Developing a Reflective Decision Support System to Evaluate Alternative Farming Technologies-- Challenges to Agricultural Economics

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by Patrick Madden

With mounting public concern about the sustainability and ecological impacts of chemical technologies used in farming, increasing attention is being given to alternative farming methods featuring a substitution of management (and sometimes also labor) for certain categories of purchased inputs. The ideal or norm is characterized as a farming system in which an abundance of safe and nutritious food and fiber is produced using farming methods that are increasingly sustainable, profitable, and ecologically harmless. In such a system, the farmer seeks profitable ways to reduce dependence on certain categories of synthetic chemical pesticides, highly soluble forms of fertilizers, and other substances that are known or suspected to be harmful to human health or environmental integrity. To the maximum extent feasible, this approach to farming relies on methods such as natural enemies or biological control agents, mechanical cultivation, and crop rotations to control pests. Renewable sources of soil nutrients such as manures and legumes (in rotation or overseeded into row crops) are largely or totally substituted for chemical fertilizers, following a transitional phase.

Surveys of farmers and visits to farms where various alternative farming methods are used on all or part of the acreage have provided several insights regarding the profitability and potential for widespread adoption of these farming methods (Lockeretz et al, 1981;

Madden, 1987; Lockeretz and Madden, 1987). Successful adoption of alternative farming methods (IPM, organic, biodynamic, or regenerative) usually requires more labor and management than comparable size farms where major reliance is placed on use of synthetically formulated chemical pesticides and fertilizers. Several instances have been documented of farmers who are employing methods characterized as organic, regenerative, or similar terms, and earning profits comparable to (occasionally greater than) that of similar farms using conventional farming methods.

While some farms are operating profitably after having applied such methods for several years, it is clear that most farmers attempting to switch abruptly from chemical-intensive to certain kinds of low-input farming methods could experience major financial losses. Much more research must be done before we can adequately understand how commercial-scale farmers in various locations and types of farming could make the transition from chemical-intensive to regenerative farming methods, without incurring severe problems with weeds, insects, soil fertility, and other difficulties that could cause financial disaster. Very little is known about the macroeconomic impacts that would accompany more widespread adoption of various kinds of alternative farming methods. Agricultural economists have an essential role to play in answering these and many other questions.

Research Needs

Much alternative farming is based on practices that do not generate profits for the purveyors of essential technologies. This is in direct contrast to the profitable sales of inputs such as agricultural chemicals, hybrid seeds, and machinery. There is often little or no profit incentive that would induce the private sector to develop better crop rotation strategies, legume cultivars with improved capacity for biological nitrogen fixation, integrated pest management programs, and other such technologies. For example, a familiar example of the motivating power of profits in generating support for potentially profitable agricultural technologies is the case of plant genetics, where private for-profit corporations are attempting to develop cultivars of crops that are immune to certain herbicides, whereas scientists in the public sector are seeking pest-resistant cultivars and other methods that will obviate or greatly reduce application of synthetic chemical pesticides. It is clear that if is in the public interest that such alternative technologies be developed and widely adopted, then it is incumbent upon the public sector (USDA, land grant university experiment stations and extension services as well as other public institutions) to perform the research, developmental work, and educational programming necessary to improve the options available to farmers who wish to find and adopt alternative farming methods. Frankly, it is hard for me to envision a more noble or essential role for the public sector to play-- nor can a more satisfying accomplishment be imagined.

Publicly funded (USDA and land-grant university) research has been categorized as to its relevance to "organic farming systems." Research studies considered to have special relevance to organic systems were found to have a total budget allocation of $24.4 million annually (4.2 percent of total). These studies included research on subjects such as crop rotations, green manure crops, composting, amd biological methods of pest control. Another 88.5 percent of the total ($574.7 million annual budget) consisted of research studies considered applicable to both conventional and organic systems (Schaller et al., 1986:2).

Some research highly relevant to organic system is also being done in the private sector, for example, at the Rodale Research Center (RRC). The RRC is conducting experimental research on thirteen selected farms in locations across the U.S. (Rodale Institute, 1987)

The public sector of the conventional agricultural technology delivery system is renowned for its effectiveness in developing and advocating the adoption of improved technologies. Unfortunately, the criterion most widely used to guide this development has been increasing yields, with little apparent concern for possible detrimental effects of some of the substances applied (pesticides, fertilizers, growth hormones, subtherapeutic doses of antibiotics, etc.) in attaining these increases in yield.

Most (if not all) land grant universities produce physical and biological science-based agricultural "guide books" (such as agronomy guides) and farm management handbooks. The guide books focus on physical inputs and outputs from crop enterprises, with relatively little attention to the monetary costs and returns. The farm management handbooks, on the other hand, deal almost exclusively with the effects of enterprise choice on the income per acre or per animal, based on abbreviated versions of data from the guide books. These two types of information can be used jointly as a valuable aid to decision making in many instances. However, key deficiencies are obvious. First, they rarely provide information regarding various reduced-input methods, including organic or regenerative techniques. Second, they stop short of providing whole-farm management plans based on unbiased, comparable data for various alternative and conventional methods of production. Recent developments in the application of artificial intelligence technology to agriculture in the form of "expert systems" software features computerized data bases and decision trees that seem to have considerable potential for making scientific and technical information readily accessible to users (Rajotte et al., 1987).

