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Staff Paper

BUILDING AN INTERDISCIPLINARY TEAM FOR EXTENSION EDUCATION IN SUSTAINABLE AGRICULTURE

by
Luanne Lohr, Oran Hesterman, James Kells, Douglas Landis and Dale Mutch

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Building an Interdisciplinary Team for Extension Education

in Sustainable Agriculture

Luanne Lohr, Oran Hesterman, James Kells, Douglas Landis, Dale Mutch*

* The authors are Assistant Professor in Agricultural Economics, Associate Professors in Crop and Soil Science, Assistant Professor in Entomology, and District Cooperative Extension Agent, all affiliated with Michigan State University.

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Building an Interdisciplinary Team for Extension Education in Sustainable Agriculture

Increasingly, the need for an integrated systems approach to sustainable agriculture extension education is being recognized. However, little guidance is provided as to how to operationalize this strategy, particularly in light of institutional and attitudinal barriers to interdisciplinary work. Successful team approaches in extension exist, but usually do not reflect the highly integrative nature of a sustainable agricultural system. This paper describes one recently developed extension effort and explores the process and requirements for building an effective interdisciplinary team to develop a sustainable agriculture extension education program for farmer audiences.

Agricultural economists may have particular difficulty integrating their expertise in the scientific team approach due to paradigm differences between social and biological sciences. For this reason, special attention is given to this subgroup of scientists. Not only are the program participants likely to have disciplinary frames of reference, but the audience for an extension farm program is usually heterogeneous in terms of experience, familiarity with the topics and receptiveness to the information presented.

Sustainable agriculture education programs which use a systems approach may magnify these tendencies. Such programs often require involvement by a broader range of agricultural specialists, compel a greater depth of integrative effort in preparing and presenting materials and demand more from the audience in absorbing and processing a diverse body of information. The challenge for extension professionals is to determine what the program objectives should be, what level of detail is appropriate, how to combine the disciplinary components to convey the inherent systems structure and how to present the information so that both the components and the system are recognizable and comprehensible.

Recognition of the importance of education programs in sustainable agriculture is evidenced in the 1990 Food, Agriculture, Conservation and Trade Act. Chapter 3 under the Research Title concerns technology development and transfer, including development of educational materials for agricultural producers. The materials are to detail crop selection, rotation practices, soil building practices, tillage systems, and nutrient, weed and pest management, among other production practices (U.S. House of Representatives). Though not explicit in the provision, economic analysis of these systems will also be necessary to help farmers evaluate the profitability of such practices for their operations (National Research Council [NRC]).

Explicit reference was made to the appropriateness of interdisciplinary methods for sustainable agriculture extension education in the NRC's 1989 report on alternative agriculture. Interestingly, four authors for the Council for Agricultural Science and Technology, which prepared a somewhat harsh review of the NRC report, concurred on the need for interdisciplinary research and identified barriers to following this approach (Abernathy, Carter, Dickson, Marten).

Despite being mentioned several times in the NRC report, suggestions for extension programming were not detailed, and appeared to be treated identically with applied research. Delivery methods for systems research results may need substantial reworking from the traditional commodity-specific format for effective transmission.

This paper addresses the deficiency in understanding extension's role in developing delivery systems to educate farmers about sustainable agriculture. Fundamental to this goal is the synthesis of effective interdisciplinary teams for collaborative work on extension programming. We describe a process for building an interdisciplinary team and link this integrative format to the development of extension materials for Sustainable Agriculture Systems Education (SASE).

In the first two sections of the paper, concepts in interdisciplinary sustainable agriculture extension education are discussed and attitudinal and institutional barriers are delineated. A successful extension program at Michigan State University (MSU) is described in the following section. In the fourth section, a linkage is made between theoretical considerations in team building and the factors which made the MSU program work. Conclusions are presented in the last section.

Nature of SASE

There are several concepts regarding the nature of a SASE program which should be clarified before a team begins to develop and implement a program. The group members should determine, either explicitly or implicitly, how they view concepts such as "team building," "interdisciplinary effort," "sustainable agriculture," "farming systems" and even "extension education." Debate about these concepts often brings out fundamental distinctions in disciplinary approaches and permits group members to bridge these differences in forming a common point of reference for program development.

While this paper is aimed at extension specialists, many of the principles apply equally to research team building. In fact, many extension specialists conduct research as part of their appointments and a number of field staff assist farmers with on farm demonstrations. Concepts and conflicts described affect both research and extension teams and the interaction between them. The following sections describe the confusion which may arise over the five concepts.

Team Building

The definition of "team building" is commonly referenced in terms of the "team", a group of specialists brought together for a single purpose. Team building is the process of selecting and combining these individuals. Not all programs will benefit from a team strategy. Francis *et al.* (1982, p.43) described indicators of the need for a team approach in research:

> When it has been determined that an objective is too broad for solution by a single scientist or discipline, too complex to be studied by a single department, or requires more and varied resources than are available in one narrowly-oriented research group, then a team approach is probably indicated. Only those research objectives which can be met more efficiently, rapidly, or completely by a team need be approached in this manner.

