

Participants and Format

This report summarizes discussions among 19 agricultural researchers from 12 institutions or university departments (listed in the Appendix). Each participant has substantial experience planning and performing on-farm research, with special attention to reducing environmental problems related to agricultural practices. They vary in geographic region, in the crops or livestock they study, their academic discipline, and in their affiliation (private grass-roots organization, state university, or state Department of Agriculture). However, the geographic diversity was not as great as we had wished, because limitations in travel funds prevented some people outside the North Central region from attending. For this reason, most of the discussion was based on participants' experience with field crops.

The workshop format was presentations by individuals or teams about their on-farm projects, interspersed with group discussions. We encouraged participants to talk about innovative methods they were attempting to use and specific problems they had encountered and perhaps not yet resolved. Especially to foster candid discussion of the latter topic, there was no audience, and participants were assured that no names would be attached to specific statements.

The discussions covered a wide range of questions, many in considerable detail. The topics under which we have grouped this material do not correspond to the workshop agenda. Instead, we decided the report's organization after the workshop to bring out generic issues that apply beyond the specific circumstances of each speaker's project. In condensing two days of intensive discussions into a reasonable length, we did not restrict ourselves to questions on which there was agreement; all that mattered was whether the point seemed of general interest. Indeed, we were more interested in areas of disagreement than settled issues, and we intentionally invited people with different viewpoints so that conflicting positions could be aired. Where strong disagreements were expressed, we report them. However, the absence of reported disagreement does not imply a consensus: we did not ask that the participants explicitly approve individual statements, although we did ask them to comment on this report in draft.

Who Owns The Research Agenda?

The Divergent Constituencies of On-Farm Research

A very important consideration in planning on-farm research is who will control the planning and execution of the research. This is an especially sensitive issue now because different kinds of organizations are getting involved in on-farm research, research is receiving more public scrutiny, and competition for existing research support is tight. The various types of groups doing on-farm research include: farmer organizations created for the purpose; grass-roots organizations that do research as part of a broader agrarian program, often with hired staff who are not commercial farmers; land-grant university research and extension personnel; and state-funded programs with hired staff, usually supported through a state Department of Agriculture. Each type has different supporters, resources, and objectives; so each sponsors different kinds of projects. This can make communication among the groups difficult, because what is highly valued by one may not be especially important to another.

An example is the difference of opinion on farmers' role in the research. There are many exceptions, but generally speaking, grass-roots organizations, state-government-supported programs, and farmer organizations emphasize farmer-initiated research, regarding it as a crucial characteristic of a quality project. These groups also tend to support heavy farmer involvement throughout the project, a point that we discuss later. In contrast, land-grant university researchers usually prefer researcher-originated work. Similarly, they do not necessarily solicit much farmer involvement beyond what is necessary to carry out a project (getting permission to use a field, perhaps arranging for the farmer to provide labor, etc.). Intermediate positions between these two extremes are also possible, of course.

Farmers' Research versus Researchers' Research

Although the kinds of projects initiated by researchers and farmers overlap, some general distinctions can be offered. Farmer-initiated projects tend to be short-term and not to involve basic research. The most common anticipated results of these projects are techniques or recommendations that help solve a production problem, although the projects sometimes deal with off-farm effects as well, such as water pollution from manure-spreading. Farmer-initiated research with high farmer involvement typically moves from general to specific principles (i.e., "What will work on my farm?"), whereas researcher-originated projects with low farmer involvement tend to move in the opposite direction (i.e.,"What do the results on this farm tell us about general agricultural processes?"). Farmers sometimes view typical experiment-station plots as unrealistically small or overly controlled, and thus inapplicable to their farms. On the other hand, researchers sometimes criticize farmer-controlled projects for their site-specificity and lack of experimental designs appropriate for answering the questions posed.

Research initiated and controlled by farmers can have strong benefits besides its findings. To some groups, the process itself is a benefit. It enables farmers to participate in the activities of their public universities and to work with other farmers. It also can help them sharpen their powers of observation. It can enhance their sense of competence and independence as they learn to make more informed judgments of alternative methods, using techniques learned from researchers. When farmers have experience conducting on-farm research, they are better able to assess the credibility and generalizability of research conducted by other farmers and by researchers. However, the farmers who tend to benefit most from contact with researchers are probably those who need it least, because they already are keen observers who have good judgment and are curious about why different practices have different effects.

The advantages of active farmer involvement in setting research agendas are not restricted to projects that take place on their own farms. An effective strategy in some people's view is for state experiment stations and other research sponsors to set up farmer advisory committees. However, farmers as a group are a conservative influence, and may not appreciate or support projects that do not appear relevant to their farms.

