Recent Developments in Alternative Agriculture in the United States

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Abstract

During the four decades following World War II, the U.S. agricultural production system became highly mechanized and specialized, and dependent upon fossil-fuel energy, chemical fertilizers, and pesticides. The 1980 USDA Report and Recommendation on Organic Farming found that because of the economic, social, and environmental concerns created by these farming practices, many farmers began shifting away from conventional, chemical-intensive farming systems to a less intensive approach based on sod-based rotations and mixed crop-livestock enterprises. The changes that have occurred in the past 10 years on farms in the United States are discussed as are the concepts and terminologies of alternative or low-input, sustainable agriculture; the degradative processes and conservation practices that affect soil productivity, and the factors which affect crop quality and nutrition. Research needs and priorities are suggested.

Introduction

A recent book entitled Alternative Agriculture published by the National Research Council (1989) relates how agriculture in the United States was transformed from a predominately mixed crop-livestock farming system, based on crop rotations, to highly specialized cash grain and confined livestock operations. It describes how this has led to many of the current problems we face including excessive soil erosion, ground water pollution by agrichemicals, and doubts by consumers about food safety and quality.

At the end of World War II most farms in the United States were mixed crop-livestock operations. Farmers produced forages and feed grains for their animals through long-term crop rotations which required minimal purchased inputs, including chemical fertilizers. Soil productivity was maintained by crop rotations including nitrogen-fixing legumes, and the return of crop residues and animal manures to the land. Few pesticides were used. Weeds, insects, and plant diseases were controlled through crop rotations, mechanical cultivation, and biological means such as natural predators.

Following World War II, United States' agriculture became more specialized and dependent on purchased off-farm inputs of chemical fertilizers, pesticides, energy, and credit. Government programs and farm subsidies reduced the risk of specialization which encouraged the separation of the livestock component from feed grain production. This resulted in the decline of two very vital soil and water conservation practices, i.e. the return of animal manures to the land and the rotation of grain crops with grasses and legumes. Consequently, farmers that specialized only in cash grain production, often monoculture systems, then had to increase their inputs of chemical fertilizers and pesticides to compensate for the lost benefits of crop rotations. Thus, for most of four decades U.S. agriculture has substituted machinery, pesticides, chemical fertilizers, irrigation, and energy for diversity, labor, land, and good management as the principal components of agricultural production.

Meanwhile during the same time, livestock production shifted toward large-scale feedlot confinement which required increased use of antibiotics and assorted vaccines to suppress diseases. Another consequence was that these feedlot operations created mountains of manure that had become the ultimate waste material which nobody wanted.

The capacity of U. S. agriculture to produce food and fiber in these highly specialized systems has been rather impressive even though there has been a steady trend toward fewer but larger farms. An often quoted statistic is that one U.S. farmworker currently produces food and fiber for about 78 people. Yet, despite this production capacity many of our farmers are going bankrupt because of the high cost of purchased inputs, low prices received for basic agronomic crops relative to the cost of production, inefficient methods of production, over-capitalization, poor management practices, and a high level of indebtedness.

Energy inputs in U.S. agriculture have escalated to the point where it takes three calories of energy input to produce one calorie of food output. Buttel and Youngberg (1982) estimated that the total energy input to output ratio for producing, transporting, processing, marketing, and preparing food for consumption in the U.S. is approximately 10 calories expended for one calorie of gain.

Consequently, for survival many farmers must focus strictly on intensive production of cash grain crops, e.g., wheat, soybeans, and corn, for short-term economic gain while essential conservation practices are largely neglected. Moreover, there is increasing evidence that excessive soil erosion associated with conventional farming systems is causing a significant loss of soil productivity.

Concern for the present structure of U.S. agriculture, i.e., highly specialized, large-scale, and capital- and chemical-intensive, and the economic, social, and environmental problems associated with it, caused former Secretary of Agriculture Bob Bergland to commission a team of scientists in 1979 to study organic farming methods and practices in the U.S. and abroad for possible alternatives. This paper discusses the results of that study and its impact on U.S. agriculture.