While this approach assumes an objective which guides the selection of a group, a team building strategy may be an end in itself. In the corporate setting, productivity and creativity of workers may be enhanced by participation in a designated team. In the academic setting, such a team might be brought together as part of an institute or subject matter group without a definitive task, but with the goal of studying various aspects of a problem area. This is less typical than the many committees, task forces and collaborative multidisciplinary groups which are formed in response to particular problems, or with specific objectives in mind.

Supporters of the team concept have outlined several characteristics of effective team work (Dyer). In essence, these characteristics focus on the presence of an informal and supportive atmosphere, discussion in which all members participate, existence of a well understood and accepted objective, disagreement and constructive criticism with consensus building in resolution, clear assignment of tasks, recognition of the resource value of each member, and subordination of individual ambitions to group success. Ideally, the formation of a team in this context lends support to all members and results in a working unit which can function at a more efficient, more productive or more creative level than any individual member could do.

The existence of a defined objective for a team implies both a starting and an ending point for the group. Most teams directed to perform a particular task or set of tasks follow a pattern of formation, action, and dissolution. If the team has been successful in fusing the contributions of each member into a result with which all members are satisfied, using a process which enhances each member's contribution, then group members are likely to have an affinity toward both the process and the other team members. This makes future team assignments attractive to the participants and more effective in the outcome.

This effect may be explained in part by reference to learning curves. Past group participants have more practice at being team members, so that increasing familiarity with the process reduces the adjustment costs of changing from an individual approach to a team one. Psychic rewards derived by participants from working with the team as a group and as individuals may promote greater effectiveness in the next team experience. Positive reinforcement from the team effort can also generate greater interest in future group activities.

Interdisciplinary Effort

Most academic personnel are familiar with the term "interdisciplinary effort", but the definition is in some dispute. Sauer distinguished between "multidisciplinary" and "interdisciplinary." Participation by researchers in several disciplines is a feature of both, but with multidisciplinary efforts, the project is planned, executed and evaluated by each person separately, while interdisciplinary teams perform these functions through mutual effort.

Boger and Boyd phrased the definitions of "multidisciplinary" and "interdisciplinary" differently. The primary distinction they used (p. 88) was the level of interaction among group members, with multidisciplinary efforts having "limited" interaction and interdisciplinary ones having "continual intellectual interaction and conceptual synthesis." They added another organizational concept - "transdisciplinary" effort. This type of project is characterized by "a mutually accepted systems organization with an overall set of systems goals."

For extension educators, the definitions might also reference the level of interactive cooperation on program design and presentation. Programs conceptualized, designed and carried out by individuals within a discipline with limited assistance (information only) from specialists in other disciplines might be characterized as "multidisciplinary." Those which include more integrated planning and presentation by specialists from more than one discipline might be called "interdisciplinary." A "transdisciplinary" extension effort might be more systems oriented, from conceptualization to presentation.

Many extension educators, especially in program areas organized along commodity lines, have experience collaborating in some way with specialists in other disciplines. However, frequently these efforts are ones in which an individual proposes and designs a program with only informational support from extension specialists in other disciplines. While there may be interest in more integrated work, specialists may lack time, support or preparation for advancing interdisciplinary methods.

A team, however it comes together, should make a determination of the level of interaction members will have. More integration requires more energy and time be expended by each participant, rather than small contributions being made by several with a much greater effort by one or two team leaders. The concepts, rather than the labels, should be the focus of discussion for team participants. Lack of agreement on the characteristics of the effort may lead to problems in designing and evaluating the program and each individual's contribution to it.

Sustainable Agriculture

The definition of "sustainable agriculture" has been in dispute almost since the term was first coined. In a broad sense, sustainable agriculture may be defined by simultaneously met social objectives such as agricultural productivity, environmental protection, fulfillment of basic food and fiber needs of consumers, economic viability for farmers, and enhancement of farmers' and society's quality of life, as was adopted by the American Society of Agronomy (Schaller).

Others have attempted to define sustainability in terms of prescribed production practices, or as a form of management. The term "low input sustainable agriculture", or LISA, has been attributed to the U.S. Department of Agriculture, with emphasis on reducing purchased chemical inputs[1] (*Implement and Tractor*). This term has become synonymous with sustainable agriculture in many policy discussions.

Schaller proposed two reasons for the lack of a single agreed-upon definition. One is that sustainable agriculture is a philosophy or way of thinking, rather than a set of practices or

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[1]The terms "chemical inputs" and "chemicals" used throughout refer to agrichemicals including fertilizers, insecticides, herbicides and other synthetically derived materials used for crop nutrition or protection and purchased off farm.

methods. Second, LISA is a reaction to the adverse environmental and economic externalities associated with agriculture which is capital and chemical intensive and specializes in monocultures. However, the range of such reactionary farming systems is quite broad. Schaller suggested that a means *vs.* ends continuum be used to examine the various definitions of sustainability and their components. Those concepts which stress social and individual goals for agriculture tend toward the ends boundary; those which stress production methods tend toward the means boundary.[2]

Lockeretz (p. 174) noted that "'Sustainable agriculture' is a loosely defined term for a range of strategies to cope with several agriculturally related problems causing increasing concern in the U.S. and around the world." Several general production concepts underlie the practices commonly accepted as "sustainable agriculture", with emphasis on self-sufficiency of the farm, suitability and diversity in output mix and attention to externality problems such as soil and nutrient loss.