If farmers are to be advisors about research, it is important to include different kinds of farmers. Also, asking a committee for advice does not mean giving it control over the program. Administrators must remain free to exercise their judgment, and researchers must be allowed to use their professional competence and imagination, without getting mired in conflicting attitudes about the purpose of research. Farmers' advisory committees are not suitable for programs or projects that are not directly applicable to farmers' needs.

For university researchers, a possible long-term benefit of more farmer-run research is that it will relieve some of their workload. When farmers can answer highly applied, site-specific questions for themselves, researchers will be free to deal with more basic questions for which they have special training.

Farmers are more likely to offer their insights and to collaborate enthusiastically in projects where both farmers and researchers contribute significantly at all stages than in projects initiated by researchers. A good way to select research questions in this mode of work is for the researcher to walk the farm with the farmer, looking at problems and discussing them. Focus groups are another way for farmers to get their ideas to researchers, and vice versa. These processes help identify research topics that farmers will find interesting and that are feasible for researchers.

University researchers are more likely to regard on-farm research as one component of a broader research agenda determined partially by disciplinary considerations, rather than simply by what farmers want to have investigated. In this view, an on-farm project need not have a potential economic payoff for farmers; that is, it might not deal with methods that farmers hope will prove advantageous. A drawback, from the researchers' perspective, is that farmers' interests do not necessarily mesh with disciplinary needs; so finding collaborators may be difficult. However, advancing one's discipline and serving farmers do not necessarily conflict; people with both extension and research responsibilities may be able to do both satisfactorily.

Researcher-originated projects must meet formal criteria for experimental design, but farmers may not consider these necessary. Part of the professional training of agricultural researchers is understanding the limits of informal observation and non-replicated studies; therefore researchers believe strongly that objectivity and true cause/effect relationships can be ascertained only by following proper research protocols. They see part of their responsibility as explaining to farmers the advantages of multi-year, multi-site research as a guide for management decisions, in contrast to a single year's results from just their own farms.

Research and Social Change

Grass-roots organizations and state-supported alternative agriculture programs often have a frank bias: they want to promote social change, and participation in research is a means of bringing about this change. They tend to be especially concerned with health and safety issues, and they emphasize the social value for farmers of participating in research. They often believe that university researchers have deemphasized these issues, for example by investigating chemical control of pests at the expense of not developing and promoting cultural controls. In some states, grass-roots organizations have embarrassed land-grant university departments into addressing some of these neglected issues. Of course, there have always been individuals in land-grant universities who have been concerned about negative social and environmental effects of conventional farming practices, but grass-roots advocacy of alternatives has made it much more acceptable politically to give priority to these problems.

Conflicts can arise when the same group is involved with research and advocacy, because the purposes of the research are not made clear or are misconstrued by outside observers. Even if a project is conducted by strict research standards, people familiar with the advocacy organization may assume that the research was designed to prove a point consistent with the organization's purposes. Researchers in private or advocacy groups tend to downplay this conflict, arguing that to insure their reputation and therefore maintain their effectiveness, research that carries their name must be accurate and unbiased.

The issue of bias is not confined to activist groups. Even university research that supposedly is unbiased has value-driven underpinnings, if not in the interpretation then at least in the selection of research topics. Particularly if commercial interests are involved, "research" may be designed to get particular answers. Justifiably or not, farmers may assume that a bias exists, even if the researcher believes that the work is completely objective.

When and Why is On-Farm Reasearch Appropriate?

Reasons to do a given project on commercial farms fall into three groups: those that demand a working farm regardless of whether the farmer participates; those that demand both a farm site and involvement of the farmer; and other advantages even when a farm site is not essential (these may or may not need farmer participation). The first category refers to projects requiring conditions not available on experiment station land. These conditions can be physical, such as particular soil types and geological substrata. They can also be biological, such as a pest infestation or a cultivar of a perennial crop that requires several years to become established. Working on farms is especially important in large, heterogeneous states that do not have experiment stations in all the important agricultural regions. Also, the experimental design of a project may not be compatible with the constraints of the experiment station. For studies of insect pests or beneficial species to be realistic, they should be done on a scale appropriate to the distances that the insect moves, which may be too great for an experiment station to encompass.

Similarly, a multi-crop, multi-treatment rotation study may need more land than can be obtained easily on the station.

Both farmer participation and a farm site are necessary if the research involves an innovative system that the farmer knows how to operate better than the researcher does, or if the farmer's ability to manage the system is part of the experiment. This is not to say that farmers should not also participate in on-farm research set up for other purposes, just that their involvement is not essential in those projects.