1980 USDA Report and Recommendations on Organic Farming

The U.S. Department of Agriculture's *Report and Recommendations on Organic Farming* (USDA, 1980) cited increasing concern among farmers, environmental groups, and the general public about the adverse effects of the U.S. agricultural production system, particularly the intensive monoculture of cash grains (wheat, soybeans, and corn) and the intensive and often excessive use of chemical fertilizers and pesticides. Among the concerns most often expressed to the USDA study team were:

1) Increased cost of, and dependence on external inputs of chemicals and energy;
2) Adverse effects of agricultural chemicals on human and animal health, wildlife, and on food safety and quality;
3) Decline in soil productivity from excessive soil erosion and nutrient runoff losses;
4) Contamination of surface and ground water from fertilizers and pesticides; and
5) Demise of the family farm and local marketing systems.

Because of these concerns, questions have been raised about the long-term sustainability of the U.S. agricultural production system, which has become so dependent on nonrenewable resources and exploitive of the natural resource base. The USDA Report found that many farmers, in addressing these concerns, had shifted away from conventional (chemical-intensive) farming systems to a less intensive, low-input approach based primarily on sod-based rotations and mixed crop-livestock enterprises.

The USDA Study Team found a broad spectrum of organic farming practitioners, ranging from purist or strict avoidance of synthetic chemicals on one extreme to a more liberal philosophy of selective use of chemicals as a last resort. To encompass the entire spectrum of organic agriculture, the USDA Study Team defined organic farming as:

> A production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests.

A major conclusion of the Report was that these low-input farming systems are environmentally-sound, energy conserving, productive, profitable, and tend toward long-term sustainability. However, the organic farmers interviewed in the USDA case studies expressed the need for specific research and education programs that would benefit not only organic farmers but conventional farmers as well (USDA, 1980; Parr et al., 1983). These programs include:

1) Investigate organic farming systems using a holistic research approach to elucidate the interrelationships of organic waste recycling, nutrient availability, crop protection, energy conservation, and environmental quality.

2) Determine factors responsible for low crop yields during transition from conventional to organic farming.
3) Investigate the availability of phosphorus and potassium from low-solubility sources and their rate of release from soil minerals in organic farming systems.
4) Expand research on biological nitrogen fixation.
5) Develop more effective biological/non-chemical methods for control of weeds, insects, and plant diseases.
6) Establish curricula at agricultural universities on organic farming and alternative agriculture.
7) Develop educational/informational materials for extension agents on organic farming and alternative agriculture that would facilitate technology transfer to farmers.

Alternative Agriculture and Related Terminology

A number of terms and definitions have emerged in recent years that refer to a spectrum of low-chemical, resource- and energy-conserving, and resource-efficient farming methods. For example, words such as biological, ecological, regenerative, natural, biodynamic, eco-agriculture, and resource-efficient are specific terms used by certain advocates and groups to refer to various alternative agricultural production practices and technologies that, they feel, are essential to the development of long-term, sustainable farming systems. The more general terms that have come to be most widely used by the public during the last decade are alternative, organic, and low-input (Youngberg et al., 1984). Many of us in the United States who have been seeking alternatives to conventional agriculture tend to view the term alternative as one which encompasses most, if not all, of the others. The word organic would appear to come closest to being a generic term which represents these low-chemical, resource-efficient methods of farming. Thus, despite the reluctance of some to accept the term organic, particularly within the scientific community, its meaning is widely recognized and generally understood by a broad cross-section of the American public. The desire by certain advocates within the alternative agriculture community to find a term that is more acceptable to agricultural scientists may, in fact, help to explain the proliferation of these terms.

Our use of the term alternative agriculture is shown in Figure 1, which depicts a spectrum of farming methods as related to the use of synthetic agricultural chemicals. We have placed organic farming on the extreme left and associated it with nonuse of synthetic chemicals. Low-input farming seeks to reduce the amount of synthetic chemicals that are applied but allows for their limited use. This part of the spectrum is designated as alternative agriculture, with the remaining portion of the spectrum denotes conventional agriculture and unlimited use of synthetic chemicals.