Terms which stress some or all of these production concepts are often used interchangeably - "sustainable," "alternative," "low input," "ecological," "regenerative" and "organic." However, as Lockeretz pointed out, by reference to everyday usage of these terms, clear distinctions exist. For example, "sustainable" includes an indefinite time dimension for continuation, while "alternative" describes some divergence from existing or conventional practice with the implication of choice among the options. The ambiguity and diffusion of the meanings of these terms arises from the imprecise usage by authors who are actually speaking of different approaches to or philosophies of agriculture.

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[2]A case could also be made for a means-ends spectrum which identifies environmentally and economically sound production practices as the end and uses social and individual goals as a part of a process or means to achieve this end.

Each team member who works on an extension program is likely to have independently conceptualized the term "sustainable agriculture." While it is not necessary to develop a precise definition of the meaning of the term, group participants should have a mutually agreed-upon framework for the specific program to be developed. The reason for this is that extension education usually carries a message beyond the content of the program. Since these programs are usually publicly funded, the topic choices and the perceived biases imply something about the institutional views of the administering agency. Also, choice of content and program presentation reflect the individual presenter's philosophical and disciplinary biases. Agreement within the group on the relevant aspects of sustainability enhances uniformity of both the content and the underlying attitudinal message sent to the audience.

Farming Systems

Norman (p. 32) defined a "system" as "any set of elements or components that are interrelated and interact among themselves." Norman placed the farmer at the center of a set of complex interactions of interdependent external (institutions, community) and internal (farm, household) components. Hart described this interrelationship as a set of hierarchically related agricultural systems with both vertical and horizontal system interaction. The farm system combines a socioeconomic subsystem with crop and (or) animal agroecosystems, which themselves are partially human directed and partially the consequence of natural ecosystems.

Other systems models have been described by Wilson and Morren, who distinguish between a "hard" systems approach and a "soft" one. The latter approach emphasizes not only the procedures to reach an objective, but also the process of reaching a consensus on the objective. The farming systems research and extension model characterized by Norman and Hart is labelled a "hard" systems model because the objective of improved farming methods or productivity is not in question. Many alternative models begin with the concept of the farm as a human activity system or with the idea that a farming system is a series of activities and flows that represent a range of human activities associated with farms, not limited to farm production. This approach is challenging for most quantitatively based sciences because it requires study of factors which are not easily measured nor organized. At issue is how welfare concerns such as viability of farm communities, pollution externalities and food distribution should fit into the system.

Francis *et al.* (1990) commented on the complexity of biological and physical systems, the longer time frame and the expanded spatial relationships which must be considered to provide an adequate systems educational program. They noted the expanded focus for extension from narrow production issues to teaching the systems perspective and the process approach to problem solving. Educators now must also be concerned about renewable resource use and efficiency, diversity of enterprises and products, risk assumption and rural community viability.

MacRae *et al.* argued that reductionist thinking (dividing the whole system into its components) is a major barrier to the systems approach necessary to study sustainability. Hidden biases in favor of or against particular theories and approaches may be disguised by scientifically provable facts. Researchers who hold these biases find objectively derived facts and subjectively interpret them to prove an established idea. There is also an emphasis on quantification, regardless of applicability so that the qualitative aspects of systems research, which may not be readily measurable, are ignored.

Woeste commented that an analytical, systems building approach to assembling extension programs helps to minimize the chances of a client group being exposed to narrow, single alternative, prescriptive programs. Unless set by other priorities, the interdisciplinary team should determine its objectives in terms of the human activities it desires to influence and should describe the subsystems affected by those goals.

Extension Education

As agricultural colleges struggle with means to encourage interdisciplinary work in sustainable agriculture, the role of extension is coming under increasing scrutiny and subject to dispute. The traditional approach for production-oriented extension programs is to communicate specific technical recommendations in commodity-segmented programming. Alternative viewpoints have been proposed.

Holt suggested that in the face of declining national political and financial support for extension programs, broader based approaches are necessary for competitiveness in the markets for agricultural information and education. Holt singled out the potential of interdisciplinary research and extension in natural resource management systems which achieve multiple objectives. He cautioned against maintaining outdated programs at the expense of more appropriate approaches, giving the example of the Integrated Pest Management, which required 45 years to progress from development of an adequate knowledge base to implementation of the first pilot extension program.

McDowell claimed that extension has two objectives - to educate its clientele and to collect political support for the system and funds for the university budget, particularly at the state level. McDowell argued that extension programs should be designed in ways which not only provide educational benefits, but link those benefits uniquely to extension. Information which is packaged in a way that is highly generalizable and is easily circulated to a wider audience may not build a constituency because the identification of extension as the source of the information is lost. One option is the use of general, printed materials in a particularized program, where the information is presented in a way which places it in a context unique to the presentation audience.