Even when the research does not have to be done on-farm, it may cost less to do so than to investigate a similar question on-station. But in comparing costs, one should keep in mind that the two kinds of sites allow different intensiveness in monitoring the experimental plots, so that on-farm research may not provide adequate answers for some of the questions addressed at experiment stations. Sometimes, a farm site is advantageous if intensive monitoring is necessary, because the operator is always there and does not have to commute long distances to reach the study area. However, intensive monitoring that requires special technical skills or equipment usually is better done on-station.

On-farm research frequently is more credible and accessible to farmers, particularly if it is done with large, machine-harvested plots. Also, working with farmers helps assure that the project is relevant to farmers' practical needs: they can tell researchers immediately if an alternative method is not worth studying because farmers will not use it.

All these are valid reasons for considering on-farm sites for projects. In contrast, when research is done on farms just because of pressure from funding sources or supervisors, its quality suffers. Although the intentions may be good, the consequence often is that on-farm research is added to projects for which it is not appropriate, either because the work should be located on-station or because on-farm demonstrations would suffice.

On-farm research can complement research conducted on-station; the choice does not have to be only one or the other. In studying a particular topic, a good sequence is to begin with exploratory on-farm research to find the range of practices in use in some area, and to get a qualitative idea of how well they work. Next, on-station research can examine why some of the most promising practices work, and help fine-tune recommendations for varying environmental conditions. Also, on-station research usually is the appropriate place to screen riskier alternatives, experiments that may make a field look bad, or experiments that could leave farmers with a lingering problem, such as weeds. After suitable investigations on-station, a small set of alternatives can be tried out on farms for verification, in demonstrations or research projects, before making more general recommendations.

Another way the two can support each other is that both can contribute data to be synthesized into whole-farm models. When doing this, one must keep in mind that there may be systematic differences between farm and station data. For example, corn yields from large machine-harvested plots will be consistently lower than yields from small hand-harvested station-type plots, because machine-harvesting misses lodged stalks. However, if the treatments being compared have different effects on lodging, machine-harvested yields are more realistic. Another example is that small-scale studies in an experiment station orchard typically will involve hand spraying, whereas a commercial operator will use an airblast sprayer. There can be important differences in the effectiveness of insecticides applied by these two techniques.

On-Farm Activities That Complement Research

Some people regard on-farm research as inferior to station research. They consider it less rigorous and credible, more subjective, based more on informal observations than systematic data collection, and incapable of determining causal relationships. These assumptions are unwarranted: on-farm research can have any degree of objectivity, and is fully compatible with hypothesis-testing methods. Mistaken impressions of on-farm research come about because it sometimes is not distinguished clearly from non-research activities that serve different purposes. These activities include demonstrations, observations, and case studies.

Demonstrations must be visually convincing, but they do not necessarily include data collection or analysis. They are usually at one site, short-term, and non-replicated. For these reasons they tend to be easier and cheaper than research projects. They can stimulate farmers' thinking about different systems, as well as convey simple recommendations. The results of demonstrations are of more restricted use than research, because there is no way to know their limits of confidence.

In deciding whether demonstration or research is appropriate, project planners need to keep in mind for whom the work is done and what would convince that audience. The difference lies in the purposes of the activities: research seeks to answer a question, whereas demonstrations seek to communicate and persuade. Unfortunately, the lower status often imputed to demonstrations may tilt the choice toward research when a demonstration would have been more appropriate, or cause a given activity to be called research even though it properly should be called a demonstration. Two approaches can be taken to avoid the possible misinterpretation of a demonstration. One is to design the activity in such a way that it validly serves both purposes. The other is simply to let farmers observe the outcome of the demonstration and draw their own conclusions, rather than collect data to support the conclusions.

Sometimes individual on-farm demonstrations do not reach enough farmers to make them a suitable mechanism for Extension, and the extra effort in converting a demonstration to a more broadly-publishable research project is small. If the question is posed by a farmer and will be answered by a demonstration, the researcher should not ask the farmer to take on the extra trouble required by randomization and replication. On the other hand, farmers may not thoroughly understand the differences between research and demonstration because they do not realize that a single-farm demonstration is not as informative as the combined results of a multi-farm study. However, sometimes the best answer for an individual farmer *is* the result obtained on that one farm; which strategy is more valuable depends on the farm-to-farm variability of the phenomenon being investigated.

On-farm collaboration allows farmers and researchers to share observations, and lets the researcher draw on the farmer's experience with a farm and its problems. This can be a good beginning for choosing topics suitable for demonstrations or research. However, observation *per se* is not research. Every person who observes a farm notices different things and interprets them differently; research methods were developed precisely to allow these observations to be standardized. In practice, research often leaves out indicators of environmental quality that are important to some farmers, such as leaching of fertilizers or pesticides into groundwater, changes in earthworm density, or soil organic matter accumulation. There is no reason these cannot be investigated in a research project, although they increase its cost.