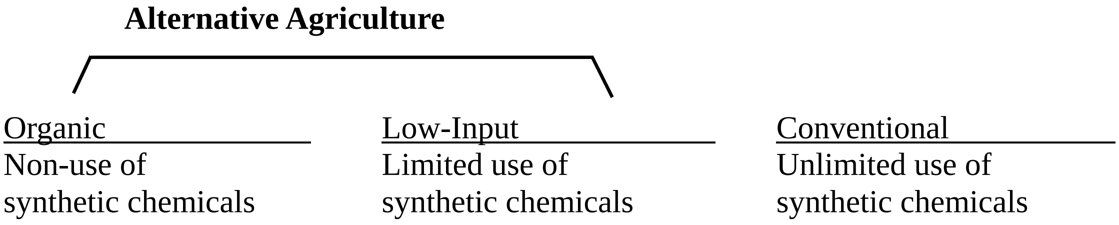

Figure 1. Alternative Agriculture Is Part of a Spectrum Which Includes Organic Farming, with Nonuse of Synthetic Chemicals, and Low-Input Farming Which Allows Their Limited Use.

The concept of alternative agriculture shown in Figure 1 was reinforced with publication of the book Alternative Agriculture by the National Research Council (1989). It states that

> Alternative Agriculture is not a single system of farming practices. It includes a spectrum of farming systems ranging from organic systems that attempt to use no purchased synthetic chemical inputs, to those involving the prudent use of pesticides or antibiotics to control specific pests or diseases. Alternative farming encompasses, but is not limited to, farming systems known as biological, low-input, organic, regenerative or sustainable.

Alternative agriculture is defined by the National Research Council (1989) as any system of food or fiber production that pursues the following goals:

1) More thorough incorporation of natural processes such as nutrient cycling, nitrogen fixation, and pest-predator relationships into agricultural production systems.
2) Reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of farmers and consumers.
3) Increased use of the biological and genetic potential of plant and animal species.
4) Matching appropriate cropping patterns to the productive potential and physical limitations of agricultural lands to ensure long-term sustainability.
5) Profitable and efficient production with emphasis on improved farm management and conservation of soil, water, energy, and biological resources.

Certification Standards for Organically-Grown Foods

During the last decade the term organic has evolved from its previous generic definition into one which has become widely used to develop certification standards for organically-grown foods. The demand for organic produce has increased significantly in the United States in recent years because of the public's concern about residual pesticides in food and possible adverse effects on human health. In a recent publication by the Center for Science in the Public Interest (Howell, 1989), it was reported that some 16 states have now passed laws or adopted regulations defining organic for labeling purposes. Such laws give consumers assurance that food labeled as organic was actually grown without the use of synthetic chemicals, especially pesticides.

Moreover, five states-Texas, Washington, Minnesota, New Hampshire, and Vermont-have developed inspection programs to certify that organic producers are actually in compliance with state certification standards and regulations. Most state regulations require that organic producers farm without synthetic agricultural chemicals for three years before they can claim their products are organically-grown.

Taxing Synthetic Agricultural Chemicals

Some states have become increasingly concerned about the pollution (both real and potential) of ground water by agricultural pesticides and fertilizers. This was evidenced in 1987 with passage of Iowa's Ground Water Protection Act. This Iowa State law authorized the taxing of all pesticides and synthetic nitrogen fertilizers sold within the state. This landmark environmental legislation provides $11 million through the taxation of agricultural chemical sales to support research and demonstration programs designed to reduce the use of synthetic chemicals in agriculture. Some $6.6 million of these funds were used to establish the Leopold Center for Sustainable Agriculture at Iowa State University to study alternative agriculture methods and to disseminate information to farmers, and another $1.3 million to study the effects of pesticides on human health. It is likely that other states will pass similar legislation in the future.

The Concept of Low-Input/Sustainable Agriculture

The word sustainable has become increasingly popular in describing different versions of alternative agriculture. According to Lockeretz (1988), "sustainable agriculture is a loosely defined term that encompasses a range of strategies for addressing a number of problems that afflict U.S. agriculture and agriculture worldwide." Such problems include loss of soil productivity from excessive erosion and associated plant nutrient losses; surface and ground water pollution from pesticides, fertilizers, and sediment; impending shortages of nonrenewable resources; and low farm income from depressed commodity prices and high production costs. Furthermore, sustainable implies a time dimension and the capacity of a farming system to endure indefinitely (Lockeretz, 1988).