To these objectives might be added the need to provide sufficient information for farmers to make choices among the production options, including those which are more management-intensive. Increasingly sophisticated farmers are unlikely to rely on extension information that does not provide explanations for input recommendations. Huffman and McNulty showed that increased schooling among farmers is correlated with decreased demand for county extension services. In an earlier study, Huffman demonstrated that such an increase is positively correlated with adoption of new technologies, indicating more interest in innovative techniques among better educated farmers. Guttman showed that more schooling is linked to a greater stock of farmer human capital and greater access to political information, implying that better educated farmers will not only be better prepared to accept greater management responsibilities, but will form a stronger constituency for generating political support for extension.

Woeste commented on the increasing sophistication of farmer clientele in terms of an enhanced understanding of the possibility for systems impacts of a change in a single practice. With greater sensitivity to risk in decision making, farmers have requested program content organized by systems of production, rather than fragmented information. According to Woeste, farmers want more information about the impact of practices on the entire crop system and on the economic returns to farming. Concern for environmental impacts should be added to this list, in response to current pressures from nonagricultural groups representing other social goals.

Francis *et al.* (1988) described a model for extension programs in sustainable agriculture. They suggested eight points on which to focus in designing educational outreach. These include systems rather than components, internal (on-farm or locally available) resources, information as a key production input, participatory systems for developing information, process rather than product, diversity of enterprises and products, community well being and value-based decision making which emphasizes human welfare rather than technology. Francis *et al.* (1990) proposed an educational method which emphasizes case studies and demonstration trials in an attempt to promote participatory types of learning for farmers.

Ikerd promoted this approach in the context of agricultural economics. He argued that educational programs should focus on processing research information, integrating it into logical economic analyses and teaching the processes of economic decision making. To utilize the advanced training most extension specialists receive, Wallace argued that economists should apply cutting edge economics to multifaceted resource use problems, despite the risk of failing to develop a widely accepted program. Wood concurred with the need for utilizing both theory and analytical tools in extension economics to develop problem- or issues-oriented programming.

Libby commented on the importance for extension agricultural economists of maintaining and upgrading their knowledge base in economics. Effective application of economic principles to issues which arise in extension requires first and foremost the skills of a good economist. The ability to construct a theoretically defensible program is basic to excellence in extension teaching and maintenance of credibility.

Woeste noted that an element of risk is essential for an effective extension program. As he indicated, there are rarely complaints that extension is too innovative, too far ahead of farmers in methods relayed or too aggressive. More commonly, extension is criticized for its sluggishness in recognizing and addressing emerging issues. Woeste advocated the need to be creative and innovative and to help clients contemplate new alternatives. As Woeste (p. 877) said

> Helping people recognize and evaluate new alternatives can be disquieting to them. It also can be threatening to economic and social interest. If, however, we are going to fulfill our mission and earn the respect of the leadership, we must help them be masters of their fate.

The sustainable agriculture agenda may give extension the opportunity to develop ties with broader clientele groups. However, team members must decide what level of advocacy each is comfortable with and should reach a consensus on the role of the extension educators for any particular program.

Barriers to Interdisciplinary Team Building

Some of the benefits of interdisciplinary research were enumerated by Mitchell. One potential benefit is enhanced creativity which arises from the stimulation of being challenged on the precepts, methods and consequences of one's disciplinary approach. Another possible advantage is improved synthesis of a wider range of perspectives into a system which addresses problems from a more integrated frame of reference. More efficient use of both human and physical resources may be realized through an integration of efforts and an improved understanding of each discipline's contribution. Data may be used more intensively since it is analyzed and applied through a broader range of disciplines. An additional result may be improved communication of results since quality of research and breadth of audiences may be enriched. Finally, disciplinary justification and explanation may be enhanced within the university and public sector contexts.

Derivation of these benefits depends on the level of integration the team is able to achieve. Despite a general recognition among many administrators and extension specialists of the potential advantages of interdisciplinary work, institutional and attitudinal barriers may preclude their realization. These are discussed in the following subsections.

Institutional Barriers

Chief among the institutional barriers facing interdisciplinary team building are the reward structures for specialists and the way universities encourage competition among and strength within disciplines. The academic world tends to reward individual efforts within a disciplinary context. Madden noted that, though reward systems vary across institutions, the number of sole-authored articles using highly technical analytical methods and theories are favored by departmental and university committees as a measure of individual success. Wallace claimed that this criterion is also used for extension specialists who have faculty appointments, in part due to the lack of comparable quantitative measures of their effectiveness.

Several authors have discussed the need for recognition and rewards for group activities (Francis *et al.* (1982), Russell and Sauer). According to Madden, faculty perceive that interdisciplinary team efforts which apply existing knowledge to farm-level problems carry less prestige than individual, disciplinary approaches and are even penalized in the reward system of salary and tenure decisions. Madden recommended that interdisciplinary team efforts be given at least as great rewards as disciplinary work in the institutional setting.

