NATIONAL AGRICULTURAL LIBRARY ARCHIVED FILE
Archived files are provided for reference purposes only. This file was current when produced, but is no longer maintained and may now be outdated. Content may not appear in full or in its original format. All links external to the document have been deactivated. For additional information, see http://pubs.nal.usda.gov.

Alternative Farming Systems Information Center, http://afsic.nal.usda.gov
National Agricultural Library, http://www.nal.usda.gov
Agricultural Research Service, U.S. Department of Agriculture

Web Policies and Important Links, http://www.nal.usda.gov/web-policies-and-important-links

REPORT AND RECOMMENDATIONS ON ORGANIC FARMING

UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT AND RECOMMENDATIONS ON ORGANIC FARMING

Prepared by

USDA Study Team on Organic Farming

United States Department of Agriculture

July 1980

FOREWORD

We in USDA are receiving increasing numbers of requests for information and advice on organic farming practices. Energy shortages, food safety, and environmental concerns have all contributed to the demand for more comprehensive information on organic farming technology.

Many large-scale producers as well as small farmers and gardeners are showing interest in alternative farming systems. Some of these producers have developed unique systems for soil and crop management, organic recycling, energy conservation, and pest control.

We need to gain a better understanding of these organic farming systems -- the extent to which they are practiced in the United States, why they are being used, the technology behind them, and the economic and ecological impacts from their use. We must also identify the kinds of research and education programs that relate to organic farming.

As we strive to develop relevant and productive programs for all of agriculture, we look forward to increasing communication between organic farmers and the U.S. Department of Agriculture.

BOB BERGLAND
Secretary of Agriculture

PREFACE

One of the major challenges to agriculture in this decade will be to develop farming systems that can produce the necessary quantity and quality of food and fiber without adversely affecting our soil resources and the environment. This study was conducted to learn more about the potential contribution of organic farming as a system for the production of food and fiber.

We wish to thank Mr. Robert Rodale for allowing us to have access to the results of the Rodale Press survey of The New Farm readers. This survey produced a great deal of valuable background information and has added depth and perspective to this report. We are also indebted to the many persons in Cooperative Research, Extension, Land-Grant Universities, State Agricultural Experiment Stations, and other cooperating institutions who responded to our requests for information, assistance, and guidance. The Study Team wishes to extend a special note of gratitude to those organic farmers who so willingly explained their farming operations. We have benefited greatly from their experiences and testimony, and their cooperation is deeply appreciated.

ANSON R. BERTRAND, Director
Science and Education

ACKNOWLEDGMENTS

The study team wishes to express its appreciation for the excellent advice and counsel on organic farming that it received during this study from:

Mr. Eliot W. Coleman, Executive Director
International Federation of Organic
Agricultural Movements (IFOAM)
The Coolidge Center
Topsfield, Massachusetts

and

Dr. Richard R. Harwood, Director
Organic Gardening and Farming Research Center
Rodale Press, Inc.
Emmaus, Pennsylvania

We acknowledge the generous assistance of those scientists who reviewed various segments of the report and provided such helpful and constructive suggestions. The clerical staff of the Biological Waste Management and Organic Resources Laboratory also deserves special thanks for their diligence and patience in preparing the preliminary drafts and the final document.

CONTENTS

1. INTRODUCTION---------- 1
1.1 BACKGROUND---------- 1
1.2 NATURE OF THE STUDY---------- 2
1.2.1 Objectives---------- 2
1.2.2 Methods---------- 3
REFERENCES---------- 4

2. ORGANIC AGRICULTURE: DEFINITIONS AND PHILOSOPHY---------- 6
2.1 INTRODUCTION---------- 6
2.2 FORMAL DEFINITIONS---------- 6
2.3 THE ORGANIC SPECTRUM: SOME ADDITIONAL CATEGORIES---------- 8
2.4 ORGANIC AGRICULTURE: SOME BASIC TENETS---------- 8
2.5 ORGANIC FARMING: ITS MEANING IN THIS REPORT---------- 9
REFERENCES---------- 9

3. CURRENT STATUS AND CHARACTER OF ORGANIC FARMING IN THE UNITED STATES------- 10
3.1 BACKGROUND INFORMATION---------- 10
3.1.1 Number of Farms---------- 10
3.1.2 Geographic Distribution---------- 10
3.1.3 Farm Size---------- 10
3.1.4 Farm Ownership Characteristics---------- 11
3.1.5 Age and Farming Experience---------- 11
3.1.6 Educational Background---------- 11
3.1.7 Motivations for Farming Organically---------- 11
3.1.8 Other Characteristics---------- 11
3.2 CROP PRODUCTION---------- 12
3.2.1 Cropping Practices---------- 12
3.2.2 Cultural Practices---------- 12
3.2.3 Soil and Water Conservation---------- 13
3.2.4 Application of Plant Nutrients and Organic Matter---------- 13
3.2.5 Pest Control Methods---------- 15
3.2.6 Crop Yields and Quality---------- 16
3.3 ANIMAL PRODUCTION---------- 16
3.4 MARKETING---------- 17
3.5 GROWER AND MARKETING ORGANIZATIONS---------- 18
3.6 ORGANIC AGRICULTURE IN EUROPE---------- 18
3.7 ORGANIC AGRICULTURE IN JAPAN---------- 19

4. ANALYSIS OF ORGANIC AGRICULTURE: PRODUCTION, ENVIRONMENTAL, AND SOCIO-ECONOMIC IMPLICATIONS---------- 22
4.1 PLANT NUTRIENT BUDGET---------- 22
4.1.1 Nutrient Requirements---------- 22
4.1.2 Nutrient Budget Concept---------- 22
4.1.3 Nitrogen---------- 23
4.1.4 Phosphorus and Potassium---------- 23
4.1.5 Effect of Organic Matter on the Solubility of Calcium Phosphates---------- 27
4.1.6 Potential Impact of Mycorrhizal Fungi---------- 27
REFERENCES---------- 28
4.2 IMPACT OF ORGANIC METHODS ON SOIL PRODUCTIVITY AND TILTH---------- 29
4.2.1 Effect of Organic Nutrient Sources on Crop Production--------- 29
4.2.2 Effect of Organic Methods on Soil Organic Matter---------- 30
4.2.3 Effect of Chemical Fertilizers and Pesticides on Soil Microbiological and Physical Properties---------- 32

REFERENCES---------- 34
4.3 ORGANIC FARMING AND ORGANIC WASTES---------- 35
4.3.1 USDA Report, Improving Soils with Organic Wastes (1978)-------- 35
4.3.2 Composting to Enhance the Usefulness and Acceptability of Organic Wastes as Fertilizers and Soil Conditioners---------- 38
REFERENCES---------- 39
4.4 NONTRADITIONAL SOIL AND PLANT ADDITIVES---------- 40
REFERENCES---------- 41
4.5 PEST CONTROL---------- 42
4.5.1 Weed Control---------- 42
4.5.2 Insect Control---------- 42
4.6 ECONOMIC ASSESSMENT OF ORGANIC FARMING---------- 43
4.6.1 An Economic Comparison of Organic Crop Rotations and Continuous Conventional Cropping---------- 45
4.6.2 Possible Economic Impacts of Increased Organic Farming in the Future---------- 46
REFERENCES---------- 49
4.7 PRODUCTIVITY IN ORGANIC FARMING---------- 49
4.7.1 Relation to Energy---------- 49
4.7.2 Comparison of Crop Yields on Organic and Conventional Farms---------- 52
REFERENCES---------- 56
4.8 LABOR INTENSIVENESS ON ORGANIC FARMS---------- 56
REFERENCES---------- 58
4.9 WATER CONSERVATION---------- 58
4.9.1 Tillage---------- 58
4.9.2 Cropping Practice---------- 58
4.9.3 Organic Matter---------- 59
REFERENCES---------- 59
4.10 IMPACT OF ORGANIC AGRICULTURE ON ENVIRONMENTAL QUALITY---------- 59
4.10.1 Soil Erosion Control with Organic Farming---------- 59
4.10.2 Nutrient Loss with Organic Farming---------- 61
4.10.3 Pesticide Pollution---------- 62
REFERENCES---------- 63
4.11 NUTRITIONAL QUALITY AND FOOD SAFETY---------- 64
4.11.1 Background and Terminology---------- 64
4.11.2 Nutritional Quality---------- 64
4.11.3 Health Safety---------- 65
REFERENCES---------- 67
4.12 PUBLIC POLICY AND ORGANIC FARMING: SELECTED ISSUES AND POLICIES------- 67
4.12.1 Introduction---------- 67
4.12.2 National Policies and Issues---------- 67
REFERENCES---------- 70

5. CURRENT RESEARCH AND EDUCATION PROGRAMS ON ORGANIC AGRICULTURE---------- 71
5.1 CURRENT RESEARCH ON CROP PRODUCTION THAT RELATES TO ORGANIC FARMING---- 71
5.1.1 Introduction---------- 71
5.1.2 Biological Nitrogen Fixation---------- 71
5.1.3 Application of Municipal and Industrial Waste to Land---------- 72
5.1.4 Application of Animal Manure to Land---------- 72
5.1.5 Soil Fertility---------- 72
5.1.6 Economic Evaluations---------- 73
5.1.7 Food Safety and Quality---------- 73
5.1.8 Pest Control---------- 73
5.2 EDUCATION PROGRAMS IN ORGANIC FARMING---------- 73
5.2.1 University Programs---------- 73

5.2.2 Cooperative Extension Service Educational Programs---------- 75

6. FACTORS AFFECTING THE FUTURE OF ORGANIC FARMING---------- 78
6.1 FACTORS WHICH SUPPORT SUCCESSFUL ORGANIC FARMING OPERATIONS---------- 78
6.1.1 Skilled Management---------- 78
6.1.2 Available Sources of Nutrients---------- 78
6.1.3 High Phosphorus and Potassium Status of Soils---------- 79
6.1.4 Soils Highly Buffered with Phosphorus and Potassium---------- 79
6.1.5 Benefits from Organic Matter Management---------- 79
6.1.6 Improved Soil Physical Conditions---------- 79
6.1.7 Farm Ownership---------- 79
6.2 BENEFITS, OPPORTUNITIES, AND INCENTIVES THAT LEND SUPPORT TO ORGANIC FARMING PRACTICES---------- 79
6.2.1 Environmental Quality---------- 79
6.2.2 Food Safety---------- 80
6.2.3 Energy---------- 80
6.2.4 Conservation of Natural Resources---------- 80
6.2.5 Economic Factors---------- 81
6.2.6 Technology Development---------- 81
6.3 POSSIBLE LIMITATIONS AND BARRIERS TO ORGANIC FARMING---------- 81
6.3.1 Plant Nutrients---------- 81
6.3.2 Economic Factors---------- 82
6.3.3 Communication Problems---------- 83
6.3.4 Farm Ownership Patterns---------- 83
6.3.5 Crop Varieties---------- 83
6.4 FUTURE PROSPECTS---------- 84
REFERENCES---------- 85

7. RECOMMENDATIONS FOR ACTION---------- 86
7.1 RESEARCH RECOMMENDATIONS FROM EARLIER REPORT---------- 86
7.2 RESEARCH RECOMMENDED BY THE USDA STUDY TEAM---------- 88
7.3 EDUCATION PROGRAMS---------- 92
7.4 EXTENSION PROGRAMS---------- 93
7.5 RECOMMENDATIONS ON ORGANIZATION AND POLICY MATTERS---------- 93
REFERENCES---------- 94

USDA STUDY TEAM FOR ORGANIC FARMING

Dr. Robert I. Papendick, SEA/AR
Coordinator and Chairman of Study Team
Land Management and Water Conservation Research Unit
Pullman, Washington

Dr. Larry L. Boersma, SEA/CR
Washington, D.C.

Mr. Daniel Colacicco, USDA/ESCS
Assigned to the Biological Waste Management and Organic Resources Laboratory
Beltsville, Maryland

Ms. Joanne M. Kla
Maryland Environmental Service
Assigned to the Biological Waste Management and Organic Resources Laboratory
Beltsvile, Maryland

Dr. Charles A. Kraenzle, USDA/ESCS
Assigned to SEA/JPE
Program Planning Staff
Beltsville, Maryland

Dr. Paul B. Marsh, SEA/AR
Biological Waste Management and Organic Resources Laboratory
Beltsville, Maryland

Dr. Arthur S. Newman, SEA/CR
Washington, D.C.

Dr. James F. Parr, SEA/AR, Chief
Biological Waste Management and Organic Resources Laboratory
Beltsville, Maryland

Dr. James B. Swan
Department of Soil Science
University of Minnesota
St. Paul, Minnesota

Dr. I. Garth Youngberg, Chairperson
Department of Political Science
Southeast Missouri State University
Cape Girardeau, Missouri

OTHER CONTRIBUTORS

Dr. Lloyd A. Andres, SEA/AR
Biological Control of Weeds Laboratory
Albany, California

Dr. William W. Cantelo, SEA/AR
Vegetable Laboratory
Beltsville, Maryland

Dr. John W. Doran, SEA/AR
Lincoln, Nebraska

Dr. Thomas M. McCalla, SEA/AR
Lincoln, Nebraska

Mr. James W. Schwartz, SEA/AR
National Program Staff
Beltsville, Maryland

Dr. Guye H. Willis, SEA/AR
Soil and Water Pollution Research
Baton Rouge, Louisiana

SUMMARY AND CONCLUSIONS

In April 1979, Dr. Anson R. Bertrand, Director, Science and Education, U.S. Department of Agriculture, designated a team of scientists to conduct a study of organic farming in the United States and Europe. Accordingly, the team has assessed the nature and activity of organic farming both here and abroad; investigated the motivations of why farmers shift to organic methods; explored the broad sociopolitical character of the organic movement, assessed the nature of organic technology and management systems; evaluated the level of success of organic farmers and the economic impacts, costs, benefits, and limitations to organic farming; identified research and education programs that would benefit organic farmers; and recommended plans of action for implementation. This report is a condensed version of data and information compiled by the study team. More detailed and documented information will be published later.

In conducting this study, the team relied on a variety of methods and sources to obtain information. These included:

- Selected on-farm case studies of 69 organic farms in 23 States.
- A Rodale Press survey of The New Farm magazine readership.
- An extensive review of the literature on organic farming published both here and abroad.
- Interviews and correspondence with knowledgeable organic farming leaders, editors, spokesmen, and practitioners.
- Two study tours of organic farms and research institutes in Europe and Japan.

Public response to this study from both the rural and urban communities has been overwhelming and for the most part highly positive. Thus far, approximately 500 letters have been received expressing encouragement and support for the Department's efforts. Many people have generously provided valuable information for the study and innovative ideas on organic methods and techniques. Throughout the study, team members have been invited to speak before various organic producer groups and associations. In all cases, supportive and even enthusiastic receptions were noted. Finally, interviews with team members have been published in numerous newspapers, magazines, and organic newsletters.

It has been most apparent in conducting this study that there is increasing concern about the adverse effects of our U.S. agricultural production system, particularly in regard to the intensive and continuous production of cash grains and the extensive and sometimes excessive use of agricultural chemicals. Among the concerns most often expressed are the following:

(1) Sharply increasing costs and uncertain availability of energy and chemical fertilizer, and our heavy reliance on these inputs.
(2) Steady decline in soil productivity and tilth from excessive soil erosion and loss of soil organic matter.
(3) Degradation of the environment from erosion and sedimentation and from pollution of natural waters by agricultural chemicals.
(4) Hazards to human and animal health and to food safety from heavy use of pesticides.
(5) Demise of the family farm and localized marketing systems.

Consequently, many feel that a shift to some degree from conventional (that is, chemical-intensive) toward organic farming would alleviate some of these adverse effects, and in the long term would ensure a more stable, sustainable, and profitable agricultural system.

While other definitions exist, for the purpose of this report organic farming is defined as follows:

Organic farming is 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.

The concept of the soil as a living system which must be "fed" in a way that does not restrict the activities of beneficial organisms necessary for recycling nutrients and producing humus is central to this definition.

The following is a brief summary of the principal findings of this study:

(1) The study team found that the organic movement represents a spectrum of practices, attitudes, and philosophies. On the one hand are those organic practitioners who would not use chemical fertilizers or pesticides under any circumstances. These producers hold rigidly to their purist philosophy. At the other end of the spectrum, organic farmers espouse a more flexible approach. While striving to avoid the use of chemical fertilizers and pesticides, these practitioners do not rule them out entirely. Instead, when absolutely necessary some fertilizers and also herbicides are very selectively and sparingly used as a second line of defense. Nevertheless, these farmers, too, consider themselves to be organic farmers. Failure to recognize that the organic farming movement is distributed over a spectrum can often lead to serious misconceptions. We should not attempt to place all of these organic practitioners in the same category. For example, we should not lump "organic farmers" and "organic gardeners" together.

(2) Organic farming operations are not limited by scale. This study found that while there are many small-scale (10 to 50 acres) organic farmers in the northeastern region, there are a significant number of large-scale (more than 100 acres and even up to 1,500 acres) organic farms in the West and Midwest. In most cases, the team members found that these farms, both large and small, were productive, efficient, and well managed. Usually the farmer had acquired a number of years of chemical farming experience before shifting to organic methods.

(3) Motivations for shifting from chemical farming to organic farming include concern for protecting soil, human, and animal health from the potential hazards of pesticides; the desire for lower production inputs; concern for the environment and protection of soil resources.

(4) Contrary to popular belief, most organic farmers have not regressed to agriculture as it was practiced in the 1930's. While they attempt to avoid or restrict the use of chemical fertilizers and pesticides, organic farmers still use modern farm machinery, recommended crop varieties, certified seed, sound methods of organic waste management, and recommended soil and water conservation practices.

(5) Most organic farmers use crop rotations that include legumes and cover crops to provide an adequate supply of nitrogen for moderate to high yields.

(6) Animals comprise an essential part of the operation of many organic farms. In a mixed crop/livestock operation, grains and forages are fed on the farm and the manure is returned to the land. Sometimes the manure is composted to conserve nitrogen, and in some cases farmers import both feed and manure from off-farm sources.

(7) The study team was impressed by the ability of organic farmers to control weeds in crops such as corn, soybeans, and cereals without the use (or with only minimal use) of herbicides. Their success here is attributed to timely tillage and cultivation, delayed planting, and crop rotations. They have also been relatively successful in controlling insect pests.

(8) Some organic farmers expressed the feeling that they have been neglected by the U.S. Department of Agriculture and the land-grant universities. They believe that both Extension agents and researchers, for the most part, have little interest in organic methods and that they have no one to turn to for help on technical problems.

(9) In some cases where organic farming is being practiced, it is apparent from a study of the nutrient budget that phosphorus (P) and potassium (K) are being "mined" from either soil minerals or residual fertilizers applied when the land was farmed chemically. While these sources of P and K may sustain high crop yields for some time (depending on soil, climatic, and cropping conditions), it is likely that eventually some organic farmers will have to apply supplemental amounts of these two nutrients.