Case studies, the last form of on-farm activity involving farmers and researchers that we will consider here, are a way to disseminate farmers' experiences and deal with farmers' values. One kind of case study is the decision case, which is built around a single decision or problem that must be faced in managing a farm. It presents all the information and constraints that affect the decision-maker. Decision case studies are based on interviews, and include both quantitative data and the personal information and individual circumstances that are critical to management decisions. They are particularly useful as teaching tools for students, farmers, and extension personnel, because they force other people to step into the farmer's situation and weigh the alternatives. Case studies can be presented professionally and reviewed similarly to a manuscript based on field experimentation. Less formal case studies centering around some management problem can be useful in focusing discussions with groups of farmers or extension agents. Case studies can be combined with research by suggesting research questions for which answers are needed to make real-life decisions. They also complement research by bringing into consideration values that are not easily included in research projects, but that play a big part in whether farmers adopt alternative practices.

Experimental Design and Analysis

The Appropriate Choice of Farms to be Studied

Selecting appropriate study sites is a difficult problem in planning on-farm research dealing with alternatives to

conventional farming practices. Farmers who use practices intended to reduce agriculture's environmental and social problems are a very diverse group; this diversity complicates any comparison of "alternative" and "conventional" farmers and farms. Projects trying to compare such farms must clarify the characteristics of interest when planning and describing the project. Farmers' social or stewardship values should be distinguished from low use of synthetic fertilizers and pesticides. Although they are often related, particular values should not be assumed for all farmers who use a particular technique.

Selecting conventional and alternative farms, or fields within farms, becomes simpler when the alternatives of interest are defined clearly. The usual strategy is to find a conventional farm that resembles each alternative farm in physical characteristics (soil types, slope, rainfall, etc.). It may not be necessary always to use an actual conventional farm for such comparisons. In calculating farm budgets, for example, a combination of data from the Census of Agriculture, Soil Conservation Service, Cooperative Extension, and other sources might provide an adequate baseline. Often, expected yields and other information are available by soil type. Depending on the questions being asked, county- or sub-county-level information may be adequate. In addition, expert opinions, such as those of extension agents, can be helpful in characterizing the conventional system to which an alternative is being compared. Granted, this introduces an element of judgment; but it may be adequate for the project's purposes, and funds to do the job more systematically may not be available.

Mock farms on experiment stations are one option that some states are using to study environmentally-benign farming practices. Although these tend to allow greater control and precision than studies on commercial farms, they are expensive to set up and maintain.

Research Scope: Whole-Farm versus Components

On-farm research often is equated with whole-farm research, but it can be focused on specific fields or enterprises just as much as experiment station research. However, when farmers use their own implements and do the fieldwork, even work on a single field has a whole-farm aspect because the project will be managed as part of the farm and will be subject to whole-farm constraints. The need to make a profit from a farm and to have the work on the research plots fit in with all the other jobs the farmer has to do will force some compromises into a strict research schedule. But performing the fieldwork under whole-farm constraints does not mean that the analysis incorporates variables from the entire farm. Conversely, working on a station does not preclude a whole-farm focus. As mentioned earlier, data from station research plots can be supplemented with appropriate data from other sources to create whole-farm models.

Some investigators combine the two scales of on-farm work. They collect data intensively from specific sites, but also collect data from the farm as a whole. Typically, microsite-level data involve biological and physical variables, such as soil flora and fauna, whereas the whole-farm analysis is usually economic.

Layout of Experimental Plots and Statistical Issues

Design decisions, such as the number of treatments and replicates or the size of the plots, must always be made with consideration of what the farmers are willing to do and what they can do within the constraints of operating a commercial farm. Sometimes this means making compromises, lest the entire study fail.

There is considerable controversy over the best way to lay out plots on working farms. If the farmers are willing to provide the labor and if credibility to farmers is important, then large, machine-harvested plots are usually preferable. Farmers are more inclined to believe results from large plots because it is easier to picture how the demonstrated technique would work on their own farms. Also, use of machine-harvested strips reduces experimental coefficients of variation. This is probably because large plots average out soil heterogeneity better than small plots. However, coefficients of variation are not the only measure of how good a design is. Although larger plots may have smaller coefficients of variation, treatment differences can be confounded with variation in soil type. Small plots are more appropriate when soil homogeneity is important. Also, small plots may be preferable for high-value crops if some treatments may significantly lower income. Even though the researchers usually offer

to compensate farmers for the loss, farmers may not be willing to risk heavy yield losses on large areas. Some researchers advocate smaller plots for the riskiest treatments in an experiment, but this creates problems with statistical analysis.