Universities and college subdivisions tend to encourage competition among departments. There is a priority on developing strong nationally and internationally recognized disciplinary programs in order to garner the best faculty and graduate students and large extramural grants which are often a function of such rankings.

There is substantial variability in the degree to which integration is fostered in colleges of agriculture. According to a survey of 37 agricultural experiment station directors by Russell and Sauer, there may also be inconsistency in support for interdisciplinary research at different administrative levels. When university tenure and award committees and administrators support traditional disciplinary research, interdisciplinary projects are viewed as second-rate efforts. Only six of the directors interviewed felt that incentives (project funding, faculty evaluation and research objectives) for participation on interdisciplinary teams were comparable between their experiment station and their university administration.

Lacy and Busch surveyed agricultural scientists from 16 fields in the social, biological, engineering, environmental and basic sciences who were participating in projects listed in the Current Research Information System in 1982. They found that most agricultural scientists receive little exposure to fields not closely related to their own in terms of academic training. Of the disciplines studied, only four had more than 50 percent of their practitioners with any academic degrees in fields other than the disciplinary field.

Problems which may be addressed by a single discipline are easier to define and to evaluate in terms of disciplinary significance and are more likely to result in a successful outcome and to add to the body of disciplinary knowledge. Yet, Lacy and Busch found that across all disciplines surveyed, measures of the influence of peer approval and compatibility with organization priorities on problem choice were relatively low. This result may have negative implications for the effectiveness of an institutional agenda promoting interdisciplinary extension programs.

Attitudinal Barriers

Institutional barriers need to be recognized, but are not likely to be resolved before beginning an interdisciplinary extension project. A more immediate factor is settling the attitudinal conflicts which may arise between disciplines. Woeste commented on the difficulty of developing interdisciplinary extension programs which attempt to take a holistic approach. Individuals and departments may be territorial, with maintenance of turf overshadowing the program goals. Educators may be tempted to act as specialists outside their individual areas of expertise, with the result that incorrect or conflicting information may be communicated to the client group.

MacRae *et al.* claimed that agricultural scientists tend to have narrow world views due to lack of diversity in training, gender and race in their professions. Researchers are alleged to have unexpressed fears of change in "conventional wisdom" which might invalidate previous research paths, even entire careers. These personal factors reduce the researcher's capacity to work in interdisciplinary teams. While it may not be possible to change one's background, an awareness of potential limitations helps the scientist overcome them.

Swanson pointed out that both the knowledge of epistemological problems and social elements must be overcome in resolving the paradigmatic differences in disciplinary training. An example borrowed from Swanson exposes the possible differences in approaches by collaborators. Suppose an agricultural economist uses a conceptual approach which combines a unidirectional-causal paradigm and a random-process paradigm (perhaps production theory) and a collaborating biological scientist operates under a mutual-causal paradigm (perhaps theory of linkages in an ecological system). Both are examining the same farming system. While the biologist treats the system as a series of dynamic feedback loops supported by concepts of self regulation and natural equilibrium, the economist is describing the system in terms of the implied causality of regression analysis, supported by static theory of the firm. There is limited overlap in these approaches.

Without explicit recognition of paradigm differences and agreement on which to use, there is a high probability of frustration in group communication. Specialists may be aware of vocabulary or language differences, but be unaware of underlying conflicting paradigms. According to Swanson, the resulting difficulty in communication may be attributed to unwillingness to cooperate or to professional incompetence. Shared paradigms, particularly at the conceptualization stage, are crucial to successful integration.

The social component referred to by Swanson consists of the organizational framework incorporated in the program. There are varying levels of integration in information exchange, task assignment and responsibility, and preparation and presentation of outputs. The leadership role is of particular importance, since this may range from a single leader who communicates separately among team members and prepares the final output to limited separation of tasks among members with mutual exchange and review and common effort in preparation and presentation of the product.

Agreement among the extension team as to the organizational structure to be adopted facilitates the coordination of program development. A successful team will also make an effort to discuss the paradigms each member uses in approaching the project. The goal should be to resolve as many barriers as possible before beginning.

MSU Sustainable Agriculture Extension Program

There are several extension programs at MSU which deal with individual aspects of sustainable agriculture, such as integrated pest management. While these programs typically combine information from more than one discipline, such as entomology and economics, they are not interdisciplinary in a systems sense.

This single component approach ignores the context into which the component fits. When the total system is deemphasized in this way, the linkage among relevant disciplines is weakened. There are nonlinearities in the way the components relate to each other. That is, results of several single component studies cannot simply be summed to determine the interactions of the components in the system.

One sustainable agriculture program developed in the fall of 1990 took an integrated approach. This program, known as Sustainable Agricultural Systems Education for Michigan (SASEM), was created in response to a perceived need among farmers for information about alternative cropping systems for cash and feed grains.

The project combined the expertise of a weed scientist, entomologist, agricultural economist, forage specialist and extension integrated pest management agent. Originally conceived to describe alternative methods of weed, insect and nitrogen management, the basic idea evolved into a series of modules on these topics in addition to a comparative systems assessment. The MSU Cooperative Extension Service provided funding for graphics, slide development and duplication.