(10) The study revealed that organic farms on the average are somewhat more labor intensive but use less energy than conventional farms. Nevertheless, data are limited and a thorough study of the labor and energy aspects of organic and conventional agriculture is needed.

(11) This study showed that the economic return above variable costs was greater for conventional farms (corn and soybeans) than for several crop rotations grown on organic farms. This was largely due to the mix of crops required in the organic system and the large portion of the land that was in legume crops at any one time.

(12) There are detrimental aspects of conventional production, such as soil erosion and sedimentation, depleted nutrient reserves, water pollution from runoff of fertilizers and pesticides, and possible decline of soil productivity. If costs of these factors are considered, then cost comparisons between conventional (that is, chemical-intensive) crop production and organic systems may be somewhat different in areas where these problems occur.

In conclusion, the study team found that many of the current methods of soil and crop management practiced by organic farmers are also those which have been cited as best management practices (USDA/EPA joint publication on "Control of Water Pollution from Cropland," Volume I, 1975, U.S. Government Printing Office) for controlling soil erosion, minimizing water pollution, and conserving energy. These include sod-based rotations, cover crops, green manure crops, conservation tillage, strip cropping, contouring, and grassed waterways. Moreover, many organic farmers have developed unique and innovative methods of organic recycling and pest control in their crop production sequences. Because of these and other reasons outlined in this report, the team feels strongly that research and education programs should be developed to address the needs and problems of organic farmers. Certainly, much can be learned from a holistic research effort to investigate the organic system of farming, its mechanisms, interactions, principles, and potential benefits to agriculture both at home and abroad.

REPORT AND RECOMMENDATIONS ON ORGANIC FARMING

INTRODUCTION

1.1 BACKGROUND

The intensive and highly mechanized agricultural technologies now utilized in our U.S. agricultural production system have led to greatly increased productivity and labor efficiency, but also to a concomitant decrease in energy efficiency (1)[1] and to other concerns involving both farmers and the general public. There is a growing concern about the adverse effects of intensive production of cash grains and about the extensive, and sometimes excessive, use of chemical fertilizers and pesticides (2). Among the matters in question are these:

- Increased cost and uncertain availability of energy and chemicals.
- Increased resistance of weeds and insects to pesticides.
- Decline in soil productivity from erosion and accompanying loss of organic matter and plant nutrients.
- Pollution of surface waters with agricultural chemicals and sediment.
- Destruction of wildlife, bees, and beneficial insects by pesticides.
- Hazards to human and animal health from pesticides and feed additives.
- Detrimental effects of agricultural chemicals on food quality.
- Depletion of finite reserves of concentrated plant nutrients, for example, phosphate rock.

[1] Numbers in parentheses refer to references cited at the end of each section.

- Decrease in numbers of farms, particularly family-type farms, and disappearance of localized and direct marketing systems.

Some previous assessments of organic farming systems have suggested that this method of farming is associated with a low level of productivity and is essentially unadaptable to widespread use in the United States for adequate food and fiber production. In view of recent efforts by the U.S. Department of Agriculture to assess possible consequences of certain trends in the structure of our agricultural production and marketing system, certain questions have arisen. For example, were earlier assessments of the productivity of organic agriculture in the United States valid? Under what specific circumstances and conditions can organic farming systems produce a significant portion of our food and fiber needs? What are the costs and benefits of organic farming, and what are the relationships between energy and labor?

Proponents of organic agriculture face many of the same problems that confront those who practice chemical-intensive (conventional) farming. Both must provide adequate supplies of nutrients, water, and energy for crop and livestock production. The basic difference, however, is that organic farmers avoid or restrict the use of synthetic fertilizers and pesticides, and must therefore achieve nutrient recycling and pest control by other means. These include proper management of crop residues and animal manures, green manure crops, crop rotations, and use of nonsynthetic fertilizers and pesticides. The productivity of any agricultural system, organic or chemical, depends primarily on the level of available and applicable inputs in accord with climatic, soil, and cropping considerations.

The growing interest in organic agriculture reflects an ideology shared by many urban and rural people, that is, that a stable and sustainable agriculture can be attained only through the development of technologies that are less demanding of nonrenewable resources, less exploitive of our soils, and at the same time environmentally and socially acceptable. It was because of these interests and concerns that the U.S. Department of Agriculture decided to conduct a comprehensive study of organic farming in the United States. In April 1979, Dr. A. R. Bertrand, Director of Science and Education, USDA, designated a coordination team for organic farming and the study was begun (3).

1.2 NATURE OF THE STUDY

1.2.1 Objectives

The objectives of the study were to:

1. Conduct selected case studies of organic farmers and review published technical reports to inventory and assess the activity of organic farming in different parts of the United States.

2. Investigate the reasons why farmers turn from conventional practices to organic farming and vice versa.

3. Determine the information needs of, and technological barriers to, successful and profitable organic farming.

4. Assess the economic impacts, costs, benefits, and problems associated with organic farming.

5. Identify the research and education programs currently underway which support organic farming and inventory the extent of this level of activity.

6. Determine research and education programs needed by organic farmers and recommend plans for action and implementation.

This report defines and describes organic farming; addresses some concerns of organic proponents; and evaluates the advantages, limitations, and opportunities for organic farming as an option in U.S. agriculture. An appraisal is made of current USDA research and education programs which impact upon organic farming, and recommendations are offered for new programs that would further our knowledge and support of organic farming.

1.2.2 Methods

Information was obtained from interviews with organic farmers by use of questionnaires; by specific requests sent to State Cooperative Extension Services and State agricultural experiment stations; and by communication with county agricultural Extension agents; as well as from a Rodale Press survey of organic farmers, a library literature survey, and discussions with colleagues. In September 1979, four members of the study team traveled to Europe and spent a week gathering detailed information on organic farming practices in Germany, Switzerland, and England. In December 1979, one team member spent a week observing organic agricultural practices in Japan.

1.2.2.1 USDA Case Studies -- Team members interviewed 69 organic or combination organic-conventional farmers in 23 states on farms which represented a wide range of climates, soils, and types of agricultural enterprise. The locations of these on-farm interviews, conducted during the summer of 1979, are shown in figure 1.1.

Information was obtained on the background and attitudes of the farmers, farm composition, soil resources, types of crops and livestock grown, crop sequences, tillage methods, production inputs and management practices, and marketing procedures. During each interview, visual observations were made of crop conditions, including stands, growth, and degree of weed and insect infestations.

Farmers were selected for these case studies through contacts with one or more of the following: Land-grant universities, the State Cooperative Extension Service, organic producer associations, publishers of organic literature, and commercial companies that deal with organic growers. Most of the farmers selected met preestablished criteria of having farmed organically for 5 or more years, and of earning 50 percent or more of their income from the farm operation. Prior to each interview, team members contacted the agricultural Extension agent in the appropriate county and invited him to attend. In most cases, the county agents were receptive to the invitation and helpful during the interview. The farmers interviewed were not necessarily representative of all organic farmers but more probably of the more successful members of this group. Since the purpose of the study was to estimate the prospects for future success of organic farming, this selection process is considered to be not unreasonable.

1.2.2.2 Information Requests -- The Cooperative Extension Service in each State was contacted by mail for information on the current level of organic farming activities in their State, and for research data associated with organic farming systems, including recycling of organic materials, energy and labor requirements, and marketing methods. Information was also sought on studies of long-term soil fertility and soil nutrient depletion trials.

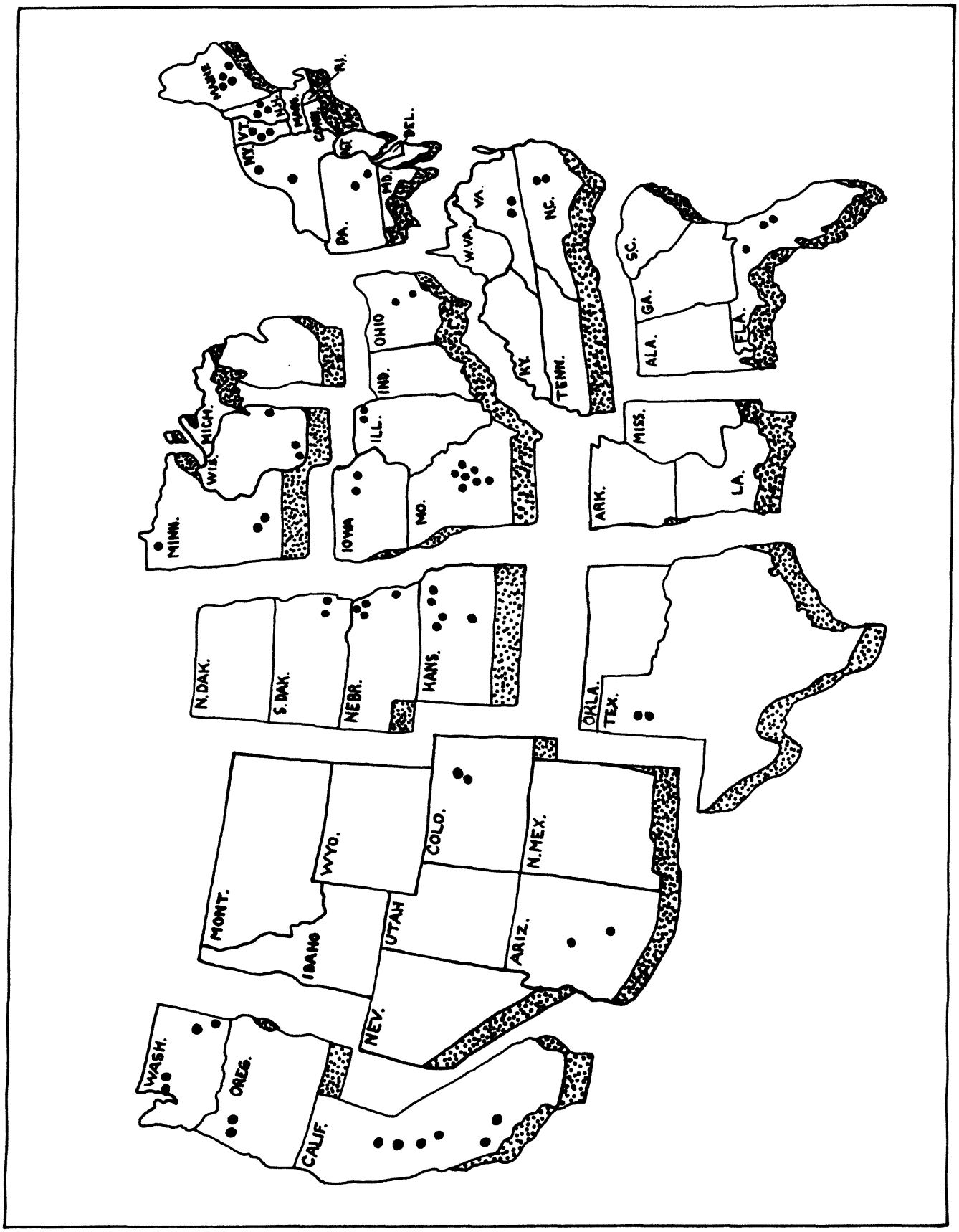


Figure 1.1 Locations of on-farm interviews in the USDA case studies

Questionnaires were also sent to program leaders in the State Cooperative Extension Services, and to appropriate agricultural departments in land-grant universities of each State for information on ongoing and anticipated research and education programs on organic farming.

1.2.2.3 Rodale Press Survey -- Rodale Press of Emmaus, Pa., very recently conducted a mail questionnaire survey of subscribers to The New Farm magazine, many of whom are "organic" or "combination conventional-organic" farmers. Questionnaires were mailed to 1,000 subscribers and a 70 percent response was obtained. The results were made available to the study team. The questions asked were similar to those used in the USDA case studies and could, therefore, be used to augment the earlier results. In response to the questionnaire, 112 readers identified themselves as "conventional," 95 as "organic," and 204 as "combination conventional-organic" farmers. The remainder were nonfarmers.

1.2.2.4 Study of Organic Farming in Europe and Japan -- Four team members visited several research institutes in Germany and Switzerland where studies on various aspects of organic agriculture are in progress. Field visits were also made to several organic farms, to an organic food processor, and to a machinery manufacturer specializing in equipment for organic farmers. Dr. George C. Cooke, Chief Scientist for the Agricultural Research Council, Ministry of Agriculture, London, briefed the team on the organic farming movement in the United Kingdom. One team member spent a week in Japan with the Nippon Yukinogyo Kenkyukai (Japan Organic Farming Research Institute) observing organic farming enterprises and studying aspects of production and marketing of organically grown fruits and vegetables.

1.2.2.5 Literature Survey -- An in-depth literature search was conducted to gather information on the scientific, historical, and philosophical aspects of organic agriculture. This information was used to provide further insight to field observations and as additional background to support the conclusions and recommendations of this study.

1.2.2.6 The Need for Separate Reports -- A voluminous amount of information was compiled during this study. This abbreviated and condensed version is intended for use primarily by administrators. Where appropriate and necessary, more extensive accounts, including greater detail, data, and references, will be prepared by the individual authors.

REFERENCES

1. Pimentel, D., L. E. Hurd, A. C. Bellotti, M. J. Forester, I. N. Oka, O. D. Sholes, and R. J. Whitman. "Food Production and the Energy Crisis," Science Vol. 182, (1973) 443-449.

2. Risser, J. "Environmental Crisis Down on the Farm," The Des Moines Register. Sept. 10-16 (1978).

3. Bertrand, A. R. "Designation of SEA Coordinator and SEA Coordination Team for Organic Farming." Memo April 16, 1979 to R. Papendick, C. Kraenzle and J. Schwartz. 3 pp.

ORGANIC AGRICULTURE: DEFINITIONS AND PHILOSOPHY

2.1 INTRODUCTION

There is no universally accepted definition of organic agriculture. Some definitions, for example, simply specify a list of allowable practices, thus ruling out various other technologies and general approaches. These so-called negative definitions are most visible in those State and Federal laws and regulations pertaining to the meaning of the word "organic." Other definitions not only address technological and management practices but also include statements on various underlying societal and personal values involving such issues as environmental protection, conservation, and health. To some extent, therefore, the difficulty of defining "organic agriculture" stems from multiple conceptions of its basic character and scope.

Organic farmers use various combinations of technological and cultural practices because of certain underlying values and beliefs. The organic agricultural spectrum ranges from so-called pure organic farming on one extreme to more liberal interpretations of organic philosophy on the other. At this latter end of the spectrum, organic agriculture begins to merge with so-called conventional agriculture. At this point the two systems share many common agricultural practices and organic and conventional farmers express a number of common concerns. Here, the merging and overlapping of the two systems causes some difficulty in arriving at a concise definition for both organic and conventional agriculture.

A common misconception by many people is that today's organic farmers have regressed to agriculture as it was practiced in the 1930's. Consequently, it is often erroneously assumed that the agricultural technologies that were utilized then are sufficient for contemporary organic agriculture. This is not the case. While it is true that some earlier technology and research remains applicable to modern organic agriculture, most of today's organic farmers use modern farm machinery, recommended crop varieties, certified seed, sound livestock management, recommended soil and water conservation practices, and innovative methods of organic waste and residue management. Moreover, organic farmers have developed systems that are often highly productive despite the avoidance or greatly restricted use of chemical fertilizers and pesticides. Yet, there are problems that could be solved by new research. Thus, the study team has recommended a comprehensive research agenda on aspects of organic farming that will address the needs and problems of this unique method of farming as well as explore the applicability of this knowledge to current problems in conventional agriculture.

This section (a) selectively reviews various definitions and tenets of organic agriculture and (b) defines the term "organic" as it is used in this report.

2.2 FORMAL DEFINITIONS

Three States, Oregon, Maine, and California, and at least one Federal regulatory agency, the Federal Trade Commission, have recently developed formal (legal) definitions of organic agriculture. Because of their similarity, only the California law will be used to illustrate (a) the nature of a negative or restrictive definition of organic farming, (b) some of the issues surrounding the word "organic," and (c) that a formal definition of the word "organic" does not resolve the debate. Many people in the organic food production and distribution system continue to oppose various aspects of these formal definitions.

The California Organic Foods Act of 1979 suggests that the word organic applies to food which is "naturally grown," "wild," "ecologically grown," or "biologically grown," as well as that which is "organic" or "organically grown."

According to the California law, foods bearing the above labels must meet the following requirements:

(1) "Are produced, harvested, distributed, stored, processed, and packaged without application of synthetically compounded fertilizers, pesticides, or growth regulators.

(2) Additionally, in the case of perennial crops, no synthetically compounded fertilizers, pesticides, or growth regulators shall be applied to the field or area in which the commodity is grown for 12 months prior to the appearance of flower buds and throughout the entire growing and harvest season of the particular commodity.

(3) Additionally, in the case of annual crops and 2-year crops, no synthetically compounded fertilizers, pesticides, or growth regulators shall be applied to the field or area in which the commodity is grown for 12 months prior to seed planting or transplanting and throughout the entire growing and harvest season for the particular commodity" (1).

After stipulating this list of prohibitions, the California legislators further delineated those technologies and management practices allowable under the Act as follows:

"Only microorganisms, microbiological products, and materials consisting of, or derived or extracted solely from plant, animal, or mineral-bearing rock substances, may be applied in the production, storing, processing, harvesting, or packaging of raw agricultural commodities, other than seeds for planting, in order to meet the requirements of this subdivision. However, before harvest, the application of Bordeaux mixes and trace elements, soluble kelp, lime, sulfur, gypsum, dormant oils, summer oils, fish emulsion, and soap are permitted, except the application of aromatic petroleum solvents, diesel, and other petroleum fractions, used as weed or carrot oils, are prohibited" (2).

The Act further specifies:

(1) That its passage neither denies or confirms the notion that organic foods are in any way superior to conventionally produced food,

(2) That any chemicals or drugs used in the production of meat, poultry, or fish to stimulate or regulate growth, or for the treatment of disease, may not be "introduced within 90 days of the slaughter of such animal...," (The time restriction is 30 days for milk-producing animals.)

(3) That foods with pesticide residues "in excess of 10 percent of the level regarded as safe by the Federal Food and Drug Administration" may not be labeled as organically grown,

(4) Strict and clear labeling requirements for both organically grown and processed foods,

(5) That growers keep accurate 2-year records of their management practices, and

(6) That processors and manufacturers must keep accurate 2-year product records, including the names and addresses of sellers.

In a general sense, the California law divided organic proponents into two camps. Those who feared that the law was so strict that many organic farmers would be unable to survive were aligned against those who argued that the bill was so badly watered down that "agribusiness interests will be able to pass-off their chemically grown produce as organic" (3). Setting a 12-month prohibition against the prior use of chemical fertilizers or pesticides was, for example, a major point of dispute. Some organic certification groups and organic food suppliers already require much longer periods. Some organic carrot growers opposed the bill's ban on use of carrot or weed oil. Given the difficulty of growing carrots organically, these producers insist that such technology is needed to control weeds. The outlawing of urea was an equally divisive issue. Some growers say that its use is absolutely essential while others view it as incompatible with organic technology. There was also some concern that local growing conditions (soil, climate, and crops produced) could markedly influence the degree of organic purity obtainable. This raises still further unresolved questions regarding the definition and meaning of "organic agriculture."

