Development of more effective conservation farming systems through participatory on-farm research

S.B. Wuest, D.K. McCool, B.C. Miller, and R.J. Veseth

Abstract. *Research aimed at advancing conservation farming practices is typically performed using traditional scientific approaches, which have been highly successful in increasing agricultural output and efficiency. With the current emphasis on environmental and economic sustainability of agriculture, there is a need for a more integrated approach to applied agricultural research. Participatory research helps to bring scientific methods and the integrated production needs of farmers together to develop practical, effective, and carefully tested farming methods. The strength of participatory research is in the synergism of scientists and farmers working together to design, implement, and evaluate research. The development of new technologies for farming systems large or small, conventional or organic, can be greatly enhanced through more extensive use of participatory research.*

Key words: sustainable farming systems, technology transfer, research agenda

Introduction

Successful farming is as much an art as a science, requiring experience, attention to detail, and the desire to succeed. A well-informed, conscientious farm operator fulfills conservation and production needs by integrating current technologies, the quantity and quality of available resources, economics, and local environmental conditions into a site-specific farm management system. The farm operator, whether in the USA or in any other country, needs flexibility to select the most effective, efficient, and sustainable solutions to environmental and economic challenges (Ervin, 1994). Each farm operator develops a management system unique to his or her operation. In the search for sustainable cropping systems, the contribution of scientists becomes more important and also more difficult as the need for integrating regional and site-specific factors increases (Bunch, 1990).

This paper discusses the benefits of the partnership of farmers and scientists in the process of on-farm research and technology transfer. Experience in the Pacific Northwest has demonstrated how participatory research provides for more efficient exchange of ideas between farmers and scientists. In fact, the interaction of ideas while planning and implementing research is sometimes more beneficial than the data produced by the actual field trials.

Traditional Agricultural Research and Technology Transfer Methods

Traditional agricultural research and technology transfer are stepwise processes. The first step is applied research using small plots. Next, conclusions drawn from promising small plot trials need to be measured on a larger scale under more realistic conditions. If the practice still appears useful and practical, it must then be explained and demonstrated to farmers. If farmers accept the results and conclusions, the new practice might be tried and proven by farmers in actual production, this sometimes being the first fully integrated examination of the new practice by an end-user. The overall process, from technology development by scientists to general adoption by farmers, may consume a decade or more, much of which is spent in the technology transfer process. The stepwise nature of traditional research is due at least in part to the separation of research from technology transfer, and of research priority-setting from actual agricultural production (Tripp and Anandajayasekeram, 1990).

Farmers are often understandably reluctant to change farming methods. The potential for making errors while learning a new practice can be a substantial economic risk which is difficult to bear when profit margins are narrow. Timing of operations, equipment settings, rate of input applications, and other management factors have considerable impacts on yields and net returns or losses. Farmers need to see convincing tests and demonstrations under farming conditions similar to their own before taking the risk of changing practices (Rzewnicki, 1991). Even when a farmer commits to applying a new practice, a period of learning and adaptation is necessary.

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The Need for New Approaches

The traditional research approach is also not efficient at studying an entire integrated cropping system. During the past 50 years, agricultural research has largely focused on widely applicable, yield-enhancing component technologies such as chemical fertilizers, new varieties, pesticides, and mechanization (Francis and Madden, 1993). This is equally true for small farms and for alternative farming systems in the use of organic amendments and crop rotations. Such component research, investigating one or two factors at a time, has been vital to advancing methods of food and fiber production; however, it does not address the systematic, whole-farm problems that must be solved in the future. The current challenge is to precisely tailor the use of production inputs such as fertilizers, organic amendments, varieties, tillage, and rotations to specific soils, pests, crops, watersheds, and climates. We need to develop sustainable farming systems that prevent soil loss and environmental degradation and at the same time improve competitiveness in a global market. This need for the development of site-specific, management-intensive systems is increasing at a time when public funding for agricultural research is declining.