In 1985, the U.S. Congress passed the Agriculture Productivity Act as part of the Food Security Act. Public Law 99-198 (otherwise known as the 1985 Farm Bill). This act provided USDA with the authority to conduct research and education in alternative agriculture, or, more specifically, on low-input or sustainable farming systems (USDA, 1988). For Fiscal Year 1988, Congress appropriated \$3.9 million to implement the research and education programs requested in the Agriculture Productivity Act. This funding was increased to \$4.5 million for Fiscal Year 1989.

The concept that has emerged from these initiatives is one of low-input/sustainable agriculture or LISA which is shown in Figure 2 (Personal communication from Dr. Neill Schaller, USDA-CSRS, Washington, D.C.). The ultimate goal of sustainable agriculture is to develop farming systems that are productive and profitable, conserve the natural resource base, protect the environment and enhance health and safety, and do so over the long-term. The way to achieve this is through low-input methods and skilled management which seek to optimize the management and use of internal production inputs (i.e., on-farm resources) in a manner that provides acceptable levels of sustainable crop yields and livestock production and results in economically profitable returns. This approach emphasizes such cultural and management practices as crop rotations, recycling of animal manures, and conservation tillage to control soil erosion and nutrient losses and to maintain or enhance soil productivity. Low-input farming systems seek to minimize the use of external production inputs (i.e., off-farm resources), such as purchased fertilizers and pesticides, wherever and whenever feasible and practicable; to lower production costs; to avoid pollution of surface and ground water; to reduce pesticide residues in food; to reduce a farmer's overall risk; and to increase both short- and long-term farm profitability.