The California law also depicts what might be called "pure" organic farming. For example, synthetically compounded fertilizers, pesticides, and growth regulators are banned entirely. Many organic farmers insist on achieving at least the level of purity stipulated in the California law. Clear standards, it is argued, are essential to the growth of the organic foods industry. Many believe that consumer confidence in organic foods depends upon the enforcement of strict certification requirements.

For some organic farmers, any deviation from these standards also violates their personal values and beliefs about farming. In other words, some organic farmers follow these strict standards out of personal commitment, as well as for market considerations.

2.3 THE ORGANIC SPECTRUM: SOME ADDITIONAL CATEGORIES

Not all organic farmers adhere to the allowances and prohibitions set forth in the California law. For example, instead of totally excluding any use of synthetic pesticides, some organic farmers might, if absolutely necessary, use such substances selectively and in limited amounts. Some organic farmers, while rejecting synthetic pesticides, would not hesitate to use limited amounts of synthetic fertilizers if needed. Still others might follow pure organic technology on part of their land while farming the remainder with conventional methods. Finally, some use commercial "organic" products while others rely solely on traditional organic inputs such as manures and legumes for plant nutrients, and crop rotations and cultivation for plant protection. These combination organic-conventional farmers form an important part of this study.

2.4 ORGANIC AGRICULTURE: SOME BASIC TENETS

Despite the range of agricultural practices followed by organic farmers, most of them are guided by certain basic values and beliefs which may be called the "organic ethic." Some of the principal tenets of this ethic are summarized below. However, not all organic farmers would place equal weight on these tenets.

Nature is Capital -- Energy-intensive modes of conventional agriculture place man on a collision course with nature. Present trends and practices signal difficult times ahead. More concern over finite nutrient resources is needed. Organic farming focuses on recycled nutrients.

Soil is the Source of Life -- Soil quality and balance (that is, soil with proper levels of organic matter, bacterial and biological activity, trace elements, and other nutrients) are essential to the long-term future of agriculture. Human and animal health are directly related to the health of the soil.

Feed the Soil, Not the Plant -- Healthy plants, animals, and humans result from balanced, biologically active soil.

Diversify Production Systems -- Overspecialization (monoculture) is biologically and environmentally unstable.

Independence -- Organic farming contributes to personal and community independence by reducing dependence on energy-intensive agricultural production and distribution systems.

Antimaterialism -- Finite resources and Nature's limitations must be recognized.

In summary, organic farmers seek to establish ecologically harmonious, resource-efficient, and nutritionally sound agricultural methods.

2.5 ORGANIC FARMING: ITS MEANING IN THIS REPORT

The analysis of organic farming presented in this report encompasses the entire spectrum of organic agriculture. Case study interviews, the Rodale Press survey, and the literature of organic agriculture all reflect the various combinations of organic practices and beliefs. Thus, for the purpose of this report, the following definition of organic agriculture will be used.

Organic farming is 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.

REFERENCES

1. California Assembly Bill No. 443, Chapter 914, Section 4. September 1979.

2. Ibid.

3. "Industry Divides on 'Organic' Issue," Natural Food Merchandiser. May 1979.

CURRENT STATUS AND CHARACTER OF ORGANIC FARMING IN THE UNITED STATES

3.1 BACKGROUND INFORMATION

Information is limited on the number, geographic distribution, farm ownership characteristics, and other vital statistics of organic farmers. The USDA case studies and the Rodale Press survey provide information on these characteristics; however, these two data sources are not necessarily representative of organic farmers generally. The case studies were not randomly selected. The Rodale survey is based on a random sample of The New Farm readership and is not necessarily representative of the total population of organic farmers. The Rodale respondents seemed to represent smaller scale organic producers than the organic farmers in the case studies. Despite these limitations, the data provide considerable information on organic farmers in the United States.

3.1.1 Numbers of Farms

Knowledgeable observers have previously estimated that there are about 20,000 organic farmers in the United States. The Rodale Press survey indicates that this may be a conservative number. The Rodale sample consisted of 1,000 randomly selected subscribers to The New Farm magazine out of a readership of 80,000. Of 679 respondents, 95 identified themselves as purely organic farmers. This gives an estimate of 11,200 (that is, 80,000 x 95/679) purely organic farmers among the readers of The New Farm. Extrapolating the 204 respondents who identified themselves as combination conventional-organic farmers (that is, those who may only farm a portion of their land organically, or apply only some aspects of organic technology and management) gives an estimate of 24,000 such farmers within the readership of The New Farm. Because it is unlikely that all organic or combination type farmers subscribe to the The New Farm, it is reasonable to assume that there is a much larger number of such farmers in the United States.

3.1.2 Geographic Distribution

Organic agriculture is practiced in all regions of the United States. However, it was difficult to locate organic farmers for case studies in parts of the Southern United States (see fig. 1.1); from this, the team concluded that there are fewer organic farmers in the South than in other regions. Several sources indicated that climatic, soil, insect, and market factors limit organic farming in the South. The Rodale survey generally confirmed this pattern. For example, among the The New Farm readership, 60 percent of the organic respondents resided in the Northeast, Lake States, or Corn Belt regions.

3.1.3 Farm Size

Organic agriculture is being successfully practiced on a wide range of farm sizes. While many organic farmers do manage relatively small operations, our study confirmed that organic technology is feasible on relatively large farms. For example, several case studies examined farms of 300-500 acres in size on which no synthetic chemical fertilizers or pesticides were used. One farm in Texas of 1400 acres was operated with only organic technology and cultural practices. The Rodale survey revealed that 11 of the 95 purely organic respondents are farming over 100 acres; two indicated farm sizes of over 500 acres.

Combination conventional-organic farmers manage even larger operations. For example, the study team interviewed one farmer with over 6,000 acres and eight with

farms in excess of 1,000 acres. Of the 204 combination-type farmers in the Rodale survey, 44 reported farms in excess of 100 acres and 4 with 500 acres or more.

3.1.4 Farm Ownership Characteristics

In the USDA case studies, a high percentage of the organic farmers studied owned either all or most of the land they farmed. For example, 53 percent of these farmers owned all of their land.

The Rodale survey revealed that 79 percent of purely organic, and 72 percent of the combination conventional-organic farmers owned 100 percent of their land. Only 50 percent of the conventional farmers in the same survey owned 100 percent of their land.

3.1.5 Age and Farming Experience

Most of the organic farmers in the case studies were highly experienced farm operators and were evenly distributed in all age categories. For example, 42 percent were 50 years of age or older; 10 percent were 65 or older. Eighty percent of the case study respondents had at least 8 years of farming experience and 44 percent had 30 or more years of experience. The Rodale survey revealed a similar pattern; 27 percent of the purely organic farmers had 20 or more years of farming experience; nearly 38 percent of the combination-type farmers had farmed for 20 years or more.

3.1.6 Educational Background

Data from both the USDA case studies and the Rodale Press survey indicate that organic farmers are, as a group, well educated. Over 50 percent of the case study farmers had attended college. Similarly, the Rodale survey showed that nearly 50 percent of the purely organic farmers had attended college, while 13 percent held college degrees and 8 percent had earned a graduate school degree. The combination-type farmers in the Rodale survey displayed a similar educational pattern.

3.1.7 Motivations for Farming Organically

Farmers are motivated toward adoption of organic methods by a wide range of contributing factors. Both the case studies and the Rodale survey revealed similar reasons for farming organically or for shifting from chemical to organic farming methods. Soil health, food safety, environmental protection, and soil and water conservation were primary considerations. Other frequently stated motivations included the belief that organic agriculture produces food of superior quality and protects human and animal health.

3.1.8 Other Characteristics

The study team found that the organic farmers interviewed were generally good managers dedicated to responsible husbandry of their soil, crops, and livestock. A common goal was to develop practices that are less exploitive of nonrenewable resources and which would sustain agricultural production indefinitely and with good economic return. With few exceptions, they were following acceptable soil, water, and energy conservation practices. These farmers also place a very high value on environmental quality.

3.2 CROP PRODUCTION

3.2.1 Cropping Practices

A legume-based rotation with green manure or cover crops was an integral part of the management system on most of the organic farms studied. Legume crops frequently comprised 30 to 50 percent of the cultivated acreage. However, in some cases legumes were not used; for example, on vegetable farms receiving heavy applications of manure and in low rainfall areas. Other crops in the rotation were generally similar to those grown on neighboring farms. However, in areas where farm size was smaller, organic farmers seemed more inclined than their neighbors to produce vegetable crops for fresh markets.

The Rodale survey disclosed that about 50 percent of the farmers grew legume hay, mixed hay, or pasture in their rotations. A high percentage (50 percent) of these organic farmers were vegetable and/or small fruit producers that grew only limited amounts of small grains and cultivated field crops. As the farm size increased, the percentage of farmers growing meadow increased sharply (15 percent for farms of 9 acres or less, 71 percent for farms of 100 acres or more). The survey also showed that the percentage of farmers growing vegetables and small fruits decreased sharply with increasing farm size. These data emphasize the importance of legumes in rotation with small grains and cultivated field crops on organic farms.

Organic farmers on non-irrigated land followed crop rotations similar to those used on farms 30 to 40 years ago. A typical pattern was to follow a heavy green manure crop with a high nitrogen-demanding crop such as corn, sorghum, or wheat. For example, in a corn-soybean area such as the Midwest a rotation might be: oats - 3 years of alfalfa - corn (or wheat) - soybeans - corn - soybeans. On more productive soils, there might be an additional corn or wheat and soybean crop after 3 years of alfalfa. Vegetable crops grown with or without legumes are rotated so that the same crops are not followed sequentially. Organic vegetable farmers alternate deep and shallow rooted crops, root crops, and above-ground crops throughout the growing season by careful crop selection and consideration of planting and maturity dates. Organic farmers using irrigation often did not follow rotations systematically but instead based their cropping patterns on short-term demand for produce, plant disease problems, and availability of land and water.

Most of the organic farmers who were interviewed used recommended crop varieties and certified seed. However, some of them questioned the adaptability of those varieties for their particular soil and crop management systems because they were selected for performance in chemical-intensive systems.

3.2.2 Cultural Practices

Most of the organic farmers had either never used a moldboard plow or had shifted to chisel or disk-type implements as the primary tillage tool. Many also favored shallow tillage (no deeper than 3 to 4 inches) which mixes the soil but does not invert it. They reasoned that plowing disrupts the established and active microflora near the surface and places the organic materials at greater depths where conditions are less favorable for decomposition and release of plant nutrients. They also believed that fewer weed seeds would be brought to the surface for germination. Shallow incorporation of organic materials by disking or chiseling would maintain an active amount of organic matter near the surface where it is most beneficial for improving

surface conditions. This transition from the plow to other tillage implements, however, is not unique with organic farmers since plowing as a primary tillage practice is decreasing because of increased use of conservation tillage.

Seedbed preparation, planting and harvesting techniques, or equipment used by organic farmers did not differ greatly from those of their conventional neighbors. However, most of the organic farmers stressed the importance of proper timing of tillage and planting for weed control and maintenance of good soil tilth. Without herbicides, an extra one to three cultivations were required for weed control. Delayed planting was another technique used to control weeds. This would also allow increased time for mineralization of organic matter and release of plant nutrients. Farmers who used delayed planting said that it did not affect their crop yields.

Large-scale organic farmers appeared generally satisfied with types of machinery that were commercially available. Small-scale organic farmers indicated the need for smaller, less sophisticated equipment which would be more adaptable and economical for their operations. Often the equipment that they desire is not available from U.S. equipment manufacturers. Therefore, the farmer must either overhaul or rebuild older machines to meet his needs, or obtain equipment from nondomestic dealers.

3.2.3 Soil and Water Conservation

The case studies pointed out that organic farmers are strongly committed to soil and water conservation and used the latest and best technology available to control runoff and erosion. Terraces, grassed waterways, stripcropping, and contour farming were commonly used and we saw little evidence of erosion on these farms. Critical areas such as steep slopes or shallow soils were usually maintained in sod. Most of the farmers said that since they had converted to organic methods infiltration was noticeably improved, and there was more water available for crops.

3.2.4 Application of Plant Nutrients and Organic Matter

Animal manure, crop residues, nitrogen symbiotically fixed in association with legumes, organic fertilizers, and to a much lesser extent synthetic fertilizers were the chief sources of plant nutrients and organic materials utilized on the organic farms. There was very little use of other materials such as sewage sludge, septage, or processing wastes by the farmers in either the USDA case studies or the Rodale Press survey.

3.2.4.1 Supply of Nitrogen, Phosphorus, and Potassium -- Organic farmers are concerned with maintaining an adequate supply of nitrogen for their crops. The nitrogen (N) is obtained chiefly from legumes, animal manure, crop residues, and to a limited extent from organic and inorganic fertilizers applied as a supplement for high N use crops. Organic fertilizer sources included leather dust (10-0-0) and cottonseed meal (7-2-1). A few farmers occasionally use ammonium sulfate (21-0-0) but at relatively low application rates (for example, never more than 50 pounds of N per acre.)

Rock phosphate and greensand (unprocessed glauconite) are acceptable sources of phosphorus (P) and potassium (K), respectively, used by organic farmers. The study team found that, with the exception of a number of farms in the Northeast Region, only a few farmers were applying any mineral sources of phosphate. Those who did were applying ground rock phosphate to a limited acreage at rates of 500 to 1,000 pounds per acre. The Rodale survey showed that only about one-third of both the conventional and organic groups used rock phosphate.

Acidulated rock phosphate (processed phosphatic fertilizers) was used by a few farmers in situations where rock phosphate was not marketed, or where crops did not seem to respond well to rock phosphate. In several cases bonemeal (2-25-0) was used as a phosphate source.

Very few farmers in either study applied any form of mineral K. In the USDA case studies, only two or three farmers were using greensand, though in limited quantities. A few were applying a product labeled Sul-Po-Mg (sulfate of potash-magnesia) which is about 19 percent K. Some were using wood ashes (0-0-5). Only rarely did farmers use muriate of potash, i.e., KCl (0-0-60) on soils with severe K deficiency.

Some farmers, largely in the Northeast States, were using lime in limited quantities to increase soil pH. About 50 percent of both the organic and conventional farmers in the Rodale survey used lime in their farming operations.

3.2.4.2 Manure -- Most of the livestock manure generated on organic farms was applied to the land. In some cases where livestock numbers were limited, imported manure from outside sources such as feedlots or packing plants was utilized. Sometimes there was a charge for the manure (for example, $1 per cubic yard for chicken manure) in addition to transportation costs.

Many farmers were using composted or partially composted animal manure. Several had developed their own composting systems using windrows and turning machines but often the manure was merely stockpiled for several months without treatment. Some farmers purchased composted manure from commercial processors. The reasons given for composting were to (a) facilitate handling of manure, (b) reduce bulk, N loss, and nutrient tieup following application, (c) kill weed seeds, pathogens, and insects, and (d) preserve the manure during storage until a time when application was desirable or feasible.

3.2.4.3 Crop Residues -- A standard practice on most of the organic farms was to return the crop residues to the soil. Only occasionally were the residues harvested for feed or grazed. In some cases animals were not allowed on the cropland because of a standing green manure crop or because of concern for soil compaction by animal traffic.

3.2.4.4. Chemical Fertilizers -- Most of the organic farms used no chemical fertilizers. Those that did used fertilizers conservatively and as a supplement to, rather than a primary source of, plant nutrients. For example, they might use low rates, apply the fertilizer infrequently or to limited acreage (e.g., on leased land because of landlord insistence). During the transition from conventional to organic farming, some farmers continued to apply limited amounts of commercial fertilizer until soil fertility could be maintained with organic nutrient sources. Low analysis fertilizers were preferred over concentrated forms. For example, organic farmers almost universally opposed the use of anhydrous ammonia or acidulated phosphates, although some accepted ammonium sulfate and most accepted rock phosphate. Many organic farmers believe that repeated applications of concentrated nutrient sources are ecologically disruptive to soil organisms and lead to nutrient imbalances and decline of tilth.

The Rodale survey showed that 80 percent of the organic farmers did not use any type of chemical fertilizer, whereas more than 50 percent of the conventional farmers applied fertilizers on 75 to 100 percent of their crop and pasture land. About 10 percent of the organic farmers used chemical fertilizers sparingly on limited acreages.

3.2.4.5 Other Products -- A considerable number of farmers regularly applied seaweed and fish emulsion products foliarly to a wide variety of field and vegetable crops. Users were convinced that these products provided essential minerals and elements for plant growth and plant protection, and benefited crop yield and quality but were not able to give a dollar value assessment.

A rather high percentage of the organic farmers contacted were either using or had used various commercial products (nontraditional soil and plant additives) marketed as soil humates, microbial fertilizers, microbial inoculants (excluding *Rhizobium* preparations), soil (microbial) activators, soil conditioners, and plant growth stimulants in their farming operations. The Rodale survey showed that 20 percent of both the organic and conventional farmers were using these products. Some of the farmers that we interviewed believed the materials were beneficial during their transition from chemical to organic farming but were not needed after a full rotation cycle. Others discontinued their use after several years of experimentation because of no beneficial results and high costs.

Some of those products are marketed in accordance with a prescribed management program for long-term soil improvement. However, only a few of the organic farmers we contacted were participating in this type of program.

3.2.5 Pest Control Methods

While weeds, and insects to a lesser extent, were a problem on many of the organic farms, the nonchemical control methods used (cultivation, delayed planting, and roguing) were reasonably effective. Nematodes and plant pathogens did not appear to present any serious threat to the organically managed systems we observed.

3.2.5.1 Weed Control -- Weed control on most farms was achieved primarily by crop rotations, tillage, mowing, and to a lesser extent by selective use of herbicides and hand weeding. Preventive methods were emphasized. Weeds were most difficult to control under high rainfall conditions, during wet seasons, and in close-growing crops (for example, cereals) that could not be mechanically cultivated. Organic farmers were achieving successful weed control by diligent application of such methods as timely tillage, delayed planting, crop sequence selection to prevent weed establishment, and weed sanitation. Some of the farmers also contended that weed problems were most serious during the early stages of transition from chemical to organic methods, and that infestations subsided once the rotational cycle was established.

Some organic farmers used herbicides selectively and sparingly, for example, to control localized weed patches, to support mechanical and cultural methods, or as a last resort to salvage a crop when all else failed.

Only 14 percent of the organic farmers in the Rodale survey used herbicides, compared with 81 percent for the conventional farmers. The small-scale farmers in both groups either avoided herbicides entirely or used them minimally.

3.2.5.2 Insect Control -- Organic farmers tended to avoid synthetic chemicals for insect control; however, some would use them occasionally, but selectively, to counter epidemic infestations or to control specific insects. The Rodale survey showed that only 16 percent of the organic group used insecticides and on a very limited acreage. Approximately 70 percent of the conventional group used insecticides and treated a rather large portion of their acreage.