Models can aid research on cropping systems but their applicability becomes increasingly limited when designing management practices for specific farms or fields using specific resources. There are usually too many variables and unknown or unmeasured interactions on any particular farm to use models as a primary tool for developing effective management strategies. Another problem occurs when a recommendation produced by a model conflicts with the experience-based intuition of the farmer. True environmental and economic sustainability can only be achieved if farmers retain a strong sense of stewardship, ownership, and control. Their sense of responsibility for the land will decrease if forced to use methods that they believe are not effective in conserving soil or do not enhance the overall sustainability of their farms.

Participatory Research

Participatory research includes the farmer, who is ultimately the end-user, as an intellectual partner in research. Participatory research means that farmers are involved in establishing objectives, selecting methodologies, and interpreting results. Many of us believe that farmer-initiated, farmer-implemented research has tremendous potential to foster the development and adoption of sustainable conservation measures (Francis and Madden, 1993; Sumberg and Okali, 1988).

Involving farmers in experiment station research and cooperating with farmers in on-farm research have a profound effect on the development, adaptation, adoption, and acceptance of improved technologies. Research conducted by farmers is naturally specific to the crops, climates, soils, and equipment available to them. There is also a conscious and subconscious integration of profit, production, marketing, labor, financial resources, and lifestyle that is unique to each farmer's evaluation process.

A farmer researching a practice that proves successful will often rapidly adopt it because he or she has already gained experience in implementing the practice and confidence in its performance. Recognition of this principle was vital to establishing the Cooperative Extension Service (Kittrell, 1974). Much adaptation is completed while performing an on-farm experiment. Large-scale, on-farm trials also provide data to facilitate technology transfer to other farmers.

Several studies have investigated the statistical performance of designs used in large-scale, on-farm research (Rzewnicki et al., 1988; Wuest et al., 1994a; Johnson et al., 1994). These workers have demonstrated that data obtained from on-farm tests can be as precise and statistically sound as research station data. Properly designed and interpreted on-farm research can also lead to accurate conclusions.

Examples of the Participatory Approach

In 1991 a group of researchers, representatives of local and federal resource agencies, and farmers near Spokane, Washington, began discussing ways to reduce runoff and erosion from winter wheat (*Triticum aestivum*) fields. Some were aware of claims from other areas that subsoiling on the contour after planting winter wheat was effective in opening the soil and increasing water infiltration. The researchers arranged to borrow a field-sized subsoiling machine from a manufacturer and the farmers arranged for a tractor to pull it. The group of researchers and farmers toured potential sites and chose several in which to conduct replicated comparisons of subsoiled and non-subsoiled plots. Both farmers and researchers observed the plots over the winter and spring runoff periods. Scientists and resource conservationists made measurements of soil erosion at the sites using the voided rill method (Wuest et al., 1992). Discussions during field tours over the two years the plots were in place allowed researchers and farmers to discuss the practicality and logistics of implementation, effect on crop health and other field operations, effectiveness, and cost of the subsoiling practice. It was found that subsoiling could increase infiltration in some instances, but it did not produce durable openings for water infiltration that would last through the winter rainy season. It was assumed from the beginning of the project that the practice should be conducted on the contour, but in several locations the subsoiling was slightly off contour because of the difficulty of maintaining exact contour given the width of equipment and the undulating topography. It was observed that when the subsoiling was slightly off contour, runoff water would concentrate and increase erosion. After two years of field plot observation it was generally concluded that subsoiling alone was not practical or effective for runoff and erosion control in these farmers' soils and cropping systems.