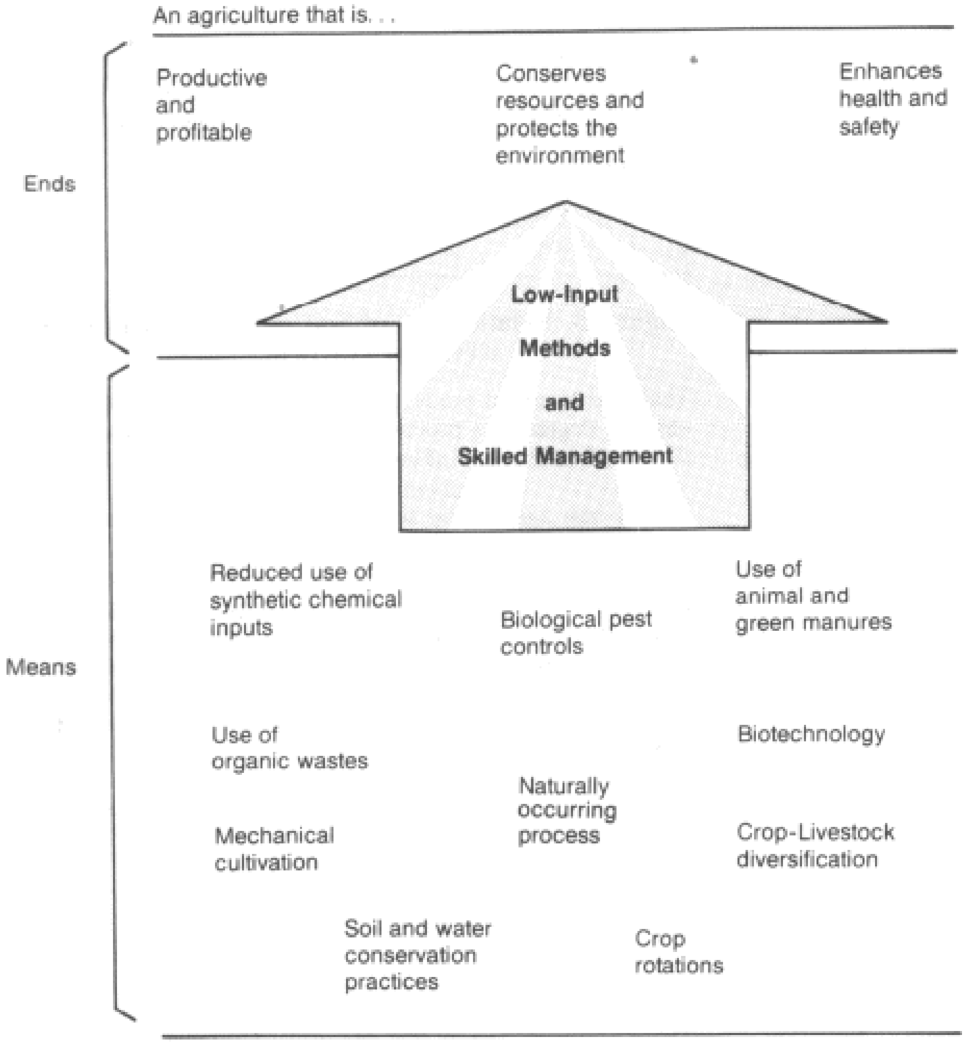

Figure 2. A Current Concept of Sustainable Agriculture in the United States Showing the Ends or Objectives and the Means of Achieving Them through Low-Input Methods and Skilled Management.

Another reason for the focus on low-input farming systems is that sooner or later most high-input systems fail because they are not economically or environmentally sustainable. Thus in the United States, sustainable agriculture has settled in as the ultimate goal. How we achieve this goal will depend upon creative and innovative methods and practices that provide farmers with economically viable and environmentally sound alternatives in their farming systems.

The Dynamic Nature of Soil Productivity

Soil productivity has been defined by the USDA (1957) as:

> The capability of a soil for producing a specified plant or sequence of plants under a defined set of management practices. It is measured in terms of outputs or harvests in relation to the inputs of production factors for a specific kind of soil under a physically defined system of management.

The key to alternative agriculture, or versions thereof, is soil productivity. An important relationship that is often overlooked is that for most agricultural soils, degradative processes such as soil erosion, nutrient runoff losses, and organic matter depletion are going on simultaneously with the beneficial effects of conservation practices such as crop rotations, conservation tillage, and the recycling of animal manures and crop residues. Thus, the potential productivity of a particular soil at any point in time is the result of ongoing degradative processes and applied conservation practices. This relationship is illustrated in Figure 3 (Hornick and Parr, 1987).

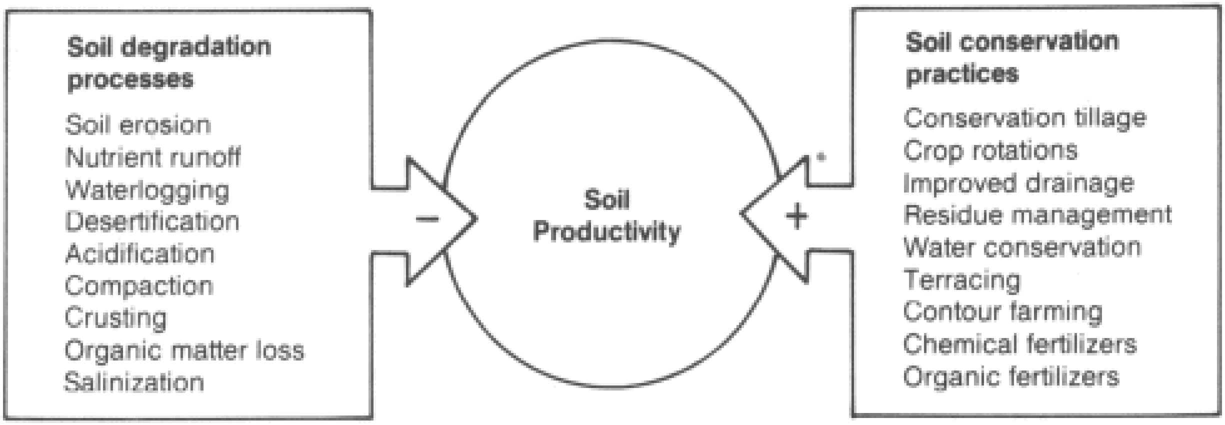

Figure 3. Relationship of Soil Degradative Processes and Soil Conservation Practices.

On our best agricultural soils, e .g. gently-sloping, medium-textured, well-structured, and deep, well-drained, a high level of productivity can be maintained by a relatively few, but essential conservation practices that can readily offset most degradative processes. However, on marginal soils of limited capability, e.g., steeply sloping, coarse-textured, poorly structured, nutrient-depleted, and shallow, poorly drained profile, soil conservation practices must be maximized to counteract further degradation. Organic wastes and residues offer the best possible means of restoring the productivity of severely eroded agricultural soils, or of reclaiming marginal soils (Hornick, 1982, Hornick and Parr, 1987).