Most farmers in our study felt that insect pests were adequately controlled in field crops by selective rotations and natural insect predators. Farmers experienced greater difficulty in controlling insects in vegetable and orchard crops with nonchemical methods. Growers generally favored combinations of organic insecticides and biological methods of pest control.

Several growers indicated that populations of beneficial predator insects, including ladybird beetles, had increased in their fields since they converted to organic farming and ceased using pesticides. There was a strong consensus that long-term and heavy application of insecticides had eliminated many natural insect predators, thus making nonchemical control of certain insects more difficult.

3.2.6 Crop Yields and Quality

3.2.6.1 Crop Yields -- In the USDA case studies, most of the farmers with established organic systems reported that crop yields on a per-acre basis were comparable to those obtained on nearby chemical-intensive farms. A small number of farmers were divided between those who believed their yields with organic methods were 10 to 20 percent higher and those who believed their yields were 10 to 20 percent lower, compared to chemical-intensive farms. This finding is almost identical to that of the Rodale survey.

Crops that respond to high N rates, such as corn, wheat, and potatoes, are most likely to have lower yields when grown in organic systems than when grown with chemical fertilizers, unless nutrient requirements for high yields are met with manure or other organic sources. Yields of other crops such as alfalfa, soybeans, and oats, which are less responsive to N, are likely to be the same or even higher than yields from conventional or chemical systems. A consensus among organic farmers in the Midwest was that yields from organic systems were often higher than yields from conventional in dry years, comparable in normal years, and lower in high-moisture years. Farmers who had previously farmed conventionally reported that crop yields were often markedly reduced during the first several years following the shift from chemical to organic farming. During this transition, severe weed infestations often occurred and crops were sometimes difficult to establish. Occasionally the crops showed symptoms of nutrient deficiency. Farmers said that after the third or fourth year, as the rotations became established, yields began to increase and eventually equalled the yields they had obtained chemically.

3.2.6.2 Crop Quality -- Many farmers interviewed in the USDA case studies felt that organic methods had little effect on improving crop quality. Some, however, strongly believed that a significant improvement in crop quality was obtained with organic farming methods, citing higher grain test weights, improved flavor of meat products, and higher quality forages for consumption by livestock.

3.2.6.3 Food Quality -- According to the Rodale Press survey, 62 percent of those interviewed felt that food produced with organic methods has a higher nutritional value than food produced with conventional farming practices. Approximately 20 percent had no opinion one way or the other, while 18 percent believed that organically grown food was not nutritionally superior to conventionally grown food.

3.3 ANIMAL PRODUCTION

Livestock comprise an essential part of most organic farms, especially on the large full-time family farms in the grain producing areas. Fewer animal units are likely to be found on mixed field crop/vegetable farms or in the absence of a

balanced production of hay and feed grains. Based on frequency of occurrence, the animals found on organic farms generally followed a decreasing order of beef cattle, dairy cows, hogs, sheep, and, to a much lesser extent, poultry.

Most of the organic growers preferred to produce feed for animals on their own farms and not to rely on outside sources. Many continually strive to achieve a balance between the production of hay and grains and the animal enterprise. For example, in a beef cow/feeder operation, if corn or other feed grain was produced in excess to hay and forages, hogs might be raised to consume the excess grain. Where feed was purchased to supplement on-farm grain and forages, the farmers usually preferred organically grown feeds over those produced conventionally. With very few exceptions, the organic farmers in our studies did not use hormones, growth stimulants, or antibiotics in their feed formulations. However, some farmers used antibiotics as needed for treatment of sick animals. A number of farmers reported that with previous chemical-intensive programs they had often incurred a higher rate of birth mortality, decreased reproductive efficiency, and increased respiratory ailments among their livestock, resulting in lower production, and higher veterinary costs.

The organic farmers did not appear to "push" their animals in the feeding programs. That is, they did not appear to strive for the highest possible rate of gain and to market the animals in the shortest possible time.

3.4 MARKETING

Most of the organic farmers in the USDA case studies sold all or a large part of their produce through conventional marketing channels. Less than 30 percent marketed most of their farm products as organic produce. The organic produce was marketed in several ways, including sales to local organic food cooperatives, organic wholesalers, organic retailers (such as natural or health food stores), or directly to consumers. Some farmers, especially on small farms, sold directly to consumers through roadside stands or through pick-your-own and pre-pick (farmer picks quantity ordered by individual consumers) operations, or through farmers' markets. More than 20 percent of the organic farmers sold nearly all of their organic products to wholesalers. However, more farmers sold directly to consumers than to wholesalers or retailers.

The organic farmers in the case studies indicated marketing to be a major problem. Some farmers near populated areas and along major highways could set up roadside stands, have consumers pick their own produce, or sell to local markets, thereby avoiding high transportation costs. These farmers had considerable economic advantage over farmers located at greater distances from markets. For example, an organic producer at a more remote location said that he spent 20 to 30 percent of his time marketing his organic produce.

In the Rodale Press survey more than half of the totally organic farmers marketed all their produce through conventional channels. Of those remaining, about half marketed 50 percent of their produce as organic. A few respondents indicated they had reduced or ceased organic production because they could not find markets for their products. Only about 23 percent of the combination conventional-organic farmers marketed some of their organic produce as organic.

Whether or not an organic farmer sells organic produce as "organic" is determined mainly by whether there is a premium price for the product and how much greater it is than the conventional market price. The premium price in turn reflects demand for the product. A relatively low percentage of the farmers that we interviewed were

receiving a premium price for certain produce, mainly vegetables and meat, from 10 to 50 percent above the conventional market price. A premium price almost always involved direct marketing to consumers.

The Rodale Press survey showed that only 20 percent of the organic and combination respondents received a premium price for organically grown products. Only 6 percent of the totally organic farmers reported receiving a premium price on all of their organic products. The price premium varied in amount and by commodity, but it was usually less than 10 percent above conventional market price. The survey suggested that organic vegetable and meat producers have a better chance of receiving a price premium, and a larger one, than the organic fruit, grain and cereal, or dairy producers.

3.5 GROWER AND MARKETING ORGANIZATIONS

Organic growers are organized mainly into State and regional groups, or associations with representation extending into all areas of the United States. There is no national organization of producers at this time. Currently, there are about 35 regional organic farming groups that are active in 29 States. The purpose of these organizations is to provide for information exchange among the members, and to help certify, inspect, market, and distribute organically produced crops in every area of the Nation.

The wholesale and retail distribution system for organic foods has also grown markedly in recent years. There are currently 6,500 full-line health food stores in the United States. The health food industry is supplied by approximately 1,000 manufacturers and distributors. Such companies provide products directly to wholesalers as well as to retail outlets. These manufacturers and distributors market one or more products, ranging from organically grown grains to vitamins. The size of the overall production and distribution system has experienced steady growth since 1970.

The International Federation of Organic Agriculture Movements (IFOAM) was formed in 1972 to serve as an international communicator as well as a coordinator of organic farming developments. IFOAM publishes a highly informative quarterly bulletin in English, French, German, and Spanish, which contains information on various developments of interest to organic agriculture. According to one bulletin, "the function of the Federation is to be a network for the diverse bodies concerned for the ecological development of agriculture in all nations." Currently, IFOAM is comprised of some 80 member groups in 30 nations. Individual memberships total approximately 40,000.

3.6 ORGANIC AGRICULTURE IN EUROPE

From September 16-26, 1979, four members of the study team interviewed a number of organic farmers, organic farming researchers, and government officials in West Germany, Switzerland, and England. A great deal was learned as a result of these interviews and onfarm tours. In general, the team was impressed with the high degree of similarity between the United States and Europe regarding organic technology and cultural practices, the number of organic practitioners, levels of governmental and university support of organic agriculture, organic marketing and certification arrangements, and the motivations of organic farmers. A partial summary listing of some of the team's specific findings and conclusions follows:

(1) Although accurate data do not exist, pure organic farmers probably represent fewer than 1 percent of the total number of European farmers.

(2) The number of European farmers who are now attempting to reduce their use of synthetic chemical fertilizers and pesticides is sharply increasing. While rising costs appear to be a major motivation, increasing concern about possible environmental degradation and impairment of health is also evident.

(3) At present, there is relatively little governmental and university funded research on organic agriculture; however, interest in organic farming is definitely increasing, as is support for research. For example, a growing number of such researchers are now collaborating with the Institute of Biological Husbandry at Oberwil, Switzerland.

(4) Governmental extension activity in organic farming is rare.

(5) University level courses in organic farming are rare.

(6) Certification of organic farmers is done by producer organizations.

(7) European organic farmers are motivated by many of the same factors as their American counterparts. They are, for example, concerned about the environment, soil, water, and energy conservation, self sufficiency, soil life, and human and animal health.

(8) There are several philosophical schools of thought on organic agriculture in Europe.

(9) In most of Europe, integrated pest management is in its embryonic stages.

(10) In most European countries, consumer interest in the quality of food as well as various environmental issues is increasing.

(11) In some parts of Europe, so-called conventional agriculture exhibits many of the characteristics of organic farming as we see it practiced in the United States. For example, the Swiss conventional system relies heavily upon various organic technologies and cultural practices.

3.7 ORGANIC AGRICULTURE IN JAPAN

One member of the study team on organic farming was in Japan during December 1-7, 1979, where he consulted with officials of the Japanese Organic Farming Research Institute (Nippon Yukinogyo Kenkyukai) on aspects of the organic farming movement there.

Prior to World War II there was only limited use of chemical fertilizers and pesticides in Japan. Most Japanese farmers relied mainly on recycling of organic

wastes and residues, often as composts, for plant nutrients. After the war, however, the Government (Ministry of Agriculture and Forestry) placed strong emphasis on the use of agricultural chemicals to achieve maximum production of food and fiber. At that time, the importance of composts was discounted and farmers were told that there was little benefit to be gained from their use. Farmers were encouraged to burn the rice straw which ordinarily would have been used for composting, and to mechanize, modernize, and decrease the labor intensiveness of their farming operations. It is noteworthy that many farmers have returned to using composts on their land, particularly for production of vegetables.

During the last decade there has been a growing concern about the possible adverse effects of intensive use of agricultural chemicals, especially pesticides, on the environment and on human health. Consequently, the Japanese organic agriculture movement was fostered and has now gained considerable support from both the urban and rural sectors of society and through an organization like the Nippon Yukinogyo Kenkyukai. Rachel Carson's book, "Silent Spring," had a profound influence on getting the organic agriculture movement started in Japan. Undoubtedly, the single most important factor that has motivated this movement has been the concern for effects of pesticides on human health, both from direct exposure to farmers in their use and from consumption of residual pesticides in food.

Some guiding principles and objectives of the organic agricultural movement in Japan include:

1) To achieve self sufficiency;

2) To recycle organic wastes back to the land (cited as being commensurate with Buddhism and its principles);

3) To protect and maintain human health; and

4) To achieve a mutually beneficial relationship between the farmer, the consumer, and the environment.

The importance of a close and cooperative relationship between the farmer and consumer in the production and marketing of organically grown produce was emphasized. One example of this relationship that has become quite popular around large metropolitan areas is the "grower-family subscriber" arrangement. In this case, a farmer may grow fruits and vegetables for 10 to 15 city families throughout the year. The families form a consumer's association and negotiate a contract with the farmer, who agrees to grow produce without chemicals. The families agree to furnish some labor for weeding and cultivating during the growing season. The farmer schedules meetings periodically to inform the subscribers of crops to be grown, planting dates, production schedules, and harvesting dates. He also attempts to accommodate special requests for unusual types of vegetables. The even and guaranteed cash flow from this arrangement is a definite advantage to the farmer. Another example of direct marketing is through organic cooperatives that purchase organically grown produce from farmers and then distribute it to the members.

There is little use, if any, of public funds to support research and education programs on organic farming in Japan. Most of the support for organic farming comes from individual citizens, consumer groups and cooperatives, and from organic farmers. There is strong support from a growing number of medical doctors who are specialists in rural mecicine and who have documented many cases of pesticide poisoning in rural communities.

There has been little or no communication between the Japanese Ministry of Agriculture and Forestry and the Organic Farming Research Institute. Officials of the latter group feel that the Ministry has chosen to ignore the research and education needs of organic farming because of its emphasis on the avoidance or reduction in use of chemicals, which is contrary to government policy. Nevertheless, at a seminar which presented a summary of the USDA organic farming study, officials of these two groups met for the first time ever and engaged in friendly and fruitful discussion. With lines of communication open, it is possible that future meetings will be held to discuss areas of interest and cooperation.

ANALYSIS OF ORGANIC AGRICULTURE: PRODUCTION, ENVIRONMENTAL, AND SOCIOECONOMIC IMPLICATIONS

4.1 PLANT NUTRIENT BUDGET

4.1.1 Nutrient Requirements

There are 16 elements that are known to be essential for crop growth, of which nitrogen, phosphorus, and potassium are most commonly deficient in agricultural soils. Secondary and micronutrient deficiencies have been widely documented in some soils, with sulfur, zinc, and boron being the most common. In order to maintain high crop yields, the additions and release of nutrients, particularly N, P, and K, must be sufficiently great so that the nutrients are always at a level of availability that will not restrict yields.

4.1.2 Nutrient Budget Concept

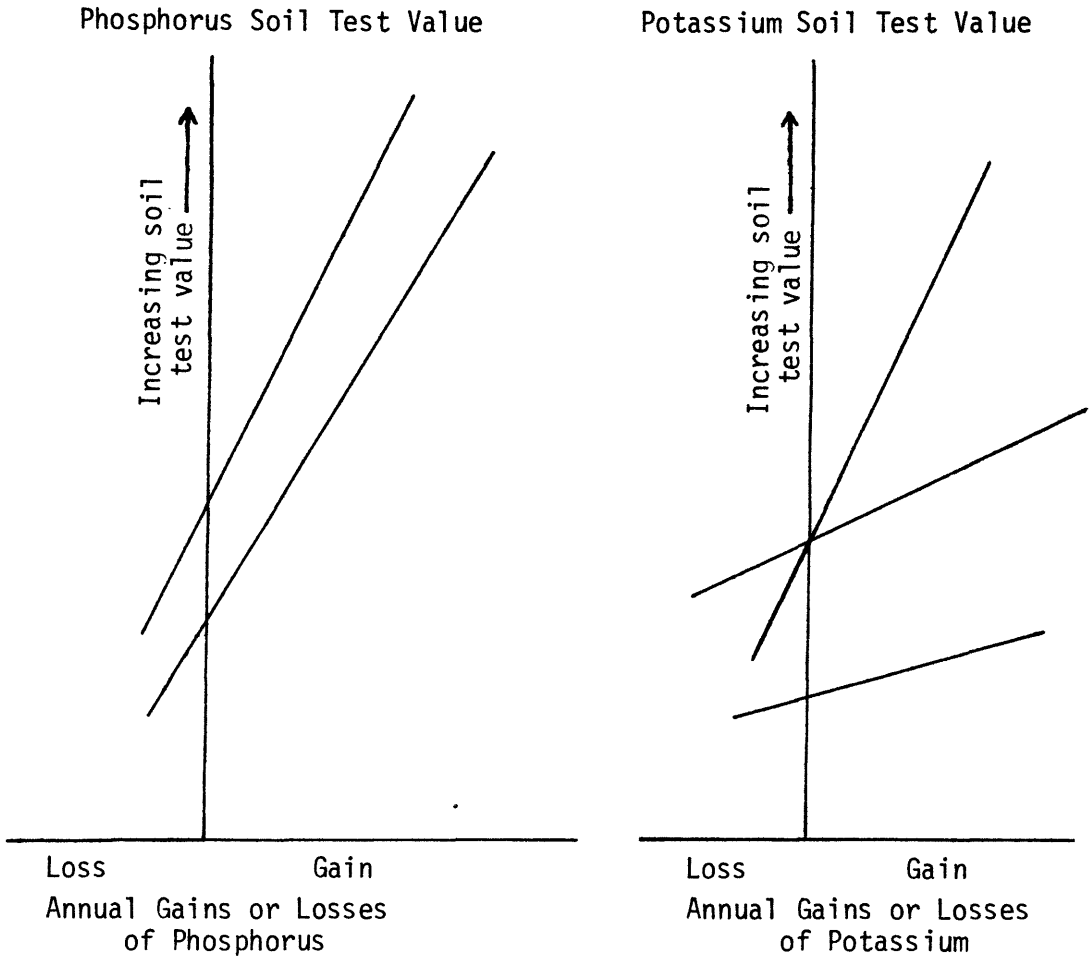
The plant nutrient budget is a key factor in determining potential limits to the productivity of farming systems in general (1) and of systems with limited nutrient input from external sources, including "mixed farming" or "self-sustaining unit" systems (2).

From the nutrient budget standpoint, most organic farming systems represent modifications of the "self-sustaining unit" system. They do, however, range from an almost pure "self-sustaining unit" system to some modification of the "intensive agriculture" system mainly used in Europe, North America, and parts of the USSR and Japan. This latter system is characterized by a continuous and heavy application of commercial fertilizer and a steady removal of crop products from the farm. Basically, the budget involves inputs, transformations within the system, and losses of nutrients from the system (1).

4.1.2.1 System Stability -- A stable and long-term cropping system requires a balance between nutrient inputs and losses. While nutrient cycling occurs, the system has "leaks" which require certain inputs to maintain crop yield levels. Nutrient availability is maintained by energy inputs ultimately derived from photosynthetic processes. Sustained productivity can be achieved by either (a) matching nutrient losses from the cropped area to the rate of nutrient release, or (b) satisfying a projected nutrient deficit with commercial fertilizer or nutrient-rich organic material produced off the site (1).

4.1.2.2 Example -- The nutrient budget concept is illustrated by the following example which shows that the balance between the additions and removal of P and K directly affects their status in the soil as indicated by soil test values. Figure 4.1 shows the longterm effects of gains and losses of P and K on soil test values for several soils (3). For each soil, the greater the accumulation of P and K, the higher the soil test value; while the greater the net loss of P and K, the lower the soil test value. The soil test only reflects part of the budget, since release, fixation, and leaching are not included. The data illustrate differences which exist between soils both in the actual soil test value for a given addition or loss of P and K and the change in soil test that results from annual gains or losses of P and K.

Figure 4.1 Long-Term Rotation Experiments[1]



[1]Based on data from Mattingly and Johnson (3). Each line represents a different site.

4.1.3 Nitrogen

4.1.3.1 Nitrogen Supply -- Organic farmers generally are able to supply a sufficient level of N for moderate to high yield levels by extensive use of symbiotically fixed nitrogen, return of crop residues and animal manures, and proper selection of crops in rotation. Such systems require livestock enterprises to utilize the grain and forage produced and to recycle nutrients within the system. Nutrient recycling on organic farms can be regarded as an energy input similar to the energy consumed in the manufacture and distribution of chemical fertilizers.

The feasibility of using legumes to provide most of the nitrogen for high-yielding corn hybrids is substantiated by studies in several States, but such practices restrict corn acreage. The amount of nitrogen produced by green manure crops is often insufficient to produce maximum yields of crops such as corn. Where factors such as available water limit crop yield, lower N levels may be adequate to meet the lower yield potential.