In a series of eight team meetings over five months, the systems to be evaluated were discussed and finalized. General system descriptions are given in Table 1. Four systems, with varying crops, tillage, nitrogen, weed and insect management were assumed. System I has continuous corn with conventional tillage and primary reliance on fertilizers for plant nutrition and pesticides for pest control. System II consists of a rotation of wheat, corn and soybeans, which breaks up the pest life cycles, reduced tillage for less soil erosion and changes in pesticide strategies, due to the benefits of crop rotation. System III is similar to system II, but relies on legumes for part of the nitrogen requirement, a combination of banded herbicides and mechanical weed control (rotary hoeing and cultivation) and a mix of scouting and seed treatments resulting in less frequent insecticide applications. The system IV rotation uses ridge tillage, only legumes for nitrogen, mechanical weed control, scouting and seed treatment for insect and disease control.

The key idea in designing the systems was to move from a high degree of chemical dependence to a very low level, with substitution among inputs occurring on a systems level. For example, reducing chemical inputs requires another type of activity be substituted, such as rotations for nitrogen fertilizer or insecticides or mechanical weed control for herbicides. The emphasis was on what parameters needed change to accommodate chemical reductions (systems approach), rather than only variation in levels of chemical inputs (component approach).

Each system was treated as a whole, and the impact of levels of farming activities and quantities of materials on productivity and stability was carefully considered. Working out the details of the system components took the majority of the 20 to 25 hours spent in group meetings. Substantial time was also required by each individual to complete the system descriptions, perform the economic analysis and prepare materials for presentation.

The amount of time required to prepare this program was a function of several factors. First, there was substantial initial disagreement over the system descriptions. Two group members were enthusiastic proponents of low chemical input agriculture, while two were more hesitant to endorse the chemical input reductions in systems III and IV. The fifth person was relatively neutral, but was concerned about the credibility of the system descriptions for extension agents and farmers.

Of primary concern was the perceived problem of credibility in discussing inputs and outputs from production systems which had not been empirically tested in Michigan. Agreement on the inputs and outputs for systems I and II was quickly reached. These systems have been empirically tested and are well understood. While components of system III have been researched in Michigan the entire production regime has not been studied. Research on system IV is just beginning and some group members expressed considerable uneasiness regarding extending information before completion of research.

A joint decision was reached to rely on existing information on components of these systems from research performed both in Michigan and other states if necessary. Team members felt that evidence of component success in other places in the Midwest lends some credence to the combination of characteristics selected for system IV.

Inclusion of systems III and IV into the program was encouraged by district and county extension agents. They supported the inclusion of a very low chemical input system as a basis of comparison for other cropping practices currently used by Michigan farmers. As a compromise, it was agreed that during presentations, the hypothetical nature of systems III and IV would be stressed.

A second reason for the time spent was the difficulty in settling on detailed component descriptions which were mutually compatible within each system. Initially, each component was treated separately, with limited debate among the group members. As discussion within the group proceeded and as other experts in the respective departments were consulted, there was more emphasis on the interactions among the various farming practices and inputs used. This awareness resulted in several revisions in components until each system was complete. Decisions about exact amounts of chemicals to use and numbers of times and dates for completion of each activity had to be made so that the economic analysis would be realistic.

A similar exercise took place in setting yields. There was difficulty in deciding how to treat yields in all systems, particularly systems III and IV, for which little research data exists. Each of the biological science specialists had concerns about the impact of stochastic elements such as weather, pest populations and weed seed banks on the systems. The agricultural economist suggested that some variability could be assumed away. There is assumed to be transition variability while systems adjust to a steady state with reduced chemical inputs. By assuming that all systems had reached this dynamic equilibrium, the biological scientists could concentrate on the effects of a reduced set of stochastic elements.

Considerable concern was raised relative to the potential effect of favorable *vs.* unfavorable conditions on systems III and IV. To address this concern, the yields for these contingent cases were specified as "best case" and "worst case." The yield discussion also stimulated some changes in the input assumptions as the group worked iteratively between the best and worst cases and their potential causes.

A third factor in time required for system design was the iterative nature of the economic analysis. The valuation relied not only on materials costs, but also on the sequencing of activities and the impact of timing on equipment costs. A machine selection program developed previously by MSU researchers in agricultural engineering and agricultural economics was used[3]. By specifying farming activities and dates for activity completion, the user is able to generate machinery, labor and fuel costs. The agricultural economist adapted this program for use with the equipment and activities needed for the four cropping systems. Initial computations indicated problems in the original sequencing of operations which was revised by the group.

A fourth time-consuming activity was the development of the information delivery mode. The purpose of the project was to design a scripted slide set for agricultural agent use. The set was to be composed of modules on alternatives to chemical inputs for plant nutrition and weed and insect management, plus the description of the four systems and the economic evaluation of them. The difficulty was in determining how to present the details of each system without confusing the audience.