If this research had been performed by researchers alone, either on a research station or in farmers' fields, it is likely that the researchers would have considered the practice as successful, because they would have carefully controlled the treatment in smaller plots to keep it strictly on-contour. After two or more years of scientist-implemented experiments, a recommendation might have been made that the practice could help reduce erosion, but the problems in implementing the practice and the costs and effectiveness when applied by

farmers would not yet be known. If this research had been conducted solely by a farmer, the research would most likely have been performed only on one farm and without control plots or detailed measurements. Any claims as to success or failure would be considered as being unsubstantiated and anecdotal. The participatory approach produced a co-educational opportunity not only for the subsoiling practice that was the subject of research, but also one of interaction between scientists and farmers that led to several additional cooperative efforts.

The availability of persons trained in on-farm research methods in the Pacific Northwest has led to participatory research efforts on practices not originally on scientists' agendas. An example is a project initiated in southeast Washington in 1993 when several growers were seeking technical assistance for establishing an annual winter wheat cropping system in a region where snow and late spring rains made spring cropping difficult and risky. The extreme slopes created unacceptable rates of erosion with traditional fallow. Growers were claiming success with production and erosion control by burning the wheat stubble, followed by fertilizing and sowing the next crop without using tillage. Scientists had been reluctant to research this alternative method because of the relatively small geographic area involved and the potential detrimental effects of burning on soil and air quality. Many farmers were convinced, although without documentation, that "burn/low-till" was one of the best systems for preventing soil erosion in this geographic region even though current erosion prediction models recommended against it. Farmers, scientists, and government resource specialists designed and conducted on-farm research to evaluate impacts of the practice on soil erosion. The results of the participatory on-farm research were of such interest that intense data collection was continued for five years (McCool et al., 1999).

The research produced two important outcomes that can be credited to its participatory approach. The first is that in implementing the on-farm research plots, farmers were able to provide scientifically measurable examples of their actual production practices. The second outcome was that the data provided documentation that soil erosion was minimal with burn/low-till and that the inputs to the erosion model needed adjustment to account for significantly less erosion than was originally estimated. Some of the observations have helped form new hypotheses on the mechanisms of erosion under specific circumstances. Thus, what started as farmer observations on the erodibility of a particular cropping system has resulted in new scientific knowledge.

Another example of participatory research that influenced a scientific outcome was an investigation of the effectiveness of emerging fall-seeded wheat plants in reducing winter erosion. Farmers near Spokane, Washington, felt that living plants had been undervalued in soil loss predictions and that early seeding and vigorous stand establishment should be given greater weight as erosion control measures. The farmers' willingness to work with scientists in on-farm research again influenced the allocation of research resources and resulted in new scientific insights on the role and specific effects of green cover for predicting soil erosion (Pannkuk et al., 1998).

In citing examples of farmers influencing research agendas by their willingness to participate in on-farm research, we are not advocating that research be solely directed toward farmers' currently perceived needs. Our point is that cooperative research efforts facilitate the integrated evaluation of actual production systems from two, often quite different, perspectives. This results in better fit of applied research to sustainable production.

Promoting and Conducting Participatory On-Farm Research

One way to encourage participatory research is to restructure and reprioritize the research agenda of scientists conducting applied agricultural research. Another way is to teach farmers how to conduct their own on-farm research so that farmers produce data that they can use in discussing their ideas and innovations with scientists. A combination of both methods would be the most likely to succeed.

The incentive for farmers to participate in research is not participation in itself, but an acceleration in the development of practical, profitable, and sustainable farming practices. Accurate, relevant data useful in making management decisions are what make the effort worthwhile. On-farm experiments should be designed to efficiently address the questions being researched with the degree of confidence required in each situation. To encourage farmers to obtain and use valid on-farm test methods even when not participating with scientists, technical help should be available to them for designing and interpreting test results. This will help to ensure that their effort is not wasted because the principles of field research are not properly understood (Rosmann, 1994).

The involvement of a technical advisor or committee that undertakes some level of oversight can also facilitate sharing of results with other farmers and scientists and increase awareness and discussion of on-farm research. Year-end reports, field tours, and other methods of disseminating information generated in on-farm trials can be very effective in stimulating discussion of new concepts (Fig. 1). An advisor or committee can also serve as a liaison among farmers, scientists, and agricultural supply and service companies, both in discussion of test results and in encouraging participatory efforts.