A design used successfully by the Practical Farmers of Iowa has field-length strips the width of farm implements, with six to eight replicates and two to four treatments. This plan uses 10 to 12 acres for the entire experiment. Treatments involving several implements on the same ground may create a problem because the implements used may have differing widths. Where enough land can be devoted to the experiment, one solution is to increase the size of the plots to a common multiple of the implements' widths.

Researchers must consider carefully the number of treatments and replicates for each experiment, rather than automatically following the customary practices of experiment station work. To answer farmers' questions, simple statistical analyses may be sufficient (e.g., t-tests); but more elaborate experimental designs and analyses may be needed to satisfy the researchers. If the coefficient of variation is reduced with large, machine-harvested plots, then an experiment can get by with fewer replicates. Regardless of the number of replicates used, the researcher needs to be sure that soil variation and treatment effects are not confounded.

Similarly, the statistical significance level should not be chosen inflexibly, but instead should depend on the purpose of the experiment. For example, a less stringent criterion may be appropriate if the purpose is to decide whether to recommend a practice that costs no more than the one it might replace (e.g., a new variety), rather than to test a research hypothesis. If researchers are only 80% confident that a new variety is better than the older variety, but if they insist on the 95% confidence level that is customary in research, farmers have missed the chance to benefit from an alternative that probably is better. In fact, provided the alternative is no more expensive and does not entail other risks, one can argue that it should be recommended whenever one has more than 50% confidence that it is better. Some researchers suggest that the best tactic is simply to report the probability of a given response to farmers, rather than to give a recommendation, and let them make the decision about whether to adopt a practice.

Especially with larger plots, establishing control plots can be a problem. Farmers often are reluctant to set up a "no-treatment" control, because the resulting weeds or other pests have consequences for the rest of the farm, either immediately or in the future. Randomization is sometimes a problem because a randomized design is more trouble for the farmer to implement. If adjacent plots are to be treated in order, the equipment needs to be set up differently after each plot (for example, the grain drill has to be emptied and filled with a different kind of seed). Alternatively, if all the plots that receive a particular treatment are to be done together, the other plots must be measured out and marked, and the operator must jump around from one part of the field to another. In either case, a randomized design takes more time and effort. There are several alternative solutions. The farmer can be compensated for the extra time required, or a technician can be hired to supplement the farmer's labor. It also might be better to avoid experimentation altogether and set up a non-randomized demonstration instead.

In a study comparing entire farming systems, farmers do not have time and space to run the two systems side by side. Instead, the whole farm can be considered as one treatment (for example, organic or conventional), with no replicates or controls within the farm. However, soil and climatic differences are confounded with management when just two farms are compared. Therefore, such comparisons usually involve several pairs of farms. Where feasible, it is preferable to have replicates within each farm and to use farm averages as single data points in a multi-farm study. That way, accurate farm-specific information can be given to each participant, but the study also can reach area-wide conclusions.

Surveys and Case Studies

Farm surveys and case studies supplement fieldwork by showing what practices are being used in an area at a particular time. They often precede more detailed studies of innovative practices by showing researchers interesting things that farmers are doing, bringing problems to the attention of researchers, and suggesting research hypotheses. They allow researchers to draw on the considerable experience of farmers, some of whom have been using alternative methods for many years.

An effective strategy is to begin with an exploratory survey mailed to a random subsample of the group of interest, followed by on-farm interviews with a subsample from the survey, then case studies from a subsample of the on-farm interviewees. More detailed information can be collected at each stage, with farmers who are unwilling to spend the time winnowed out when successive subsamples are chosen. Data from the on-farm interviews and case studies can supplement on-farm or on-station fieldwork when constructing whole-farm models.

Selecting the appropriate population from which to draw survey samples is difficult for studies of farmers using alternatives to conventional farming practices, for similar reasons that selecting fieldwork sites is difficult. There is no definitive source for learning the entire population of such farmers. This leaves three possible strategies: to take a random sample of all farmers; to sample from an existing mailing list that is preselected for interest in alternative farming (e.g., members of an organization); or to construct a composite mailing list from several such sources. None of these options is ideal: the first is expensive because a very large survey must be done to get enough farmers in the group of interest. The second and third possibilities can omit eligible farmers, or can combine farmers who differ widely in their use of alternative practices. In these cases, it is desirable to include filter questions that quickly identify respondents who do not belong in the sample.