Thus, the vital component in this dynamic equilibrium (Figure 3) is soil organic matter which must be maintained and replenished through regular additions of organic materials such as animal manures and crop residues (Parr and Colacicco, 1987) and composted municipal wastes (Hornick et al., 1984). The proper use of organic amendments is of utmost importance in maintaining the tilth, fertility, and productivity of agricultural soils, protecting them from wind and water erosion, and preventing nutrient losses through runoff and leaching.

Crop Quality, Nutrition, and Bioavailability

There are many factors that can affect crop quality. However, the cultivar and post-harvest handling probably have the greatest effect on the nutrient composition of crops. Cultivars are usually selected for their response to production inputs, especially chemical fertilizers, with maximum crop yields as the primary consideration (Hornick and Parr, 1987).

There has been much speculation on the benefits of consuming crops grown organically compared with those grown with synthetic chemical fertilizers. For example, researchers have shown conflicting results with respect to the ascorbic acid (Vitamin C) content of crops grown on soils amended with organic amendments as the sole source of plant nutrients compared with chemical fertilizers (Hornick and Parr, 1987). As farmers attempt to reduce their dependency on chemical fertilizers and pesticides, they will undoubtedly adopt various cultural practices to fulfill the plant nutrient requirement and to control weeds and insects. Thus, cultural practices could have a considerable impact on crop quality both now and in the future.

Recently, Hornick and Lloyd (1986) conducted studies to elucidate the effect of organic and chemical nitrogen sources on the ascorbic acid content of kale. They found that as the rate of inorganic nitrogen increased there was a progressive and significant decrease in the ascorbic acid content. These results indicate that increased nitrogen rates do tend to depress ascorbic acid levels of some crops. While this might be attributed in part to a dilution effect from increased yields, their work suggests that other biochemical interactions are involved.

The concept of producing better quality crops, however, is a complex issue because bioavailability of crop nutrients depends on many factors. Bioavailability refers to the amount of a particular nutrient that is absorbed from a food after consumption that is utilized by an animal or human. It is not the total amount of a nutrient in the food that is consumed

Measurements of nutrient bioavailability are difficult because of the many interactions that occur between minerals, vitamins, and food components such as fiber. For example, iron bioavailability is determined by the iron status of the individual and the source of iron being consumed. It is enhanced by the presence of ascorbic acid (vitamin C) in the meal. In addition, iron bioavailability may decrease when a meal high in dietary fiber is consumed by an individual who does not normally consume a large amount of dietary fiber. Iron, ascorbic acid, and fiber are important in the diet for optimal health and norma bodily function. However, the ways in which they interact with one another will determine the health and well-being of an individual.

In addition to these types of interactions, little is known about the bioavailability of nutrients in crops grown under different management practices. It is apparent that research is needed to determine the effect of cultural and management practices on the nutritional quality of agricultural and horticultural crops, and on the bioavailability of nutrients of foods and feeds consumed by human beings and animals.

Research Needs and Priorities

The following areas of research should be given high priority by USDA, agricultural universities, and private organizations to promote the development of alternative farming systems.

1) Conduct research on low-input/sustainable agriculture using a systems or holistic approach. We need to know the chemical, physical and biological interactions occurring in these systems and their relationship to organic recycling, nutrient availability, crop protection, energy conservation, crop quality, and environmental quality.
2) Assess the relative profitability of alternative farming systems compared with conventional agriculture.
3) Determine the reasons for decreased crop yields during transition from conventional to alternative farming systems so that farmers can avoid undue economic loss.
4) Conduct on-farm research in which the scientist, the farmer, and the extension agent work closely as a team in planning and implementing the research, and in interpreting the results.
5) Develop nonchemical methods and techniques for the control of weeds, insects and plant diseases.
6) Determine the nutritional quality of crops and the bioavailability of food nutrients for crops grown in alternative farming systems. This will be important as cultural and management practices change and as new cultivars are introduced.

7) Develop improved methods for on-farm composting of animal manures and crop residues.
8) Establish and assign proper nitrogen credits in calculating the nitrogen requirements for crops. Farmers need to know the potential availability of nitrogen from soil, irrigation water, legumes, animal manures, composts, and other organic amendments to avoid excess nitrate in the environment and ground water pollution.

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