Efficient methods for harvesting and measuring yield of test plots should be available to reduce the extra work load during harvest. Portable weighing devices for measurement of crop yield are essential to make on-farm research practical (Fig. 2). Another major challenge to on-farm testing of conservation farming systems is measurement of soil loss. There is a need for inexpensive and practical methods or devices to measure soil erosion in on-farm trials. Direct erosion measurement would increase the ability of farmers and scientists to develop and verify improved conservation practices. The voided rill method, which estimates soil movement by measurement of rill cross-sectional area, is possible only under conditions of significant rill erosion. Ideally, a method is needed that quantitatively measures all forms of soil movement, or at least allows a direct relative comparison of erosion rates between two farming practices being tested. Besides speeding the development of improved erosion control practices, direct erosion measurements would allow

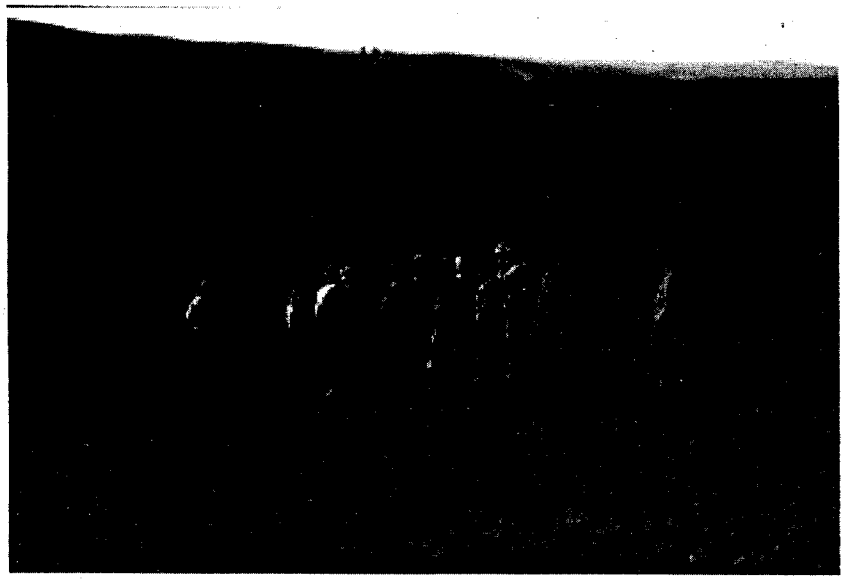

Figure 1. Farmers, resource conservationists, and scientists examine and discuss the effect of subsoiling on erosion. In the Pacific Northwest, on-farm research has become a standard research method. Field tours bring producers, researchers, and industry together to examine and discuss practical implications of the research.