Project Organization and Personnel

Many on-farm research projects need to combine people with diverse interests and backgrounds. At the very least, researchers must come to some agreement with farmers for use of their land. Frequently on-farm research involves multidisciplinary teams, especially when whole-farm phenomena are studied or the research is concerned with alternative agriculture. Also, many funding sources for on-farm research encourage cooperation between research institutions and outside groups, such as grass-roots organizations. A critical aspect of successful on-farm research is how best to combine the contributions of these diverse participants.

Collaborations among Different Kinds of Groups

Each of the groups working in on-farm research, as discussed in the section on who controls the research agenda, has a different perspective on research and brings different strengths to it. Farmers can offer their experience, their assessment of which problems are critical, and their opinions about what alternatives are practical. Extension personnel have considerable experience working with farmers and have contacts in every county, which lets them reach more farmers than the staff from any other institution. Private grass-roots organizations and state alternative agriculture programs do not have to serve a specific minimum number of farmers, and so can afford to give more attention to individuals. They are in a good position to establish and help run networks for farmers to share their experiences and problems. And since they tend to emphasize topics that are not already being researched extensively at land-grant universities, they can help assure that the research being done in a state meets the full range of public needs. University personnel have training in specialized disciplines and research methods, so they have the means to discover underlying principles that can lead to better production methods. Their training gives them a basis for judging and explaining to others the reliability of results obtained in different kinds of activities and their applicability to various conditions.

Partly because of their different views of research and different constituencies, groups sometimes have trouble working well together. For dependable collaboration, each group needs to see how its purposes will be served. Groups also need to be open to sharing control that previously they enjoyed exclusively. New private organizations and state programs, in particular, may arouse hostility from institutions that already have established working relations with farmers. Some of the hostility is a defensive reaction to a new group encroaching on an established group's perceived territory; some of it is a reaction to previous failures when attempting to collaborate. For example, in one state program that gave grants to farmers to set up on-farm research, extension personnel committed time to a project but the cooperating farmer refused to carry through with the plan once the money was in hand. Many researchers and extension personnel believe that the money for on-farm research should go to the researchers, not the farmer cooperators, so that they can control what is done with it. This helps ensure that

participation will benefit the researcher professionally and that the research will meet its original objectives. However, some people object that this practice takes too much power away from farmers, who are supposed to be the projects' beneficiaries.

Sometimes, the desired cooperation among researchers, farmers, and local extension personnel is impossible because extension agents are not familiar with unconventional practices. For example, in many states, extension agents do not have experience with organic farming methods. The alternatives being investigated as environmentally or socially beneficial are largely outside the mainstream of farming, and their practitioners have not relied on extension personnel very much in the past. On the other hand, getting local people such as the county agent involved in a project often is cheaper than bringing in consultants or technicians from outside, and lets a community know what is being done. This helps avoid defensiveness provoked by moving onto someone else's territory.

Another source of conflict is misunderstandings of the real purposes of a project. Sometimes these only become clear after the work is in progress. For example, a private organization may want to foster some social change through the project, while a university researcher may feel that promoting a particular viewpoint jeopardizes professional credibility. The best way to avoid this kind of problem is to make the purposes of the project fully clear at the beginning.

Collaboration between university researchers and outside groups is especially difficult for entry-level researchers. As we discuss later, if they feel pressure to publish frequently, they cannot afford the time and flexibility that this kind of project needs. Also, they are more vulnerable to within-university repercussions from working with non-professional groups. However, this is becoming much less of a problem, as administrators realize that cooperation with outside groups can be a valuable source of political support for the university.

Collaboration among Different Disciplines

On-farm research is not necessarily multidisciplinary, even when concerned with alternative agriculture, but in practice it often is. In fact, multidisciplinarity can be a requirement for receiving funds in some programs. However, sometimes an appearance of multidisciplinarity is created to meet this requirement; the "multidisciplinary" project may just be an assemblage of unintegrated, single-discipline components. At the other extreme of the range are fully integrated *inter*disciplinary projects, where the people from various disciplines work together at all stages of planning, conducting, analyzing, and writing up the research. Interdisciplinarity is not always the best plan; each project must decide how closely the disciplines involved need to work together. An intermediate approach that captures many of the benefits of interdisciplinary research is for people from various fields to work together in planning the project and reviewing draft manuscripts, but not when analyzing the data. Data analysis is the most difficult stage at which to combine disciplines, since each field collects different kinds of data and has different ideas about appropriate analyses.

A truly multidisciplinary approach has several benefits. First, it allows some inherently multidisciplinary topics to be studied that otherwise could not be investigated. Attention to interesting questions that would be neglected by single-discipline approaches is especially likely when widely differing disciplines are combined, such as agricultural sciences and anthropology. Including other viewpoints enriches a project by subjecting each discipline's assumptions to critical scrutiny by people who see things differently. Also, multidisciplinary projects can pool resources, such as technicians and equipment, and therefore may be cheaper or more efficient than single-discipline studies.