4.1.3.2 Limitations on Nitrogen Sources for Organic Farming -- Legumes are not well suited as a source of nitrogen in areas of the United States where water supplies are limited. For example, decreased corn yields following alfalfa are commonly observed in the western Corn Belt as a result of insufficient water. For the same reason, wheat in the Pacific Northwest often yields less following a green manure crop than wheat after fallow (4).

Use of off-farm organic wastes as N sources for organic farming is limited by factors of quality, quantity, availability, and cost, according to a recent USDA report (5).

Serious losses of nitrogen often occur during the collection, storage, and application of animal manures, which can greatly decrease their value as a nitrogen source. Nitrogen losses of 50 percent or more have been reported due to improper handling and application methods (5).

4.1.4 Phosphorus and Potassium

4.1.4.1 Two Approaches for Supplying P and K -- The methods used by organic farmers to supply P and K vary greatly, but two fundamentally different approaches can be identified.

The first approach relies on the release of P and K from primary and secondary soil minerals, equilibration reactions between soil particle surfaces and nutrients in solution, and mineralization of organic matter to make up any deficits. Recycling the nutrients through livestock and manure applications to land reduces the deficit, but the P and K budget still remains substantially negative (6). This "deficit" approach includes only minimal attempts to provide supplemental P and K from outside the system, and the long-term effect is one of depleting ("mining") the soil of P and K.

The second approach relies on large-scale "importation" of nutrients from outside the system: (a) in animal feed, (b) as animal manure, or (c) as large-scale use of diverse organic and inorganic nutrient sources. In this latter group, a large number and variety of both mineral and organic materials are applied to the soil, often in amounts far greater than the amounts normally returned as crop residues and manure. In effect, nutrients and photosynthetically derived energy are collected from a larger contributing area and applied to a smaller collecting area. The mineral materials

added in (c) are intended to release P and K slowly from "low availability" sources. This is similar in many ways to some types of organic gardening.

A wide range of organic farming operations exists between these two approaches. However, most can be classified as the "deficit" or the "importation" approach.

4.1.4.2 Replenishment of Nutrients in the Soil Solution -- The replenishment of nutrients in the soil solution, particularly the role of the capacity factors (7), provides a useful way to distinguish between the two approaches to organic farming and between the "deficit" approach and "intensive conventional agriculture" approaches using high inputs of P and K fertilizers.

> "As nutrients are removed from the soil solution, there is a tendency to replace the deficit from solid phase sources. The solution concentration of a nutrient is frequently referred to as an intensity factor and the solid phase sources which resupply the solution are referred to as capacity factors. The capacity factors can be divided somewhat arbitrarily into three categories:"

1) "Those forms which are in rapid equilibrium with the soil solution." Example - exchangeable K and surface P.

2) "Those forms which are in moderate to slow equilibrium (or pseudo-equilibrium) with the soil solutions." Example - "fixed" K and that P which has diffused beneath the surface of sorbing minerals or to the interior of aggregates but can still diffuse back to the surface in a reasonable length of time if the activity gradient is favorable.

3) "Those forms which are not in equilibrium with the soil solution because of the absence of a reverse reaction (nutrients are released but not readsorbed)." Example - release of P by organic matter decomposition and decomposition of minerals formed in a high temperature system.

a. "Deficit" approach -- Few of the organic farmers surveyed in the Midwest attempt to balance the nutrient budgets for P and K by using outside sources of these elements. These observations are in agreement with Lockeretz et al. (8) who estimated an average net deficit per acre of 12 lb of P_2O_5 and 41 lb of K_2O in a study of midwestern organic farms.

The deficit approach relies predominantly on nutrient recycling and release of nutrients from categories 2) and 3) to replace P and K from category 1). For potassium, the problem is whether the lower solution concentration of K necessary for the release of significant amounts of K from categories 2) and 3) will maintain high crop yields. In contrast, with "intensive conventional agriculture," the addition of fertilizer and release of nutrients from organic residues are sufficient to maintain category 1) forms of P and K at levels required for high crop yields. Category 2) and 3) forms generally play a secondary role in supplying P and K.

b. Long-term stability of the "deficit" system -- Extensive recycling of nutrients, through efficient application of manure produced from on-farm feeding of nearly all of the crops produced, will appreciably decrease the P and K deficit. However, the balance will remain negative unless there is considerable release or net withdrawals are decreased. Efficient utilization of manure from the livestock

enterprise can greatly reduce the rate of decline of soil test P and K. Under such conditions, well-buffered soils with high initial P and K status may supply adequate P and K for moderate to high-yield levels for a long period (40 years or possibly much longer in some cases).

In many cases the long-term stability of the "deficit" approach must be seriously questioned. Continued long-term net removal of substantial amounts of P and K will eventually reduce the levels available to the crop and yields will decrease unless:

1) The soil is strongly buffered with respect to the nutrient, or

2) Adequate additions of the nutrient are made from outside sources.

When P and K nutrient balances are negative, particularly on soils with less favorable P and K status or a low supplying capacity, a modification of farming practices to increase the nutrient supply may be necessary for successful long-term agricultural production. These conclusions are substantiated by an extensive body of research including long-term studies at experimental stations in the United States and Europe.

c. "Importation" approach -- Where large numbers of livestock are kept on a relatively small acreage requiring large amounts of imported feed, the P and K in the manure may equal or exceed the crop's requirements. Cooke (9) and Frissel (2) cite several examples of such situations in The Netherlands. Large-scale importation of animal manure may likewise supplement, or in some cases supply, all of the P and K needed by the crops. While several such farms were observed in our case studies, opportunities for such large-scale importations of manure are limited.

Where large-scale "importation" of nutrients occurs in organic farming, the system functions similarly to "intensive conventional agriculture" but with a much greater fraction of the P returned in a mixture of organic P forms. Since this approach relies on a large variety of organic and inorganic sources, the rate of dissolution and release from mineral sources and mineralization of organic material must be rapid enough to maintain the category 1) forms of P and K at a sufficiently high level, or the system will behave as described in the "deficit" approach. With large additions of organic matter, the mineralization and release of organic P may be of considerable significance, at least in some systems. Also the presence of large amounts of organic materials may affect the availability of K, because of adsorption characteristics.

d. Relevance of soil properties to the deficit approach -- The soil's capacity to supply P and K from weatherable minerals, past fertilization history, and the current nutrient level are critical factors to the long-term operation of conventional as well as organic farming. Since these factors vary greatly among soils, accurate information on the soil's nutrient status and capability to supply nutrients is of utmost importance to all of agriculture, but especially to those situations where P and K balances are negative.

The large and increased amounts of P and K fertilizer used since World War II have raised the levels of these nutrients in many soils to a point where crop production can often be sustained at moderate to high levels for a number of years without further additions (10). Where net P and K removal is reduced further by feeding part or all of the crops grown and returning the manure produced, the period over which high production levels can be sustained is extended even further. The

same effect occurs where P and K removals are decreased because of lower P and K requirements of crops or because climatic factors have reduced the yield potential. These effects have allowed many organic farmers who use the deficit approach to reduce or eliminate P and K fertilizer additions while maintaining moderate to high levels of crop production for extended periods.

4.1.4.3 Low Solubility Sources of P and K -- The effectiveness of rock phosphate in any particular soil is determined largely by three soil factors, soil pH and the concentrations of P and Ca in the soil solution. If the level of any one of these factors is not conducive to rock phosphate dissolution in the soil, rock phosphate will be relatively ineffective (11). Thus, on many soils it is unlikely that low solubility sources of P, such as rock phosphate, could maintain the soil solution concentration of P at a sufficiently high level to sustain maximum crop yields (11, 12). While this may be true, many organic farmers do not rely solely on rock phosphate as a source of P, but return ample amounts of crop residues, manures, and off-farm organic wastes to the soil, so that the contribution of P from rock phosphate is difficult to determine. Moreover, organic farmers are less likely to make a serious attempt at farming organically on P-deficient and low P-supplying soils. Many of them believe that they can enhance the dissolution and availability of P from rock phosphate by the application of organic residues and wastes, and by simple manipulation of soil pH and selection of crop sequence. However, low pH conditions which favor dissolution of rock phosphate may be too acid for satisfactory growth of many legumes.

Similarly, low solubility sources of K, such as glauconite (greensand), may be unable to provide an adequate level of K in the soil for highest crop yields. Again, most farmers would not consider farming organically on low K-supplying soils. Moreover, most organic farmers supplement applications of glauconite or rock powders with a number of different organic wastes and residues that supply K, so that the exact source of K is difficult to determine.

The various equilibria that govern the release of nutrients in a conventionally farmed soil may be somewhat different in a soil farmed under intensive organic practices. Thus, the rate of P and K release from sources of limited solubility in organic-intensive systems may require further investigation.

4.1.5 Effect of Organic Matter on the Solubility of Calcium Phosphates

On alkaline soils, organic matter has been shown to increase the concentration of P in the soil solution (13). This is important because the level of P in the soil solution determines the rate of P uptake by roots. Thus, manure can increase the availability and uptake of soil and fertilizer P by plant roots in alkaline soil (14). However, the effect of organic matter applications on P availability is less consistent on acid soils (15).

4.1.6 Potential Impact of Mycorrhizal Fungi

Several recent reports have expressed the possibility that mycorrhizal fungi inoculated into soils may have some future potential for stimulating the uptake of nutrients and growth of major food crops on a practical basis (13, 14, 16, 17). However, to date, researchers have found it most difficult to grow plant-adapted forms of these fungi in the absence of their host plants. This problem, coupled with the fact that very large amounts of inoculum would be required at considerable expense, and since cost-benefit relationships are still questionable, makes it doubtful that this procedure will become practical in the foreseeable future.

REFERENCES

1. Corey, R. B. "Soil diversity influences on change from shifting cultivation to continuous agriculture," Agronomy Abstracts, Am. Soc. Agron., Madison, Wis. p. 42. 1977.

2. Frissel, M. J. "Description and classification of Agro-ecosystems," pp. 17-26, "Cycling of mineral nutrients in agricultural ecosystems." Agro-Ecosystems, (Special issue) 4. Elsevier Sci. Publ. Co. Amsterdam. 354 pp., 1977.

3. Mattingly, G. E. G., and A. E. Johnston. "Long-term rotation experiments at Rothamsted and Saxmundham Experimental Stations: The effects of treatments on crop yields and soil analyses and recent modifications in purpose and design," Ann. Agron. Vol. 27, (1976), 743-769.

4. Horner, G. M., M. M. Oveson, G. O. Baker, W. W. Pawson. Effect of cropping practices on yield, soil organic matter and erosion in the Pacific Northwest Wheat Region States BULL-1. U.S. Dept. Agr., Agr. Expt. Stations of Idaho, Oregon, Washington, and the Agr. Res. Service. 25 p. 1960.

5. U.S. Department of Agriculture. Improving Soils with Organic Wastes. Report to the Congress in response to Section 1461 of the Food and Agriculture Act of 1977 (PL 95-113). Publ. by the U.S. Government Printing Office, Washington, D.C. 157 pp. 1978.

6. Liegel, E. A., G. H. Tempas, and I. R. Block. "Utilization of current crop production practices in obtaining optimum yield on North Central Wisconsin farms." Wisconsin College of Agr. and Life Sci. Marshfield Expt. Sta. Res. Rep. MSH-104-77. 1977.

7. Corey, R. B., and E. E. Schulte. "Factors affecting the availability of nutrients to plants," Soil Sci. Soc. Am. Proc., Ed. L. M. Walsh and J. P. Beaton. Soil testing and plant analysis, 2nd Edition. Special Publication No. 2. Madison, Wisc. 1973.

8. Lockeretz, W., R. Klepper, B. Commoner, M. Gertler, S. Fast, and D. O'Leary. "Organic and conventional farms in the Corn Belt: A comparison of economic performance and energy use for selected farms," Center for the Biology of Natural Systems, Rep. No. CBNS-AE-7. Washington Univ., St. Louis, Mo. 1976.

9. Cooke, G. W. "Fertilizing for Maximum Yield." 2nd Edition. Crosby Lockwood Staples, Ltd., London, 1975.

10. Engelstad, O. P. "Assessing P and K reserves in soils," In TVA Fertilizer Conference Proceedings, Bulletin Y-145, p. 31-36. Tennessee Valley Authority, Muscle Shoals, Alabama. 1979.

11. Khasawneh, F. E., and E. C. Doll. The use of phosphate rock for direct application to soils," Advances in Agronomy, Vol. 30, (1978), 159-206.

12. Russell, E. W. Soil Conditions and Plant Growth. Tenth Edition, pp. 587-588. Longman Group Ltd., London, 1973.

13. Olsen, S. R. and S. A. Barber. "Effect of waste application on soil phosphorus and potassium," Soils for management of organic wastes and waste waters. Ed. L. F. Elliott and F. J. Stevenson. Amer. Soc. Agron., Madison, Wisc., 1977.

14. Olsen, S. R., and A. D. Flowerday. "Fertilizer phosphorus interactions in alkaline soils," Fertilizer Technology and Use. Ed. R. A. Olson, T. J. Army, J. J. Hanway, and V. J. Kilmer. 2nd Edition. Soil Sci. Soc. Amer. Madison, Wisc. 1971.

15. Perrott, K. W. "The influence of organic matter extracted from humidified clover on the properties of amorphous alumino-silicates. II. Phosphate retention." Aust. J. Soil Res., Vol. 16, (1978), 341-346.

16. Ruehle, J. L., and D. H. Marx. "Fiber, food, fuel, and fungal symbionts," Science Vol. 206, (1979), 419-422.

17. Wittwer, S. H. "Future technological advances in agriculture and their impact on the regulatory environment," Bioscience, Vol. 29 (1979), 603-610.

4.2 IMPACT OF ORGANIC METHODS ON SOIL PRODUCTIVITY AND TILTH

Organic farmers place great importance on the recycling of organic wastes in soil for plant nutrients and for maintenance of soil productivity[1] and tilth. They are concerned that repeated heavy applications of pesticides and chemical fertilizers will have significant biocidal effects on the soil organisms responsible for mineralizing organic wastes and residues, and thus limit the release and availability of plant nutrients. Some contend that the long-term use of some chemical fertilizers can adversely affect soil structure, and lead to increased compaction and poor soil tilth. They believe that in most cases organic farming methods can increase the level of soil organic matter and maintain it at a higher level than current conventional farming methods. This section attempts to briefly address some of these concerns and beliefs.

4.2.1 Effect of Organic Nutrient Sources on Crop Production

Results of experiments on crop yields from organic compared with inorganic fertilizers are not always consistent or conclusive, although significant differences have been reported. For example, long-term studies at Rothamsted and Woburn, England, showed that annual applications of animal manure produced greater yields of wheat, sugar beets, and potatoes than did inorganic fertilizers (1). One explanation offered was that the manure supplied N and P to the crops more efficiently than did inorganic fertilizers. On the other hand, a 50-year study using a winter cereal - root crop - summer cereal - clover - grass rotation showed that yields were 15 percent higher with inorganic fertilizers than with manure (N, P, and K equalized).

A 50-year study (1890-1940) at Sanborn Field, Columbia, Missouri, showed that a combination of animal manure and inorganic fertilizer resulted in higher yields and more efficient N utilization than either nutrient source applied alone and in large amounts (2). The efficiency of recovery of soil and applied N during 50 years of

---

[1]Soil productivity as defined in "Soil," the 1957 USDA Yearbook of Agriculture, is, "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 the outputs or harvests in relation to the inputs of production factors for a specific kind of soil under a physically defined system of management."

cropping was lowest with inorganic fertilizer, intermediate for manure and crop rotations, and highest for continuous timothy (table 4.2.1). Reduction in the manure application rate from 13.4 to 6.7 metric tons/ha/yr on wheat increased the N use efficiency by 15 percent. It should be noted that yield levels in this study were quite low. However, a subsequent study of this type from 1940-60 showed that with improved tillage practices and crop varieties, yields of corn, wheat, and hay from applications of 13 metric tons of manure/ha/yr were similar to those obtained with chemical fertilizers (3).

Table 4.2.1 Efficiency of recovery of soil and applied N for several crops after 50 years of management (after Smith, 1942).

Fertility management practice	Percent recovery[1]
Inorganic fertilizer	46-58
Manure (13 tons/ha/yr)	52-87
Crop rotations (3,4, and 6 year)	84-103 (57-76)[2]
6 year rotation + manure and inorganic fertilizer	66 (57)
Continuous timothy	101

[1] (N removed in crops + soil N after 50 years ÷ soil N at start + N added) X 100

[2] Values in parentheses represent N recovery using an estimate of 112 Kg N/ha/yr fixed by clover crop in rotation.

Nevertheless, there is recent evidence that crop yields in long-term studies, such as those reported here, are higher from combined applications of chemical fertilizers and farmyard manure than from the same amount of either nutrient source when applied alone (4).

These results merely emphasize the need for additional research to determine yields and N use efficiencies for crops grown with organic and inorganic sources of plant nutrients, and with various combinations thereof.

4.2.2 Effect of Organic Methods on Soil Organic Matter

The organic matter level of virgin soil is determined by an equilibrium situation in which the loss, chiefly as CO_2, is balanced by the gain of carbon from organic residues. Agricultural activities immediately upset this equilibrium and the level of organic matter can be drastically altered (generally decreased) by tillage and cropping practices. A high level of soil organic matter is often correlated with a high level of soil fertility, productivity, and tilth. Extensive loss of soil organic matter from intensive cropping and tillage practices generally leads to concomitant deterioration in soil physical properties, decreased productivity, and accelerated erosion.

4.2.2.1 Tillage -- Tillage results in mixing of the soil with organic residues, increased aeration, increased microbial activity, and increased oxidative loss of soil organic matter. Losses of from 20 to 60 percent of the native organic matter content of some soils have been reported to occur after 40 to 50 years of cultivation (5). The magnitude of this loss depends on the type of tillage system employed. For example, losses are considerably less from conservation tillage practices, such as minimum- or no-till systems, compared with those which feature the moldboard plow tillage system. The organic matter content of some soils has actually increased by 12 to 25 percent after 5 to 10 years of no-till cropping where tillage was previously done with a moldboard plow (6). Most of the organic farmers who were interviewed were well aware of the rapid oxidative loss of soil organic matter that results from intensive row cropping and moldboard plowing, and had already shifted to disk and chisel plows for primary tillage.

4.2.2.2 Crop Rotations -- The proper mix of crops can have a profound effect on the organic matter content of most soils. Where soil is maintained in continuous grass sod, the loss of organic matter is probably negligible, and in some cases the organic matter content may actually increase, even in regions of high rainfall (5). Table 4.2.2 summarizes 50 years of data from Sanborn field in Missouri and shows the effect of cropping sequences on the soil organic matter content. Continuous cropping

Table 4.2.2 Soil organic matter content as influenced by cropping sequence (2).[1]

Cropping sequence	Soil organic matter content (no manure applied)
	Percent
Continuous	
Corn	1.45
Wheat	3.40
Oats	4.08
Timothy	4.68
Rotation	
3 yr -	
corn, wheat, red clover	3.31
4 yr -	
corn, oats, wheat, red clover	3.74
6 yr -	
corn, oats, wheat, red clover, timothy, timothy	3.83
Virgin	
(mixed grass and timber)	5.78

[1]Original data as percent N converted to percent organic matter by multiplying by 17.

with corn caused the greatest decline in soil organic matter (56 percent) and continuous timothy the least (19 percent). Long-term experiments in England also showed that decreases in soil organic matter from intensive row cropping could either be checked or slowed by inclusion of grasses and legumes in the rotation (1).