Missing from these data systems are several kinds of data necessary for analysis at higher levels of aggregation, such as a whole farm (as contrasted with one enterprise or a component thereof) as well as analysis at the level of markets for agricultural inputs and output commodities. Farmers need more and better information if they are to make informed decisions regarding ways to make a transition (on all or some part of their farm) from synthetic chemical-intensive to low-input farming systems without running the risk of financial failure. Good management requires knowledge of probabley outcomes and variability associated with alternative choices of farming system, including likely changes in farm income and off the farm income, changes in the uncertainty of yields and farm profits, and risks to human health and the environment. More resources should be allocated to collection of data on costs, resource requirements, yields, and other performance measures ordinarily captured in farm management budgets. An improved decision support system should be developed to provide scientifically valid data reflecting the current findings from the various biological and physical sciences, financial data, and estimates of the ecological impact of farm practices on human health risks, threats to water quality, and other environmental hazards.

Farmers typically make decisions as to the kinds of technology to use without fully understanding the financial, environmental, or other outcomes likely to result from those choices. It is naive to think that all farmers operate with perfect certainty or that all their decisions are intended strictly to maximize their current profits. It is equally naive to think that commercial-scale farmers ignore their financial "bottom line." Farmers constantly deal with tradeoffs between competing goals (current income versus future income, practicality versus aesthetics, production versus conservation, work versus leisure. As an aid to their decision making, farmers often seek advice from experts in the public sector (extension and research personnel at universities, for example) and in the private sector (sales representatives or hired consultants). It would be futile, as well as unethical, to attempt to persuade farmers to adopt farming methods, that would likely lead to their financial ruin. Therefore, farmers need access to comprehensive information on various possible choices of farming methods, in a form they can readily understand and use in reaching decisions.

A Reflective Decision Support System

What is needed is a reflective decision support system (RDSS) to provide such information. Production technologies to be included in an RDSS should include both conventional and alternative farming practices, featuring various levels of dependence on synthetic chemical pesticides, growth hormones, antibiotics, and other off-farm inputs. The RDSS should be designed to permit scientifically valid comparisons of the various conventional and alternative farming methods, in terms of profitability, labor requirements (relevant to compatibility with off-farm employment), environmental impacts, and other outcomes relevant to farmers, local officials, and others facing decisions regarding adoption of alternative agriculture technologies.

Since agricultural technologies and market conditions are constantly changing, it is essential that the system be designed to be frequently updated with new scientific and technical information, emerging problems, and opportunities faced by farmers and other decision makers. To this end, the RDSS should be reflective in the sense that it incorporates a feedback of information from users regarding the problems they face and the performance of the system in coping with those problems. In this way, the effectiveness of the RDSS, including the accuracy and relevance of the underlying data bases, would be continually improved.

To establish feedback mechanisms necessary for a process of continuous improvements in the system, it is essential that the decisions reached and actions taken by a panel of decision makers (eg. farmers) be monitored for several years. A certain percentage of the panel members could rotate out of the panel each year, to be replaced with other cooperators. Detailed information collection systems could be instituted so that the performance of the firms could be ascertained, and the probable contribution of the RDSS assessed. Examples of attributes to be monitored include the firm's profitability, yields, amounts of certain inputs (such as specific classes of pesticides), crop cover (relevant to estimation of soil erosion) and other behavioral characteristics of the decision maker and his/her operation. Ideally, the development of the RDSS would integrate and strengthen work currently being done in expert systems and other agricultural extension programs, as well as private-sector farm advisors and consultants. Cooperation of a longitudinal panel of cooperating farmers over several years is essential to the calibration and self-correction of the system. Part of the research and education challenge is to develop practical methods (possibly including advanced communications devices such as voice-over-data systems) that farmers will feel comfortable using, while generating essential data for operating and improving the system on a continuing basis.

Remaining Challenges

An important challenge facing the technology delivery system (again, both public and private) is to develop and the use of farming technologies that will (a) continue to provide an abundance of food and fiber, (b) reduce environmental impacts and human health risks, and (c) provide the information farmers need to decide how (or whether) to make a profitable transition to alternative farming methods (Dabbert and Madden, 1986). Clearly there is need for biological and physical scientific research as well as economic studies to improve the data base available to farmers, researchers, non-farm businesses, public policymakers, and other decision makers in the public and private sectors. It has been my observation that agricultural economists can effectively serve to provide the "intellectual glue" needed to make sense of scientific information from diverse disciplines. But we can serve in this capacity if and only if we are willing to lay aside our technical jargon, learn the languages of the other disciplines, use practical and appropriate methods (often far from the "cutting edge") and drop the idea that maximization of farm-level profits is the only goal, or even necessarily the most important goal of public and private decision making. Many economists have succeeded in doing this, but the current trends in the academic reward system seem to militate against such flexibility and practicality.

Research is also needed to determine the likely macroeconomic impact of various policy options (including current and proposed price support programs) on the adoption of various kinds of alternative farming technologies. Features of public policy that tend to discourage or prohibit farmers from adopting farming methods that are less harmful to the environment and involve less health risk than current farming methods should be identified and carefully evaluated. Likewise, macroeconomic research is needed to anticipate the effects that widespread adoption of alternative farming methods would have upon prices of various agricultural inputs and commodities, as well as the likely effects on international trade, employment, economic development, incomes of various categories of farmers, and the overall structure of agriculture.

Perhaps the greatest challenge lies in the reward systems of academic institutions (particularly the rewarding of tenure, promotions, and merit pay increases). This reward system, in its many variations across the nation, often carries strong disincentives for younger researchers to initiate interdisciplinary work necessary for the solution of practical problems in agriculture. Rather, the system tends to encourage an individual entrepreneurship mode of thinking and working that is oriented toward the production of sole- or at least senior-authored publications, preferably in prestigious refereed journals. A major challenge is to find ways to get the best of both worlds-- the rigor of thinking and methodology engendered by efforts to publish in refereed outlets and attention to important problems facing farmers, policymakers, and society as a whole. Ways must be found to encourage more and better agricultural economics research and extension efforts in this area, and to reward excellent performance within the academic reward system.

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