These benefits must be measured against the added burden of multidisciplinary research and the trade-offs that occur. Meeting with other researchers and learning the language and concepts of other disciplines requires extra time, and different disciplines have different standards of what constitutes acceptable data. Also, some methods may be prestigious in one's own discipline but irrelevant to a team project. For example, agricultural economics often places strong emphasis on sophisticated modeling, whereas a simple model may be more appropriate in a multidisciplinary whole-farm analysis of alternative systems. In addition, people from different disciplines may

need different sites to do their parts of a project properly. An entomologist might want a site where a particular insect outbreak occurs, but the factors that cause the outbreak might make the site nonrepresentative for other team members' work. Finally, in some institutions, research by multidisciplinary teams lacks support. If a department or a discipline does not value multidisciplinary work highly, this interferes with researchers' professional advancement, as we discuss below.

Whatever degree of integration is decided upon, effective multidisciplinary teams don't just happen: they require a lot of effort. First, the personalities of team members must be compatible. Also, there must be no animosity between department heads, for example, because they begrudge the time their faculty members devote to the work of other departments. But even good intentions and compatible people do not insure successful cooperation. It requires that each person understand what will be expected and what the individual benefits will be. There should be a clear agreement about how project funds will be allocated; this does not necessarily mean that they should be split evenly among participants. To keep the group working together without lasting friction, it is important to discuss interpersonal conflicts openly, perhaps delaying decisions on controversial points until all members have had a chance to think about what they need. The group should consider drawing on the expertise of people who are competent at running meetings. Also, allowing time for interactions outside regular meetings helps the group to operate cohesively. Keeping a research effort alive in an institution requires a long-term commitment by a few core people, which is much easier if institutional support exists. Deans, experiment station directors, and other administrators should be aware of the costs of multidisciplinary work in money and time, and make allowances for them.

Working with Farmers

A valuable benefit of on-farm research is the possibility of combining farmers' experience and practical knowledge with researchers' expertise. Making this partnership work in practice is not always simple. Farmers must have a real commitment to the research effort, which is much more likely if they are involved in planning and conducting the work. Farmers will be more interested in becoming involved with a specific project in the first place if they already believe in the value of performing research on their farms. Effective cooperation requires team members (researchers as well as farmers) who communicate well and who are thoughtful, insightful, and respectful toward each other.

Once enthusiastic farmer-cooperators are selected, arrangements must be made to compensate them fairly for their time. Farmers who are very eager to know from the start how much money the project will pay them probably are not appropriate cooperators; they should be motivated by more than just the money. Compensation can be a mixture of money, products (such as seeds or chemicals), and non-material benefits. The amount should depend on the complexity of the project, how much is expected of the farmers, how much income they risk losing, and whether the results are likely to be immediately beneficial to them. The farmer usually is compensated for lost income on the research plots if yields are lower with the experimental treatment, although some researchers report intransigence on the part of funding agencies to cover this expense. If the farmer must spend considerable extra time to set up plots, collect data, or keep records, additional compensation should be negotiated. If farmers and researchers work as a team with active involvement by both, the farmers sometimes are unwilling to accept money, perhaps because they prefer to keep the interaction on a social and reciprocally-beneficial professional rather than financial basis. As we noted earlier, in some on-farm research programs the process itself is considered an important benefit of farmer participation. However, offering a payment helps get the farmers' cooperation because it shows that the researchers value their time and acknowledge the risks they are accepting.

It is important to make farmers' and researchers' respective responsibilities very clear. It is not fair to expect extra work from farmers during busy seasons, nor meticulous station-type data collection. If such measurements are necessary, but it is desirable for other reasons to locate the project on a commercial farm, a technician should be hired to collect data. Also, it is not reasonable to expect farmers to make constant adjustments in their usual management to accommodate the research, nor to have to work around monitoring equipment left in fields. The

researchers must adapt the experiment to what they judge each farmer can do, and make the project as convenient as possible.

Barriers to Acceptance of On-Farm Research, and How to Overcome Them

On-farm research is not a radical departure from conventional agricultural research; it was done even before agricultural research institutions were established in the United States. It is controversial only when it involves unusual methods that are not fully accepted. Many of the problems that are of particular interest to people now doing on-farm research do involve new methods, or at least an expansion of the scope of conventional methods. For example, studying off-farm environmental effects may require whole-farm analyses to find how different parts of a farming system act as sources and sinks of pollutants. But at present, only a small proportion of agricultural research involves whole-farm studies, and the best ways of setting them up and analyzing the data have not been agreed upon.