4.2.2.3 Frequency, Rate, and Type of Organic Wastes and Residues Applied

In addition to tillage systems and crop rotations, the organic matter content of soil depends on the frequency, amount, and type of organic wastes and residues that are applied. Single applications may have little effect on the organic matter level, but with repeated dressings an equilibrium is ultimately reached in which the organic matter content in soil becomes relatively constant. The equilibrium value also depends on soil type and climate. The organic matter content of soils increases more rapidly under cooler temperatures of northern latitudes compared with southern extremes.

Long-term experiments at Woburn, England showed that when 75 T/ha of farmyard manure was applied to a loamy sand soil for 25 years, the organic matter content increased from 1.50 to 3.89 percent. However, the same rate of sewage sludge (dry weight basis) increased the soil organic matter content to 4.95 percent (1).

It has been demonstrated that chemical fertilizers can also increase the level of soil organic matter by promoting increased yields of residues both above and below ground. For example, Larson et al. (7) showed that the organic matter content in some Corn Belt soils was linearly related to the amount of corn residues produced, and that a certain level of corn production was required to maintain a certain level of soil organic matter.

Nevertheless, manures, sewage sludge, and other organic wastes and residues are more effective than commercial fertilizers in maintaining or increasing soil organic matter levels because of the additional input of organic materials they supply. For example, in Michigan, beef cattle manure applied annually for 13 years at 30 T/A on a loamy sand for growing corn silage increased the organic matter content to about 3 percent compared with only 2 percent found in soil treated with chemical fertilizers (8). Similarly, a 50-year trial in Denmark showed that farmyard manure increased the organic N content by 16 percent compared with only 7 percent for soil receiving chemical fertilizers (9).

Research is needed to determine how various organic wastes and residues differ in their ability to improve soil tilth and productivity, and to maintain or even increase soil organic matter. Some of the organic farmers interviewed were utilizing off-farm sources of organic materials (in addition to on-farm crop residues and manures) such as sewage sludge and paunch manure. Information is limited on the extent to which one particular organic waste can substitute for another to achieve a desired level of soil improvement. Studies are needed to determine (a) the rate of loss (or increase) of soil organic matter under different cropping systems as influenced by different organic wastes, and (b) the rate of mineralization of different organic wastes and their ability to supply plant nutrients.

4.2.3 Effect of Chemical Fertilizers and Pesticides on Soil Microbiological and Physical Properties

4.2.3.1 Fertilizers -- While some microbiological processes might be suppressed by unusually high levels of inorganic N or P fertilizers, the effect has been shown to be a temporary one that does not persist under field conditions. For example, the

application of anhydrous ammonia does kill many soil microorganisms in the injection zone initially, but rarely does this effect persist for very long. Eno and Blue (10) found that bacterial and actinomycete populations were decreased by 50 percent or more one day after application but then recovered quickly, and within 10 days after treatment they were 6 to 25 times higher than in the control soil. Anhydrous ammonia has a pronounced fungicidal effect on soils. Populations of soil fungi were decreased for as long as 7 weeks but then recovered to the same level found in untreated soil (10). It is unlikely that anhydrous ammonia will "kill" or "sterilize" a soil, because the point-source mode of application affects only 6 to 7 percent of the plow-layer volume. Nevertheless, this premise is based on observations following single applications, and the effect of frequent, heavy, and long-term applications of anhydrous ammonia on the types, numbers, and activities of soil microorganisms is not known.

There is some recent evidence that high application rates of some N fertilizers can reduce the numbers and activities (i.e. castings) of earthworms (11). A possible explanation for the low populations of earthworms observed in some soils receiving extensive applications of chemical fertilizers is that they do not tolerate high salt concentrations. Earthworm activity can markedly improve the structure, drainage, and aeration of soils, and they are important in almost all phases of humus formation from organic matter. Through consumption of organic matter, earthworms also accelerate the release of plant nutrients from organic residues. While earthworms have been studied extensively in some respects, there is much about them that is not well understood.

Some organic farmers, and chemical farmers as well, believe that long-time use of fertilizers, especially anhydrous ammonia, can lead to soil compaction and poor tilth. While some of our agricultural soils are experiencing problems with compaction, and what appears to be an increasing power requirement for tillage, there is no direct evidence that chemical fertilizers are the cause. Nevertheless, it would appear that research should give more attention to the long-term effects of chemical fertilizers on the microbiological and physical properties of our agricultural soils.

4.2.3.2 Pesticides -- Most herbicides and insecticides can indeed destroy soil microorganisms or suppress their activities if applied at excessive rates. When applied at recommended rates, these chemicals seldom reach soil concentrations of more than 2 or 3 ppm (assuming uniform mixing in the plow layer) and it is unlikely that they would cause any real problems. However, with increased frequency and rate of application, and where a spectrum of different chemicals is used for protection of a particular crop, it is possible that persistence of some of them and/or their degradation products would increase. In this case, adverse effects on the soil microflora are possible as well as phytotoxic effects on some crops from residual chemicals.

Soil fungicides and fumigants cause the most drastic effect on the soil microflora. Unlike herbicides and insecticides, these chemicals are intentionally applied to soils as antimicrobial agents and at much higher rates (30 to 40 ppm). While their action is directed toward pathogenic fungi and plant parasitic nematodes, it is seldom limited to pathogens. The overall effect is one of partial sterilization, in which beneficial microorganisms may be adversely affected for extended periods (12). Fortunately, many of these highly lethal, nonselective, and persistent compounds are no longer used.

The significance of many reported results of the effects of pesticides on the soil microflora is not known. While considerable data exists on the acute effects of pesticides on the soil microflora, i.e., where soils are exposed to large, massive

doses for short periods, little is known about sublethal or chronic effects on soil microorganisms from long-term exposure to lower residual concentrations that might be found in agricultural soils (12). Research should be directed toward this area and also toward the evaluation of the effects of new pesticides, and their degradation products, on the activities of beneficial soil microorganisms.

An interesting observation by Doran (6) is that microbial populations and soil enzyme activities in a no-till system of management are frequently 1½ to 2 times higher than in soil tilled with the moldboard plow. Others have shown earthworm populations to be 4 to 5 times higher in no-till soils than with plowing (13). Since no-till systems require herbicides, it may be that through the careful and selective use of these chemicals we might minimize their potential adverse effects, while enhancing the beneficial effects to be derived from the conservation of soil, water, and organic matter. This should be a high priority for future research.

REFERENCES

1. Cooke, G. W. "The roles of organic manures and organic matter in managing soils for higher crop yields - a review of the experimental evidence." Proceedings of the International Seminar on Soil Environment and Fertility Management in Intensive Agriculture, (1977). Ministry of Agriculture, Agricultural Research Council, London.

2. Smith, G. E. "Sanborn field: Fifty years of field experiments with crop rotations, manure, and fertilizers." Missouri Agr. Exp. Sta. Bull. 458, 61 p., 1942.

3. Peterson, J. R., T. M. McCalla, and G. E. Smith. "Human and animal wastes as fertilizers." Fertilizer Technology and Use. Soil Sci, Soc. Am., Madison, Wisc. 611 p., 1971.

4. Anon. "It pays to build soils for high yields." Agro-Knowledge, Potash and Phosphate Institute, Report No. 8, Atlanta, Ga. 1980.

5. Allison, F. E. Soil organic matter and its role in crop production. Developments in Soil Science 3. Elsevier Sci. Publ. Co., Amsterdam, London, New York. 637 pp., 1973.

6. Doren, J. W. "Microbial and biochemical changes associated with reduced tillage," Agronomy Abstracts. (1979) p. 156. Am. Soc. Agron., Madison, Wisc.

7. Larson, W. E., R. F. Holt, and C. W. Carlson. "Residues for soil conservation," Crop Residue Management Systems. Ed. W. R. Oschwald. Am. Soc. Agron. Special Publ. No. 31. Madison, Wisc., 1978.

8. Lucas, R. E., and M. L. Vitosh. "Soil organic matter dynamics." Research Report No. 358. Michigan State University. 11 p., 1978.

9. Iverson, K., and K. A. Bondorff. "Field experiments with farmyard manure and artificial fertilizers." Commercial Fertilizer, Vol. 82 (1951) 49-52.

10. Eno, C. F., and W. G. Blue. "The effect of anhydrous ammonia on nitrification and the microbiological population in sandy soils," Soil Sci. Soc. Amer. Proc. Vol. 18 (1954) 178-181.

11. Stewart, V. I. "The importance of fertilizers in raising soil fertility," Agriculture and Environment Vol. 4 (1979), 301-307.

12. Parr, J. F. "Effect of pesticides on microorganisms in soil and water," Pesticides in Soil and Water. Ed. W. D. Guenei. Soil Sci. Soc. Am., Madison, Wisc. 562 p., 1974.

13. Edwards, C. A. "Effects of direct drilling on the soil fauna," Outlook Agric. Vol. 8 (1975), 243-244.

4.3 ORGANIC FARMING AND ORGANIC WASTES

Organic farmers are well aware that the proper management of crop residues, green manures, and animal manures on their land is essential for protecting soils from wind and water erosion, and for preventing nutrient runoff. Certainly, they recognize that efficient and effective use of their residues and manures is essential for maintaining the productivity of their soils and for recycling plant nutrients. A 1978 USDA report, Improving Soils With Organic Wastes (1), is particularly relevant to the needs of organic farmers and some of the problems with which they must deal.

4.3.1 USDA Report, Improving Soils with Organic Wastes (1978)

The Food and Agriculture Act of 1977 (P.L. 95-113) directed the U.S. Department of Agriculture to prepare a report to the Congress on "the practicability, desirability, and feasibility of collecting, transporting, and placing organic wastes on land to improve soil tilth and fertility." The urgency for this information stems from the increased cost of energy, fertilizers, and pesticides that confronts U.S. farmers, and the problems of soil deterioration and erosion associated with intensive farming systems. This report is now available upon request from the Office of the Secretary of Agriculture in Washington, D.C. 20250. It contains detailed information on the availability of seven major organic waste materials for use in improving soil tilth and fertility: (a) animal manures, (b) crop residues, (c) sewage sludge, (d) food processing wastes, (e) industrial organic wastes, (f) logging and wood manufacturing wastes, and (g) municipal refuse. For each waste, information is reported on the quantity currently generated, current usage, potential value as fertilizers (based on major plant nutrients contained), cost of land application, competitive uses, and problems and constraints affecting their use. The report points out that this kind of information is absolutely essential for sound agricultural planning and successful implementation of organic recycling programs.

4.3.1.1 Current Usage -- A summary of the USDA report on the annual production of the seven categories of organic wastes in the United States, their current use on land, and the probability of increased use on land in the future is presented in table 4.3.1. A grand total of approximately 800 million dry tons of organic wastes is produced annually with a combined fertilizer value of about $840 million, based on their content of nitrogen, phosphorus, and potassium. This represents a natural resource of significant economic value. Thus, the proper and efficient use of these materials for plant growth and soil improvement should be emphasized. The N-P-K content and current fertilizer value of some organic wastes commonly applied to land are shown in table 4.3.2. It is noteworthy that sewage sludge has a fertilizer value comparable to high quality poultry manure. Moreover, if one considers the beneficial effects of the organic component of these wastes, the actual total value would be considerably higher. Calculation of a realistic value for the organic component as it relates to soil productivity is extremely complex and to our knowledge has not yet been satisfactorily accomplished.

Table 4.3.1. Annual production of organic wastes in the United States, current use on land, and probability of increased use (USDA, 1978).

Organic wastes	Total production			
	Dry tons (x 1000)	Percent of total	Current use on land[1] percent	Probability of increased use[2] on land
Animal manure	175,000	21.8	90	Low
Crop residues	431,087	53.7	68	Low
Sewage sludge and septage	4,369	0.5	23	Medium
Food processing	3,200	0.4	(13)	Low
Industrial organic	8,216	1.0	3	Low
Logging and wood manufacturing	35,714	4.5	(5)	Very low
Municipal refuse	145,000	18.1	(1)	Low
Total	802,586	100.0	---	---

[1] Values in parentheses are estimates because of insufficient data.

[2] Medium indicates a likely increase of 20 to 50 percent, low indicates a 5 to 20 percent increase, and very low indicates less than a 5 percent increase.

About 50 percent of the total production of organic wastes (table 4.3.1) is comprised of crop residues, while about 22 percent is made up of animal manures. Thus, about 75 percent of the total annual production of organic wastes consists of crop residues and animal manures. The USDA report established that approximately three-fourths of these two wastes are currently being applied to land for improving soil productivity.

4.3.1.2 Constraints and Competitive Uses -- Sewage sludges make up about 0.5 percent of the total organic waste generated; approximately one-fourth of the U.S. sludge production is applied to land. The other four wastes listed in table 4.3.1 have not been used extensively on land because of certain competitive uses, high costs of collection, processing, transportation, and application; and constraints on usage related to certain chemical and physical properties. For example, (a) cotton gin trash and sugarcane bagasse are now increasingly sought as sources of fuel for burning, (b) some food processing wastes may have extremely high acidity or alkalinity that may adversely affect soil pH, or they may also contain heavy metals and some organic chemicals that may be phytotoxic to plants or that may endanger the food chain after absorption and accumulation, and (c) shredded municipal refuse contains a considerable amount of solid fragments (glass, plastic, metal) that do not biodegrade readily and might detract aesthetically when applied to land.

Table 4.3.2 Nitrogen (N), phosphorus (P), and potassium (K) content and fertilizer value[1] of some selected wastes commonly applied to agricultural land (USDA, 1978).

Organic waste	N		P		K		Total value/ton
	percent of dry material	value/ ton	percent of dry material	value/ ton	percent of dry material	value/ ton	
		dollars		dollars		dollars	dollars
Beef cattle manure	2.0	6.00	0.8	6.40	1.5	3.00	15.40
Poultry manure	3.8	11.40	1.4	11.20	1.9	3.80	26.40
Wheat straw	0.6	1.80	0.07	0.56	1.0	2.00	4.36
Corn stover	1.1	3.30	0.2	1.60	1.3	2.60	7.50
Sewage sludge (undigested)	3.8	11.40	1.5	12.00	0.2	0.40	23.80
Municipal refuse	0.6	1.80	0.2	1.60	0.3	0.60	4.00

[1]Fertilizer values are based on total amounts of N, P, and K, with average costs of $0.15/lb of N; $0.40/lb of P; and $0.10/lb of K.

4.3.1.3 Potential for Increased Usage -- Table 4.3.1 shows that for the organic wastes that we generate in the United States, the potential for their increased use on land to improve the productivity of our soils is low. Only the use of municipal sewage and septage (septic tank pumpage) on land is expected to increase appreciably, but this increase is very small when compared on a national basis with the two largest waste categories, animal manures and crop residues. Competitive uses for food processing wastes and logging and wood manufacturing wastes, numerous potential toxins in organic industrial wastes, and the undesirable chemical and physical properties of municipal refuse, restrict their use as organic amendments for agricultural soils.

Crop residues are now being seriously considered as a source of energy in the United States. Larson et al. (2) have estimated that crop residues could provide sufficient energy each year to fuel 130 electric power plants of 1,000 megawatt capacity. This is equivalent to approximately 30 percent of this Nation's current annual natural gas consumption. The use of crop residues for energy production is currently limited by the cost of collection, storage, processing, transportation, and conversion technology (3). However, as the cost of conventional fossil fuels continues to rise, the use of crop residues and biomass for energy will become increasingly feasible.

The USDA report recognized that there is a growing shortage of good quality organic wastes for use in maintaining and improving the productivity of our agricultural soils. It is likely that this situation will intensify in the not too distant

future. The report cited a number of ways in which our limited amounts of organic wastes might be used more effectively as soil amendments. These include:

a. Improving methods of collection, storage, and processing (composting) of animal manures to minimize the loss of nitrogen that often occurs in these operations.

b. Utilizing manures that are presently wasted for land application.

c. Utilizing crop residues that are now being wasted for nutrient recycling.

d. Increasing the use of sewage sludge on land.

e. Increasing the use of the organic/compostable fraction of municipal refuse.

Increased usage of each waste category (table 4.3.1) on land is possible if future research should indicate that existing constraints can be removed, and if their value for improving the tilth, fertility, and productivity of soils is shown to be greater than for existing competitive uses. The time may come when organic farmers will have to compete with others for off-farm sources of good quality organic wastes to recycle on their farms.

4.3.2 Composting to Enhance the Usefulness and Acceptability of Organic Wastes as Fertilizers and Soil Conditioners

One easy way in which some of the problems associated with the utilization of various organic wastes as fertilizers and soil conditioners (e.g. odors, human pathogens, and undesirable physical properties) can be resolved is by composting. Composting is an ancient practice whereby farmers have converted organic wastes into useful organic soil amendments that provide nutrients to crops and enhance the tilth, fertility, and productivity of soils (4). Through composting, organic wastes were decomposed, nutrients were made available to plants, pathogens were destroyed, and malodors were abated. The principal parameters that are essential to the composting process and which must be considered if aerobic/thermophilic composting is to proceed rapidly and effectively were discussed by Poincelot (5).

Many of the organic farmers we interviewed were interested in composting organic wastes. Some were already composting mixtures of animal manures and crop residues. The composting technology developed by USDA since 1972 for animal wastes and sewage sludges should be useful to many of them in their efforts to enhance the availability of plant nutrients from various types of organic wastes. Extension and education programs should be developed to transfer this technology to organic farmers.

The U.S. Department of Agriculture at Beltsville, Maryland, in cooperation with the Maryland Environmental Service, Annapolis, Maryland, has developed a process for composting either undigested or digested sewage sludges (6, 7). The method is widely referred to as the Beltsville Aerated Pile Method, in which sewage sludge (approximately 22 percent solids) is mixed with woodchips or other bulking materials and then composted in a stationary aerated pile for 3 weeks. Other bulking materials that have been used successfully for composting sewage sludge include leaves, refuse, paper, peanut hulls, straw, corn cobs, and wood bark. Within several days after composting begins, temperatures are well into the thermophilic range (60° to 70°),

where they remain for several weeks. This ensures complete destruction of enteric pathogens. After 3 weeks in the aerated pile, the compost is removed and placed in a curing pile for 4 weeks before screening and marketing. The final product is a humus-like material, free of malodors and pathogens, which can be used beneficially as a fertilizer and soil conditioner. A more detailed account of the design criteria for the Aerated Pile Method of composting has been recently published (7). This technology could easily be adapted for use by organic farmers in composting animal manures or off-farm wastes such as sewage sludge and paunch manure.