Circles with divisions representing the continuous or rotational ordering of crops in the systems were decided upon early in the process. Various means of indicating the inputs and outputs on the four system circles were discussed. Arrows pointing to (inputs) and from (outputs)

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[3]The program used is called MACHSEL, A Farm Machinery Selection Model For Southern Michigan. This program was initially developed by C. A. Rotz and H. A. Muhtar, Department of Agricultural Engineering, Michigan State University in January 1986. The program was updated for use in this project by Luanne Lohr.

appropriate places on the circles were finally used. For presentation, each component was presented separately, so that there are four circles (representing nitrogen inputs, weed management, insect management and yields) for each system. Figure 1 gives a generalized sample of the circles used to convey the detailed input and output information.

By integrating the expertise of specialists in several disciplines in a team, the entire project has more of a systems emphasis than extension programs which rely on a single leader with contributions from other disciplines or those which take a separate components approach. Training in more than one field was an advantage. The agricultural economist has a B.S. in agronomy from the same school the weed scientist attended for his M.S. and the agronomist has an M.B.A. In addition, the entomologist and district extension agent are broadly trained in both weed science and entomology with emphasis in alternate methods. These commonalities enhanced communication among group members.

Revisions to the program were made based on comments from county and district agricultural extension field agents who attended a workshop at MSU where the first version of the program was given. Two presentations of the final program were made as part of meetings held in Michigan jointly by the MSU Cooperative Extension Service and the Rodale Institute. Attendance for the seminars was 110 and 130, respectively. Modifications will be made based on comments from the audience.

Considerations in Systems Team Building

A systems approach to studying farm management strategies will flow naturally from a well-integrated project group. It is important when educating about sustainable agriculture to focus on the integration of all components into a successful cropping system. Simply eliminating one or more chemicals from a cropping regime without substituting another input to perform the function of chemicals is unlikely to succeed.

The importance of these factors when building extension teams should be considered. Extension has been perceived as simply an information delivery system, where a proven technology or farming "recipe" is provided. There are more dimensions to education in relation to alternative agricultural systems. Extension education programs can assist the farmer to think in terms of the entire system so that he or she can apply specialized knowledge learned from experience with his or her own farm microecosystem.

The SASEM program was designed to do more than simply present research results. The hypothetical systems were included to generate thought and discussion about ways individual farmers can reduce dependence on chemicals. The purpose of presenting a range of chemical reliance in the four systems was to give farmers using all levels of chemical inputs in Michigan an idea of how reduction in use might be accomplished. This approach addresses the concerns expressed by Francis *et al.* (1988, 1990) in that the program stresses alternatives which incorporate different degrees of system diversity and reliance on the natural system for insect and weed control. Further, the program stresses the decision process rather than products and the importance of management variables in system results. The farmer is encouraged to think about options rather than being given a prescription for farming.

To the previously cited suggestions for developing effective sustainable agriculture extension programs could be added several recommendations which deal specifically with team building in the extension education context. First, identify extension specialists or researchers with relevant expertise and interest. Most systems analyses of production benefit from participation by soil and weed scientists, entomologists, economists and production specialists for the relevant crop. Programs which educate about alternative systems will be more credible and better balanced if the team is selected from appropriate specialties.

Second, specialists should understand their personal biases and state them up front. Some researchers and extension employees have negative views of reduced chemical farming. This does not automatically disqualify them from the team. In light of MacRae *et al.*, this may actually help diversity on the panel and can counteract overenthusiastic supporters. All members should be aware of their biases and be comfortable with expressing them to the group. This gives everyone equal information and improves the efficiency of conflict resolution.

Third, group members must make an effort to be tolerant of opposing views and be open to discussion. Certain personalities are incapable of this. These people should not be included in the project group as they will tend to either dominate the group or resist efforts to reach compromise positions.

Fourth, each participant needs to recognize the boundaries of his or her area of expertise. Sometimes the temptation to act as an authority in other fields generates turf wars. In this situation, the specialist who feels impinged upon may react defensively by attempting to elevate the importance of his or her discipline's role or interject greater sophistication to the program. Mutual respect among the group members and willingness to accede on technical points outside one's specialization can prevent this problem. Team members should utilize others in their respective areas of expertise. The interactions of inputs and the effects of system changes are complex. The number of specialists needed to cover all aspects would be unwieldy for a project team. Participants should be willing to solicit input from others who can provide additional information.

Fifth, each group member should be an active participant in the development of the program. Communication is essential. It is particularly important to verify underlying assumptions and choices of methods or parameters by raising doubts or questions early in the process. It may be necessary to come back to the same issue more than once to reconsider the choices made.

Sixth, teams should choose a definable and achievable goal. In the case described, the goal was to produce, beta test and utilize a scripted slide set on sustainable systems for feed grain production. Success in this modest goal has produced a working group with the intellectual and interpersonal skills to tackle more ambitious efforts.

Finally, the team approach should be emphasized. The traditional paradigm of a single project leader with several cooperators is less amenable to obtaining balanced input. Sometimes the leader's disciplinary approach is emphasized at the expense of other fields. This is less likely to happen when all participants feel equally responsible for the project and equally empowered in completing it. One team member may need to serve as facilitator to the administrative unit, but this role should not extend to the group activities.