Acceptance of an on-farm research project will be enhanced if its purpose is clearly identified, so that it is judged by appropriate standards. In particular, the distinction between research and demonstration must be kept clear, as we discussed earlier. On-farm research is not designed to answer the same questions as experiment station work; it has a complementary role that should be respected by land-grant university personnel and professional organizations. The strengths of on-farm research are more apparent when institutions place greater emphasis on solving real problems, rather than merely advancing disciplines. More recognition is needed for the legitimacy of types of research especially suitable for farms, including inductive, exploratory work.

In some institutions, on-farm research has lower status than projects done on experiment stations. Researchers in some disciplines believe that on-farm research can only be published in less prestigious journals. However, this is a point of dispute; in other fields, conducting research on farms carries very little professional risk. For example, some research published in prestigious agronomic journals is done on farms, but this fact is not even considered worth mentioning.

The problem of inadequate professional recognition can become aggravated when the on-farm project is multidisciplinary. First, papers from multidisciplinary projects typically will have several authors. In some departments, only senior or sole authorship gets much credit. Second, some departments and disciplines discount papers outside the author's discipline. For both these reasons, results of multidisciplinary projects often are published in several papers, each with a different disciplinary orientation and a different senior author. But as noted earlier, multidisciplinary work is very time-consuming. Therefore, each investigator will very likely get to be senior or sole author on fewer papers compared to spending the same time on single-discipline research. For this reason, junior faculty and graduate students doing on-farm research may jeopardize their future prospects. The risks are less serious for well-established professionals and people with broader responsibilities. For them, creativity and competence are more likely to be rewarded even if the project does not fit customary disciplinary expectations.

Acceptance of on-farm research has an institution-wide component; it does not come only from individual departments and disciplines. Therefore it is important for administrators to set the right tone, making it clear that on-farm research is valued at their institutions. A powerful source of institutional support has been federal and private grant programs that encourage on-farm research. Funds from outside the university have allowed university researchers to pursue some problems they previously have not been able to investigate. These funds also have made it easier and more acceptable to work with non-university groups. As mutual suspicions decline, this kind of cooperation is becoming more fruitful. A very promising benefit of on-farm research is that it can improve relations between university researchers and other groups interested in agricultural research. If this trend continues, it will improve the fit between directions in which the agricultural research profession is moving and the concerns of farmers and the rest of society.

Appendix

PARTICIPANTS IN ON-FARM RESEARCH TECHNIQUES WORKSHOP

Sharon Clancy
Carrington Research Extension Center
Box 219
Carrington, ND 58421

Kent Crookston
Department of Agronomy & Plant Genetics
University of Minnesota
St. Paul, MN 55108

Rick Cruse
Department of Agronomy
3212 Agronomy
Iowa State University
Ames, IA 50011

Thomas L. Dobbs
Department of Economics
South Dakota State University
Brookings, SD 57007

Laurie Drinkwater
Department of Vegetable Crops
University of California
Davis, CA 95616

Chuck Francis
Department of Agronomy
222 Keim Hall
University of Nebraska
Lincoln, NE 68583

Rick Gauger
Energy & Sustainable Agriculture Project
Minnesota Department of Agriculture
St. Paul, MN 55107

Walter Goldstein
Michael Fields Agricultural Institute
3293 Main Street
East Troy, WI 53120

Steve Guldan
Michael Fields Agricultural Institute
Carrington Research Extension Center
Box 219
Carrington, ND 58421

Doug Gunnick
Energy & Sustainable Agriculture Project
Minnesota Department of Agriculture
St. Paul, MN 55107

Dale Hicks
Department of Agronomy & Plant Genetics
University of Minnesota
St. Paul, MN 55108

John Moncrief
Soil Science Department
University of Minnesota
St. Paul, MN 55108

Richard Ness
Sustainable Farming Association
P.O. Box 815
Lewiston, MN 55952

Dean Polk
Rutgers Fruit Research & Development Center
Rutgers Cooperative Extension
RD 2, Box 38
Cream Ridge, NJ 08514

Diane Rickerl
Department of Plant Science
South Dakota State University
Brookings, SD 57007

Carl J. Rosen
Soil Science Department
University of Minnesota
St. Paul, MN 55108

Phil Rzewnicki
216 Agricultural Hall
East Campus
University of Nebraska
Lincoln, NE 68583-0703

Charles A. Shapiro
Nebraska Research and Extension Center
University of Nebraska
Concord, NE 68728

Donald Taylor
Department of Economics
South Dakota State University
Brookings, SD 57007

* * *

All materials contained in this report may be cited, provided credit is given.