A recent summary report, entitled "Use of sewage sludge compost for soil improvement and plant growth," based on USDA research at Beltsville, discusses the uses of sewage sludge compost for soil improvement and plant growth, including (a) establishment, maintenance, and production of turfgrass and sod, (b) use in vegetable gardens, (c) production of field crops and forage grasses, (d) use on nursery crops and ornamentals, (e) use in potting mixes, and (f) reclamation and revegetation of disturbed lands (8). Recommendations are provided as to time, methods, and rates of compost application for different soils and management practices. This report should be of considerable value to organic farmers who may be interested in using composted municipal wastes to supplement on-farm sources of organic residues and manures. The report is available upon request from the Biological Waste Management and Organic Resources Laboratory, SEA, USDA, Beltsville Agricultural Research Center, Beltsville, Maryland 20705.

REFERENCES

1. U.S. Department of Agriculture. Improving Soils with Organic Wastes. Report to the Congress in response to Section 1416 of the Food and Agriculture Act of 1977 (PL 95-113). Publ. by the U.S. Government Printing Office, Washington, D.C. 157 pp., 1978.

2. Larson, W. E., R. F. Holt, and C. W. Carlson. "Residues for soil conservation," Crop Residue Management Systems. Ed. W. R. Oschwald. Am. Soc. Agron. Special Publ. No. 31, Madison, Wisc., pp. 1-15, 1978.

3. Epstein, E., J. E. Alpert, and C. C. Calvert. "Alternative uses of excess crop residues," Crop Residue Management Systems. Ed. W. R. Oschwald. Am. Soc. Agron., Special Publ. No. 31, Madison, Wisc., pp. 219-230, 1978.

4. King, F. H. 1911. Farmers of forty centuries. Rodale Press, Inc., Emmaus, Pennsylvania. 441 p.

5. Poincelot, R. P. The biochemistry and methodology of composting. Connecticut Agr. Exp. Sta. Bull. No. 754, 18 pp., 1975.

6. Parr, J. F., E. Epstein, and G. B. Willson. Composting sewage sludge for land application. Agriculture and Environment. Vol. 4 (1978), 123-137.

7. Willson, G. B., J. F. Parr, E. Epstein, P. B. Marsh, R. L. Chaney, D. Colacicco, W. D. Burge, P. D. Millner, and S. B. Hornick. 1980. A Manual for Composting Sewage Sludge by the Beltsville Aerated Pile Method. EPA-600/8-80-022. Joint USDA-EPA Publication. U.S. Depart. Agri., Sci. and Educ. Adm.

8. Hornick, S. B., J. J. Murray, R. L. Chaney, L. J. Sikora, J. F. Parr, W. D. Burge, G. B. Willson, and C. F. Tester. Use of sewage sludge compost for soil improvement and plant growth. ARM-NE-6, U.S. Dept. Agr., Sci. and Educ. Adm., 10 pp., 1979.

4.4 NONTRADITIONAL SOIL AND PLANT ADDITIVES

There are a number of products on the market generally referred to as soil and plant additives for which the manufacturers' claims greatly exceed the performance of the product (1,2,3,4,5). According to Schulte and Kelling (5), a soil or plant additive is defined as *any nonfertilizer material to be applied to soil or plants with a claim of improved crop production, vigor, growth, or quality.*

These products include (a) *microbial fertilizers and soil inoculants* which are purported to contain unique and beneficial strains of soil microorganisms, (b) *microbial activators* that supposedly contain special chemical formulations for increasing the numbers and activity of beneficial microorganisms in soil, (c) *soil conditioners* that claim to create favorable soil physical and chemical conditions which ultimately result in improved growth and yield of crops, and (d) *plant stimulants and growth regulators* that supposedly stimulate plant growth, which results in healthier and more vigorous plants and increased yields.

These products are marketed as powders, granules, liquids, and emulsions, and are recommended for use as seed treatments, soil treatments, root dips, bacterial nutrients, and foliar sprays. According to their manufacturers, these products can (a) increase yields, (b) accelerate decomposition of residues, (c) stimulate seed germination and plant growth,(d) substitute for fertilizer and lime, (e) increase the soil humus content, (f) protect plants from diseases, and improve soil tilth (1). Many of these products (until recently) have been able to evade State fertilizer laws because they are not labeled as sources of plant nutrients.

Schulte and Kelling (5) listed a number of characteristics which most of these questionable products have in common. These include the following: (a) they have low rates of application compared with fertilizers; (b) they can be applied either as a foliar spray or directly to the soil; (c) their costs range from $5 to $10 per acre at recommended rates; (d) the product is "natural" or "organic" and "does not harm beneficial microorganisms, earthworms, or insects"; (e) the reasons for beneficial results are either unknown or are a "trade secret"; (f) the products are almost always very low in their content of the macronutrients nitrogen, phosphorus, and potassium; and (g) testimonials are offered in support of the product but rarely does the manufacturer provide valid research data on efficacy to substantiate the claims.

In most cases where researchers have evaluated these products, using acceptable scientific and statistical methods, they have been unable to demonstrate any significant increases in yield (1,3,5). Such studies have usually failed to show any additional claims of benefit. It is noteworthy, however, that there are some legitimate soil and plant additives on the market that have stood the test of time. A classic example is the commercial preparation of the nitrogen-fixing bacteria Rhizobium used for inoculating legume seeds.

In view of the large number of these products being marketed, now more than 100 according to Weaver (3), and their questionable validity and benefit, a number of States have recently moved to extend their fertilizer laws to include soil and plant additives. Some States now require proof of efficacy before such products can be registered and marketed. There is a strong consensus among agricultural scientists that requiring proof of efficacy is advisable to ensure protection of farmers from questionable products. The North Central Research Committee of Land-Grant University Agricultural Experiment Stations has also taken action concerning the efficacy of these products. Recently, this group, which represents 12 States in the north-central

region, designated a committee on nontraditional soil amendments (NCR-103) to collect and compile the available research data on these products from the States in that region. The function of this committee will be to prepare a report of the results obtained, provide an assessment of the theoretical and potential value of each product, and disseminate the information to the public. Perhaps the other regions will follow this lead.

A common belief is that organic farmers are the principal consumers of these products. However, the USDA studies and the Rodale Press survey showed that this is not the case. The incidence of usage by both organic and conventional (chemical) growers was about the same, that is, about 20 percent of both groups were using some of these products.

Organic farmers in particular should be cautious in using soil and plant additives that contain little or no nitrogen, phosphorus, or potassium. If a farmer really wants to try some of these products, he should do so on a small scale. He should lay out comparative plots, make comparisons, and record yield data. He should not base his conclusions on only one year's results, regardless of the outcome (2).

All farmers, organic or conventional, are well advised to be cautious and skeptical of any product which promises to perform extraordinary processes in soils and plants, or to have magical and mysterious beneficial effects on plants and microorganisms. Such products are invariably a poor investment, of little or no economic value, and cannot substitute for good farming methods and sound management practices.

REFERENCES

1. Dunigan, E. P. "Microbial fertilizers, activators and conditioners: A critical review," Developments in Industrial Microbiology, Vol. 20 (1979), 311-322.

2. Logsdon, G. "Soil additives: the ultimate can of worms" The New Farm Magazine, Vol. 1(4) (1979), 20-38.

3. Weaver, R. W., E. P. Dunigan, J. F. Parr, and A. E. Hiltbold. 1974. "Effect of two soil activators on crop yields and activities of soil microorganisms in the Southern United States." Southern Cooperative Series Bulletin No. 189. 24 pp. 1974.

4. Weaver, R. W. "Evaluation of the effectiveness of microbial fertilizers, activators, and conditioners," Developments in Industrial Microbiology, Vol. 20, (1979), 323-327.

5. Schulte, E. E. and K. A. Kelling. "Regional results with the use of non-traditional soil and plant additives." Proc. Fert. and Agric. Limestone Conf. 17:88-98. Dept. Soil Science, Univ. Wisconsin, Madison. 1978.

4.5 PEST CONTROL

4.5.1 Weed Control

There are a number of nonchemical methods of weed control employed by organic farmers. Based on the inherent advantages and disadvantages of each method, the farmer must carefully select that control method, or combination of controls, which best matches the unique weed situation that has arisen because of cropping and cultural practices and the habitat. In order to match the control methods to his problems, the organic farmer is as much in need of an integrated management program focused on nonchemical methods, as the conventional farmer has need of an Integrated Pest Management (IPM) program which includes herbicides.

Nonchemical methods of weed control which are used by organic farmers, but are not necessarily unique to them, include the following:

a) *Tillage* - mechanical and hand labor are universally employed over a wide range of crops, soils, and climatic conditions.

b) *Crop rotation* - alternate crops are used to retard the weeds or to enhance their control by cultivation.

c) *Preventive weed control* - this includes such things as inspecting and cleaning equipment (and livestock) before transferring it from one field to another, screening weed seed from irrigation water, and assuring that crop transplants, seed, and soil amendments are free of weed seed.

d) *Crop spacing* - reduction of the distance between rows and between plants in the row, intercropping, and relay cropping can be used to occupy open field areas that would normally be taken over by weeds.

e) *Timing of seeding and planting* - quick germinating seeds and vigorous growing plants (e.g., corn, potatoes, radishes, etc.) can be used to compete effectively with young weeds. Less vigorous plants may be transplanted to provide them a competitive advantage over weeds.

f) *Mulching* - mulches comprised of various organic materials can be used to smother weeds. This method of control is most effective on annual weeds and in late spring when rapid plant growth occurs.

Other nonchemical methods of more limited use include biological control (the use of living organisms, insects, plant pathogens, nematodes, goats, and geese to stress or destroy weeds); thermal control (briefly burning the plant with an electrical discharge or fuel burner); and genetic control (breeding crops that are more competitive with weeds or exude phytotoxins to inhibit weed growth).

4.5.1.1 Advantages and Disadvantages of Nonchemical Weed Control Methods -- Opinions were solicited from a number of weed scientists in the United States on the advantages and disadvantages of nonchemical weed control methods. The consensus was that for tillage (mechanical and hand labor) the principal constraints were the high cost of labor and limited availability of workers, higher energy costs, increased water evaporation loss from the soil, increased soil erosion, and root-pruning damage. Cultivation would be further limited in areas of rough terrain and whenever

the soil was too wet. They considered crop rotations as a disadvantage because of limited or noneconomic outlets for some of the rotated crops. Increased plant population and intensive seeding would negate the opportunity for cultivation and would increase the necessity for herbicide use.

In general, the scientists felt that weed control without herbicides would be more costly and less effective, and would actually decrease the acreage that a farmer could effectively manage with his current resources. In effect, it may reduce the farm size.

Although the scientists felt the overall benefits from herbicides out-weighed their shortcomings, they could foresee certain advantages from a decreased use. Selective herbicides applied to tolerant crops can, in some cases, impair crop growth and yield. Decreased herbicide usage would help to minimize environmental pollution by decreasing the herbicide runoff potential from farmland and by decreasing the volume of manufacturing wastes and pesticide containers for disposal. They also believed that an increase in organic farming would result in increased legume and grass production, which would reduce soil erosion, since farmers would tend to confine their row crops to more level land.

Although herbicides have increased agricultural productivity per worker hour and per acre, their use is not without problems. Some weeds have become resistant to herbicides, the species composition of weed complexes have shifted to herbicide-tolerant species, herbicides have caused alterations in crop physiology resulting in a greater incidence of damage from pathogens and insects, and some herbicides can adversely alter the populations of soil microorganisms.

4.5.1.2 Future Weed Control -- At present, scientists do not foresee any major advances in nonchemical methods of weed control. It was estimated that yields of corn and soybeans would be reduced by 15 to 20 percent if nonchemical methods were applied exclusively. However, scientists stressed the need for research that focuses on a balanced approach for weed control, including combinations of chemical and nonchemical methods, similar to the concept of Integrated Pest Management. They felt that this type of approach would be of benefit to both organic and conventional farmers alike.

4.5.2 Insect Control

A wide range of nonchemical insect control methods are available to organic farmers, including cultural, physical, mechanical, and biological methods, many of which were developed through trial and error by generations of farmers. Despite the large number of techniques developed, a very limited number are available to control any one insect in a particular crop. Also, the control achieved using these methods may still allow some crop damage to occur. This may be acceptable for most crops, but not for those where marketability depends on appearance, such as fruits, vegetables, and flowers.

A greater research effort is needed to develop plants resistant to insects. Special attention should be given to fruits, vegetables, and flowers, which have been given scant attention in the past. Development of resistance in grains, forage, and cotton has been successful, but multipest resistance should be sought. Insect resistance in grains is being included in fewer of the new cultivars than it was previously. This process should be reversed. In all cases, multigenic resistance should be the goal.

A decision to treat or not treat a crop depends on the number of insects present. Simple but reliable sampling techniques are needed so that a farmer could easily and rapidly determine the size of a particular insect population. Moreover, the relationship between the insect population and the corresponding level of crop damage or injury should be clarified so that the farmer would know the significance of the number counted (i.e., the seriousness of the infestation). Population models should be developed so that the farmer could predict the pest population size with a minimum of sampling.

Aflatoxins, potent carcinogens, have been associated with arthropod damage on corn, cotton, and peanuts. The presence and level of these chemicals on other crops damaged by insects should be ascertained to permit a comparison of hazards between organically grown produce (which sometimes has evidence of insect damage) and conventionally grown produce (which is often treated with a series of insecticide applications).

Augmentation of the natural enemies of pests and the use of microbial pathogens of insects and mites would fit well into organic farming. Further research in this area is needed.

The dynamics of an agro-ecosystem are very complex, with most components impacting on each other. Research is needed to obtain a better understanding of these processes and to determine the effects of plant combinations and densities on pest populations. The interaction between soils, plants, and insects also needs investigation: the factors that permit an insect to locate a host plant and induce it to feed are not well understood and should be investigated. In addition, holistic studies should be conducted on the entire agro-ecosystem to determine how all the components impact each other. This would best be done on model organic farms paired with conventional farms.

New advances in nonchemical pest control methods and in practical and workable programs involving IPM will enhance the probability for successful and profitable organic farming. These should be considered as high priority research areas.

4.6 ECONOMIC ASSESSMENT OF ORGANIC FARMING

Organic farming differs from conventional farming in the way resources are allocated and used. Organic farmers substitute organic waste, green manure crops, crop rotations, and/or organic fertilizers for synthetic fertilizers. They tend to use more labor, make increased use of mechanical or hand methods for controlling weeds, and substitute biological pest control and crop rotations for chemical control of insects and diseases. Consequently, the costs for organically grown products probably will be different from those for conventionally grown products. Few studies have attempted to compare the economics of organic farming with conventional farming.

Lockeretz et al. (1), in a study of 14 selected organic crop/livestock farms in the Midwest compared with similar conventional farms, found that, on the average, net returns per cropland acre were equal for the two groups. Even though average crop yields per acre were lower on the organic farms, operating expenses were low enough so that crop returns were comparable with those of conventional farms. The analysis was based on income or returns above variable costs. Fixed costs were assumed to be the same on comparable farms.

A study in Washington State that compared crop production on three organic farms with production on three conventional farms showed that net returns per acre were 33

percent higher on the conventional farms (2). However, the small sample size and the difficulty in selecting paired observations were major weaknesses of the study. In a followup study of six organic farms in the Northwest, it was found that their net return per acre was 22.4 percent higher than on representative conventional farms growing similar crops in the same area (3). Some of the organic farms, however, did use limited amounts of chemical fertilizers.

In a study comparing 15 organic crop/livestock farms with conventional farms in the western Corn Belt (five States involved), Roberts et al. (4) found that in most cases the net return from organic farms exceeded the net return from those using conventional methods. The authors concluded that "organic crop production is to some degree an alternative to present conventional agricultural production" and that further indepth research is needed on organic agriculture especially in the areas of economics based on whole-farm analysis.

The Rodale Press survey revealed that only 14 out of 95 respondents who identified themselves as totally organic farmers reported that 50 percent or more of their income was from farming. Forty-two respondents reported that less than 20 percent of their total household income was from farming. Twenty-three respondents reported that none of their total household income was from farming. This implies that many who identify themselves as organic farmers are farming not solely for economic reasons, but to supplement their own food needs, for a hobby, or for recreation.

The survey showed that most of the organic farmers believe that, compared with conventional farming, their farm income is similar or lower, prices received for products are similar, and their level of indebtedness is lower. The USDA case studies are in good agreement with these findings. An exception, however, was that a greater proportion of the farmers interviewed in the case studies received higher product prices than those in the Rodale survey.

Although research information is limited, it appears that net returns from crop production on some organic crop/livestock farms are comparable to those obtained from conventional crop/livestock farms. However, data are not available on how returns from organic farms compare with those from comparable conventional farms of varying types and sizes.

4.6.1 An Economic Comparison of Crop Rotations on Organic Farms and Continuous Conventional Cropping

The USDA case studies were used to synthesize farm budgets in order to analyze the quantity, value, and costs of organic crop production for comparison with conventional cropping. In this analysis, the income above variable costs from organic crop production was determined for each of four different rotations and compared to the income above variable costs from conventional crop production of corn and soybeans on an equal number of acres.

Crop budgets for both organic and conventional systems were developed using assumed tillage practices, data for 1977 in the Firm Enterprise Data System developed by USDA's Economics, Statistics, and Cooperatives Service and Oklahoma State University, and data from Agricultural Statistics, 1978. For the analysis, organic corn yields were assumed to be 10 percent lower than conventional yields.[1] Organic

[1] William Lockeretz. "Testimony presented at hearings on Agricultural Productivity and Environmental Quality", Washington, D.C. July 25, 1979, p. 3.

soybean yields were assumed to be the same as conventional soybean yields. For the purpose of this study, the following crop rotations were considered.

ORGANIC SYSTEM:

4-year rotation -- Alfalfa - corn - soybeans - oats

5-year rotation -- Alfalfa - alfalfa - corn - soybeans - oats

7-year rotation -- Alfalfa - alfalfa-corn - soybeans - corn - soybeans - oats

CONVENTIONAL SYSTEM:

Corn - soybeans

According to the data developed for this analysis, corn and soybeans produced by conventional methods provide a larger income above variable costs than do crops produced organically in rotation. A crop budget analysis was prepared for an actual 340-acre organic farm in the Midwest. This particular farmer was following the 7-year rotation shown above. His income above variable costs was calculated to be $39,676. Income above variable costs for conventional corn and soybean production on this same farm was calculated to be $53,221, or $13,545 greater than the income received from organic crops produced in rotation. It is significant, however, that in the organic system corn and soybeans are produced on only 57 percent of the total acreage each year.

Three hypothetical cases were analyzed. Seven-, 5-, and 4-year organic crop rotations on 320 acres of cropland were compared with the same farm growing corn and soybeans conventionally. Income above variable costs was highest for conventional corn and soybean production, i.e., $49,443 compared to $40,662, $37,263, and $34,432 for the 7-, 4-, and 5-year rotations, respectively. From this analysis, the greater the substitution of other grain crops and alfalfa for corn and soybeans in the rotations, the lower the income from crop production. Based on crop production alone, this analysis suggests that organic farming does have an opportunity cost and that this is, perhaps, a major reason why few farmers choose to farm organically. These income figures do not take into account the social costs for organic or conventional farming.