Conclusions

The principles described in the previous section were learned from the MSU SASE experience, rather than guiding it *ex ante*. They represent suggestions for forming teams to develop extension programs on sustainable agricultural systems. A key aspect is that the balanced team approach is more likely to develop a system-oriented educational product than the traditional leader-cooperator method.

The MSU SASE group is composed of specialists with diversity in expertise and opinions about reduced chemical farming. The program development sessions were sometimes stormy, but the end result was a product with which everyone, including the target audience, is satisfied.

The MSU experience is unique in the method of interaction used to arrive at hypothetical systems for comparison. It is also a bit of a leap for biological scientists accustomed to substantiating their comments with years of field trials. Some of the biological scientists were uncomfortable with this "expert systems" approach. The idea of creating assumptions by which to model a problem is not new for the agricultural economist, but for the biological scientist may represent a radical departure from the usual methodology.

Extension education in sustainable agriculture may require presentation of systems for which educators do not have all the answers. The separate component approach to production studies may be inappropriate and inadequate in meeting program objectives. The traditional models of extension programming may become obsolete as educators struggle with the mass of specialized information needed for reduced chemical farming. The MSU SASE method may be a model which can fill the need for interdisciplinary extension education programs in sustainable agriculture.

Table 1. General Description of Comparative Cropping Systems for MSU Sustainable Agriculture Systems Education (SASE) Program

Component	System I	System II	System III	System IV
CROPS	Continuous corn	Wheat-corn-soybeans in rotation	Wheat-corn-soybean in rotation	Wheat-corn-soybean in rotation
TILLAGE SYSTEM	Conventional	Reduced	Reduced	Ridge
NITROGEN SOURCE	Nitrogen fertilizer	Nitrogen fertilizer	Legumes with nitrogen fertilizer	Legumes
WEED MANAGEMENT	Broadcast herbicides	Broadcast herbicides	Banded herbicides with mechanical weed control	Mechanical weed control
INSECT MANAGEMENT	Insecticides	Insecticides	Insecticides, scouting and seed treatment	Scouting and seed treatment

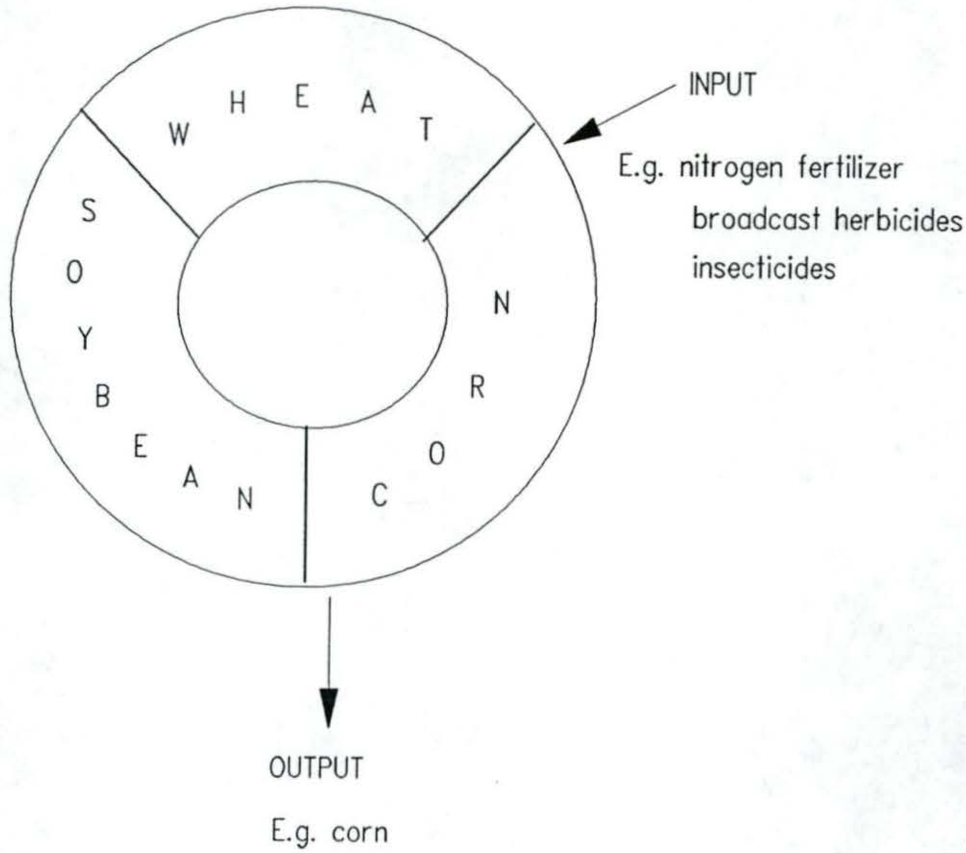

Figure 1. Sample Circle for Presentation of Inputs and Outputs of Cropping Systems

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