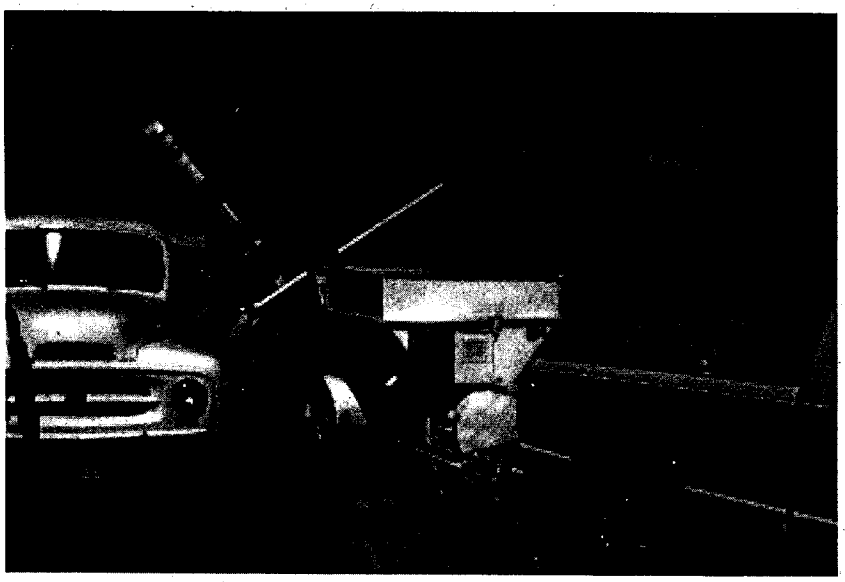

Figure 2. A weigh wagon allows plot yields to be measured quickly and accurately in the field. In the photo a tube is being used to collect a sample for grain quality analysis.

regulators and policymakers to verify that proposed conservation measures meet desired goals.

Other Advantages of On-Farm Research

On-farm research can be very cost effective. Using well-designed trials on a hectare (2.47 acres) or two, farmers can implement tests with little extra expense. For example, a two-treatment comparison with four replications in a randomized-complete-block design might be performed using eight 8 × 300 m (25 × 1,000 ft) plots occupying less than two hectares (five acres). Only half this area might be devoted to a practice unfamiliar to the farmer; the other half is the check treatment, normally the same practice that the farmer uses on the rest of the field. This means less than one hectare is subject to unexpected perils such as low yields, increased pest levels, or mechanical problems during tillage or harvest. If scientists can provide experimental design and measurement equipment, the overall cost of a cooperative research project might be modest enough to require little or no external funding. Independence from external funding sources encourages testing of a greater number of new and innovative ideas.

As in the examples presented, some farmers believe they have developed cropping systems that work as well or better than what are currently recommended. These farmers can use participatory on-farm research to compare the performance of their methods with alternative or recommended methods. Providing farmers with the means to evaluate performance of conservation methods encourages innovation. In addition, the generation of verifiable data on performance of unique practices is vital to promoting flexibility in administration of federal farm programs and environmental regulation. It is difficult to imagine how we can maximize innovation in conservation systems or facilitate their regulatory acceptance unless we take advantage of participatory research.

The development of ridge-till systems for corn (*Zea mays*) production in the Midwest of the USA is one of the most noted examples of a research program directed by a farmer (Thompson and Thompson, 1990). The impact of Richard and Sharon Thompson's efforts on developing sustainable farming practices in Iowa and throughout the northern Corn Belt has been a major contribution to U.S. farmers and sustainable agriculture. The use of scientifically-sound designs has led to the participation of scientists in the Thompsons' research (Exner et al., 1996).

Many smaller, less publicized examples of participatory on-farm research have had a significant impact on the agronomic practices of a particular region. Bunch (1990) describes impressive gains in sustainable corn production among poor farmers in Central America. Simplified but effective research methods were taught to farmers and became fundamental to the invention and adoption of improved farming methods. In the Pacific Northwest of

the USA, on-farm research has helped farmers make a successful transition to minimum tillage and no-till systems (Wuest et al., 1994b). The crucial benefit that farmers have gained from their efforts is convincing data on the effect of changes in tillage on yield. On-farm research has become a standard tool for cropping systems research by farmers and scientists in the region.

On a broader scale, participatory on-farm research can play a significant role in generating data for use in regional networks. In Denmark, the Netherlands, and France, thousands of farmers participate in tests as part of regional or national research efforts (Elkana, 1991). This sharing of information provides an accurate basis for formulation of regional guidelines and accelerates development and adoption of improved farming methods.

Conclusions

Participatory on-farm research has proven to be a benefit for farmers, researchers, the environment, and society as a whole. The rapid integration of farmer and scientist perspectives and the co-evaluation of cropping systems and practices leads to new research priorities and allows rapid development, adoption, and acceptance of new methods and management practices.

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