4.6.2 Possible Economic Impacts of Increased Organic Farming in the Future

The future for organic farming is uncertain. Much depends on the availability and price of fertilizer (especially nitrogen) and farm labor, produce-price relationships, the domestic and world demand for food, concern for soil and water conservation, concern for health and the environment, and U.S. policies toward the development and promotion of organic farming practices. Due to one or more of the above factors, it may be economical for some farmers to produce certain crops and livestock organically rather than conventionally.

From a farming systems viewpoint, the shift from conventional to organic farming, however, is limited by the availability and quality of resources. A strictly organic farming system currently cannot be maintained in some parts of the United States because of the lack of an adequate and economical supply of organic wastes and residues (5) and/or because soil nutrients and climatic conditions are not suitable

for successful and profitable organic farming. Based on our observations, the greatest opportunity for organic farming will probably be on small farms and on larger mixed crop/livestock farms with large numbers of animal units.

From the study team's observations, small-scale farms generally depend more on labor than on capital and can make use of livestock manure or other wastes. Conventional farmers producing crops and livestock and applying livestock waste on cropland are already using practices related to organic farming to some degree. Consequently, the shift to organic farming would perhaps require little change in crop/livestock mix.

The aggregate economic impact of increased organic farming on the U.S. economy depends on the number, size, and type of farms that shift from conventional to organic methods and on the reasons why farmers make the change. Agriculture is a dynamic system, and it operates in a changing environment. Consequently, unless changes are forced on certain segments of agriculture through changes in farm policy and legislation, it is difficult to assess the overall impact of increased organic farming on total U.S. agricultural production, farm income, food prices, and exports. Therefore, the possible economic impacts discussed here are tentative and in need of further research.

Current estimates are that less than one percent of the total number of U.S. farms are farmed exclusively by organic methods. Since the number of totally organic farms is small compared with the total number of farms, and the crops produced organically vary from region to region, organic farms currently have a small economic impact on total agricultural production, input usage, total farm income, food prices, or agricultural exports.

All farms with sales less than $2,500 (more than 35 percent of the total number of farms in 1977) could be farmed organically with little total economic impact on U.S. agriculture. If all farms with sales of less than $20,000 shifted to organic farming, then some economic impact could arise. In 1977, almost 11 percent of the total cash receipts were accounted for by farms with sales of less than $20,000. More than 69 percent of the total number of farms were included in this grouping (6).

A major economic impact would result if a significant number of conventional farmers producing continuous corn and soybeans or other major crops with annual sales of $20,000 or above shifted to organic farming. Nearly 31 percent of the total number of farms in 1977 had sales of $20,000 or above and accounted for more than 89 percent of total farm cash receipts.

For the purpose of examining possible economic impacts, let us assume that in 1977, 30 percent of the total acreage harvested for corn and soybeans (7) (50 percent corn and 50 percent soybeans) is shifted from continuous corn/soybeans to organic farming with a 7-year rotation with the assumptions made earlier. Also assume that sufficient livestock waste is available for use on cropland from some type of livestock or poultry enterprise. On the basis of these assumptions, total U.S. annual corn and soybean production would be decreased by 0.9 and 0.2 billion bushels, respectively. Oat production would be increased by more than 0.3 billion bushels. Alfalfa hay production would be up 32.6 million tons. Total U.S. annual production of corn and soybeans would be decreased 14 and 12 percent, respectively. Oats and alfalfa hay production would increase 40 and 41 percent, respectively.

Consequently, in comparison to 1977 actual data, corn and soybean prices would be higher and oat and hay prices would be lower. According to current demand

elasticities, corn and soybean prices would be up 28 and 53 percent, respectively. The price of oats would be down 80 percent.[1] Hay prices would be lower, and with corn prices higher, more roughages such as alfalfa hay would be fed. The increased number of livestock would put downward pressure on livestock prices.[2] Total receipts would be down since the demand for livestock at the farm gate is relatively inelastic (8).

On the input side, the use of chemical fertilizers and pesticides would decrease to some degree. As a result, average prices of these products would be lower. However, the use of farm labor would be expanded somewhat. Total farm production expenses, including additional expenditures for labor, would be lower.

The total farm income for this situation is uncertain. Total farm receipts for corn and soybeans would increase, but receipts from small grains, hay, and livestock would be down. Total farm income would be higher if total income from corn and soybeans makes up for more than the loss in income from small grains, hay, and livestock. What impact this type of shift would have on food prices is also uncertain.

Total agricultural exports would be lower since corn and soybeans are important crops in the export market. Since the foreign demand elasticity for coarse grains ranges from -.025 to -.35, depending on the region of the world, and for soybeans is -.6, corn and soybean prices would be up enough so that total income from these exports would be increased.

The above impact would be shortrun. If prices of corn and soybeans were higher because of short supply, conventional farmers would expand production in the longrun. And lower prices for livestock would force adjustments in the livestock industry.

Olson and Heady (9), with the use of a computerized linear programming model, analyzed a total shift to organic farming for 1980. The objective of this model was to minimize costs of production and transportation within the constraints of satisfying estimated domestic and export demands, but without exceeding the amount of available cropland. Their study shows that in a total shift to organic farming, crop production would meet domestic needs but potential export levels would not be met. Decreased crop production would result in higher farm grain prices and higher total farm income in all regions. Total cost per unit of production would be higher, and consumer food prices would be significantly higher.

In summary, a number of conclusions and implications can be drawn:

1. A large number of farmers who operate small farms could change to organic farming with little economic impact on the U.S. economy.

2. A total shift to organic farming would have a major economic impact on the U.S. economy. However, a total shift to organic farming could not be made in the short run. Such a change requires a 3- to 5-year transition period, which would lessen the aggregate economic impact.

---

[1]These rough estimates were based on the following demand elasticities: Corn, -.5 soybean meal, -.2; and soybean oil, -.3.

[2]This assumes that total quantity of meat would be increased even though a large percentage of livestock would probably be fed hay.

3. The lack of data on successful organic farmers and the large number of interrelationships that exist within the total economic system make it extremely difficult to estimate the economic impact of increased organic farming in the future.

4. A significant decrease in the use of fertilizers and pesticides (and energy) would occur only if conventional farmers on the large mixed crop/livestock farms and specialized crop farms producing major crops shifted to organic systems.

REFERENCES

1. Lockeretz, W., G. Shearer, R. Klepper, and S. Sweeney. "Field crop production on organic farms in the Midwest," Jour. Soil and Water Conserv., Vol. 33, (1978), 130-134.

2. Eberle, P., and D. Holland. "Comparing organic and conventional grain farms in Washington," Tilth. Spring Issue, (1979), pp. 30-37.

3. Kraten, S. L. "A preliminary examination of the economic performance and energy intensiveness of organic and conventional small grain farms in the Northwest." Unpublished M.S. Thesis, Washington State University, Pullman, Wash., 1979.

4. Roberts, K. J., F. Warnken, and K. C. Schneeberger. "The economics of organic crop production in the Western Corn Belt," Agricultural economics paper, No. 1979-6, Dept. of Agricultural Economics, University of Missouri, Columbia. 1979.

5. U.S. Department of Agriculture. Improving soils with organic wastes. Report to the Congress in response to Section 1461 of Food and Agriculture Act of 1977 (P.L. 95-113). 157 pp., 1978.

6. U.S. Dept. Agr., Econ. Stat. Coop., Serv., Agricultural Outlook, AD-37, Oct. 1978, p. 6.

7. U.S. Dept. Agr., Agricultural Statistics. 1978.

8. Ball, E. Elasticities and price flexibilities for food items. LMS-229. U.S. Dept. Agr., Econ. Stat. Coop. Serv., Oct. 1979.

9. Olson, K. D., and E. O. Heady. "A national model of agricultural production, land use, export potential, and income under conventional and organic farming alternatives." Unpublished research report, Center for Agricultural and Rural Development, Iowa State University, 1979.

4.7 PRODUCTIVITY IN ORGANIC FARMING

4.7.1 Relation to energy.

Organic farmers avoid the use of pesticides and chemical fertilizers and thereby change the proportions of labor, capital, and natural resources needed to produce food and fiber. Therefore, the productivity of these inputs, as measured by

output per unit of input, can be expected to change. The recent changes in the energy market caused by the escalation of price and questionable availability of fossil fuels, have focused concern on the productivity of energy in agriculture.

The production and consumption of food in the United States utilize about 17 percent of our total energy budget. Less than one-fifth of this energy is used to supply farmers with their inputs and/or is used directly by the farmers to produce their products. Chemicals account for about one-third of the energy used in the production of agricultural commodities. Of this, more than 98 percent is used in the production of fertilizers. In turn, about 85 percent of the energy used in fertilizer production is used to manufacture synthetic nitrogen fertilizers. Thus, it appears that the organic farmers' practice of using biologically fixed nitrogen and organic wastes in place of synthetic nitrogen fertilizers may provide an opportunity for reducing energy inputs. However, the elimination of pesticides would not result in a significant conservation of energy, since relatively small amounts of energy are used in their production. It also appears that some nonchemical methods of pest control may be very energy intensive.

The high cost and uncertain availability of energy inputs may cause farmers to reduce some of their energy inputs by changing their methods of production, reducing the application of energy intensive inputs, or changing their crop mix. In response to higher fuel costs and limited supplies, farmers have tripled the amount of land managed under conservation tillage systems, which use only 20 to 50 percent of the fuel consumed by conventional tillage practices. The current ratio of price of nitrogen to price of output requires the profit-maximizing conventional farmer to be near the peak of the crop response function, which means that a major reduction in the rate of nitrogen application results in only a small decrease in yield. With high energy prices, the farmer is expected to take acres out of corn and plant leguminous crops, such as soybeans, which do not require any N fertilizer. Organic farming incorporates many of the changes farmers might be expected to make in response to inflated prices of energy.

Several researchers have studied the energy consumption of organic farmers and compared it to the energy consumption of conventional farmers. These studies are based on survey information from organic farmers. This information is either compared to information from a paired conventional farm (1), a group of conventional farmers (2), or hypothetical farms obtained from county energy consumption averages (3).

A major problem foreseen in predicting the effects of large-scale adoption of organic methods on energy productivity is the limited supply of organic wastes and residues available to replace synthetic nitrogen fertilizers. According to a recent USDA report (4), if all the organic wastes that are not now utilized on land were so utilized they would replace only about 20 percent of the chemical fertilizers that are presently used. If all the organic wastes classified as "likely" to be available for land application were utilized on land, they would replace only 6 percent of the nitrogen fertilizers currently used.

The net energy reduction from using manures to replace chemical fertilizers on corn is estimated to be about 25 percent. Most of the energy used to apply the manure comes from gasoline or diesel fuel, while most of the energy saved from not using chemical fertilizers comes from natural gas. Therefore, substituting organic wastes for chemical fertilizers will reduce the total farm energy used but will increase the consumption of gasoline or diesel fuel. The substitution of manures for fertilizer will reduce energy consumption significantly only where animals and crops are raised in close proximity, as is the case on many organic farms.

Lockeretz et al. (1) found that the value of output per unit of energy for organic farms was twice that of conventional farms (table 4.7.1). The crop mix between

Table 4.7.1 Energy productivity of crop production by type of farm (1).

Year	Organic	Conventional
	Energy Productivity (¢ market value/10^3 BTU)	
1975	15.2	6.2
1974	13.8	5.8
Average	14.5	6.2

farmers was different because the organic farmers produced greater amounts of lower valued crops by virtue of their rotation requirements. On a crop-by-crop basis, Lockeretz et al. (1) concluded that the organic farmers received more output per energy input than conventional farmers. They found that organic farmers were 300 percent more energy efficient in producing corn and 16 percent more energy efficient in growing soybeans.

Berardi (2) studied the energy productivity of organic and conventional wheat growers in New York and Pennsylvania (table 4.7.2). The organic farmers used about 30 percent less energy per acre than conventional farmers. However, because the

Table 4.7.2 Comparison of energy inputs per bushel of wheat of organic and conventional farmers in New York and Pennsylvania (2).

Input	Conventional	Organic
	Percent of total organic energy inputs	
Machinery	29.9	38.9
Fuel	24.3	27.2
Nitrogen	24.2	2.3
Phosphorus	4.9	.7
Potassium	4.3	.7
Seeds	25.5	26.6
Electricity	1.5	1.8
Lime	1.1	1.8
Total	115.7	100[1]

[1]This represents 775,500 K cal.

organic farmers' yield per acre averaged 22 percent below that of conventional farmers, the energy consumption per bushel of wheat was only 15 percent less than the energy consumed in conventional production. Average energy accounting of the farms in this study showed that the conventional farmers utilized considerably more energy for fertilizer than organic farmers. The organic farmers utilized more energy

for all other items but significantly so for machinery and fuel. Thus, this study shows that organic farming requires less total energy to produce a bushel of wheat than conventional methods.

A study by Kraten (3) of organic and conventional small grain farmers in the Northwest showed that organic farmers used less total energy but more fuel. These data are combined with Berardi's in table 4.7.3 to compare the energy intensiveness of organic and conventional farms. The energy savings from using less fertilizer more than makes up for the higher consumption of fuel. It is noteworthy that Kraten's study included an extremely dry season in which organic yields were significantly higher than conventional yields. In this case, the organic farmers were much more energy productive than the conventional farmers.

Table 4.7.3 Comparison of energy inputs per acre for different crops for organic (Org) and conventional (Conv) farms[1]

Crop	Fuel		Fertilizer		Total		Net
	Conv	Org	Conv	Org	Conv	Org	Energy saved[2]
				k cal X 10^3			
Winter Wheat (NW)[3]	331.5	513.3	476.2	176.4	807.7	689.7	15%
Winter Wheat (NE)[4]	242.0	210.1	332.9	28.9	574.9	239.	58%
Barley	329.4	522.2	394.4	21.8	723.8	544.	25%
Spring Wheat	414.0	509.5	664.0	60.0	1078.0	569.5	47%

[1] Adapted from Berardi (2) and Kraten (3).

[2] Derived by the formula: $\frac{\text{Total Conv - Total Org.}}{\text{Total Conv}}$

[3] Northwestern United States.

[4] Northeastern United States.

4.7.2 Comparison of Crop Yields on Organic and Conventional Farms

Comparison of organic crop yields with conventional crop yields is extremely difficult and controversial. A few researchers have compared the yields from selected crops on organic farms to yields of crops on comparable conventional farms or to average county yields of the same crops.

A brief review of the yield data collected in these studies, plus other available information, provides some limited insight into organic and conventional crop yield differences. The results of these short-term studies may not reliably indicate the long-term performance of organic farming or its performance under other soil, crop, and climatic conditions. Where declining soil P or K status is expected to continue, in many cases it would eventually be expected to affect yields unless current organic farming practices were modified.

Short-term studies of organic and conventional crop production by the Center for the Biology of Natural Systems at Washington University in St. Louis, Missouri, over a 5-year period, 1974-78, showed that on selected farms in the Corn Belt, major yield differences appeared to occur in corn and wheat production. Soybean and oats yield over the 5-year period averaged slightly higher on organic farms compared to yields on conventional farms or to average yields in the respective counties (table 4.7.4).

From the studies, it was concluded that "Organic farmers had corn yields that averaged only about 9 percent below those of their conventional neighbors. Under highly favorable growing conditions, when corn can benefit most from fertilizer applications, the conventional farmers did considerably better. But under drought, which was a serious problem in parts of the region (Corn Belt) during the mid-1970's, organic farmers seemed to do about as well as, if not better than, their conventional counterparts" (4).

Table 4.7.4 Average yields reported for selected crops on selected Midwest farms.

Year	Crop	Organic farms	County average	Conventional farms	County average
			Bushels per acre		
1974[1]	Corn	74	75	71	73
	Soybeans	32	25	28	25
	Wheat	28	31	29	29
	Oats	59	55	59	59
	Hay	5		3.4	
1975[1]	Corn	74	90	94	88
	Soybeans	34	30	38	31
	Wheat	26	38	41	36
	Oats	56	NA	57	NA
	Hay	4.5		4	
1974-76[2]	Corn	76.8	80.8	82.7	77.8
	Soybeans	30.1	27.0	32.0	27.0
	Wheat	29.1	34.0	38.0	34.0
	Oats	60.8	55.0	61.9	58.0
1977[3]	Corn	77.9	84.4		
	Soybeans	33.9	33.6		
	Oats	66.2	59.9		
1978[3]	Corn	98.6	118.0		
	Soybeans	35.5	38.2		
	Oats	67.9	63.8		

[1] Klepper et al. (6).
[2] Lockeretz et al. (7).
[3] Private communication with Georgia Shearer, CBNS, Washington University, Saint Louis, Missouri, August 1, 1979. Data for conventional farms not provided.

In a limited study of organic (some farmers used chemical fertilizers and/or chemical pesticides to a limited extent) and conventional small-grain farms in the Northwest, Kraten (3) found crop yields to be considerably higher on a few paired conventional farms and higher in some cases on the paired organic farms.

Overall, however, organic farms had slightly higher grain yields than did the conventional farms. The combined average yields of all grains grown on the organic farms was 39.0 bushels per acre as compared with 35.2 bushels per acre on conventional farms.

In a 1974-75 study, Berardi (2) compared 10 conventional farmers growing winter wheat in New York State with 10 organic wheat growers in the States of New York and Pennsylvania. She found the average wheat yields to be 28.5 percent higher on the conventional farms in comparison to average wheat yields on the organic farms. Average wheat yield on the organic farms was 34 bushels per acre and on the conventional farms, 44 bushels per acre.

Roberts et al. (5), in a study on the economics of organic crop production in the western Corn Belt, compared crop production of 15 organic farmers to USDA data on conventional farms located in the same area. Data on yields for corn, soybeans, oats, and wheat were collected for 1973 through 1976. Average yields on the organic farms compared to average yields in the States where the organic farms were located were lower for corn, higher for soybeans and oats, and the same for wheat (table 4.7.5). Roberts et al. (5), with regard to crop yields on organic versus conventional farms, concluded that:

1) It was not possible to draw conclusions in the comparison of corn yields between the organic sample and the control group;

2) Soybean yields of organic farmers are at least equal to, if not greater than, soybean yields of conventional farmers;

3) No conclusions could be reached that organic oat yields are equal to oat yields under conventional farming; and

4) Organic wheat production appears competitive with conventional production.

Table 4.7.5 Organic and conventional average crop yields, western Corn Belt, 1973-76.

Crop	Conventional[1]	Organic[2]
	Bushels per acre	
Corn	78	75
Soybeans	28	32
Oats	47	64
Wheat	34	34

[1] Five-State average yields reported by Statistical Reporting Service (SRS).
[2] Weighted average yields based on production years 1973 through 1976 (5).

The above information should not be interpreted as representative of all organic farmers growing the same crops. Crop yields depend not only on soil fertility but upon seed varieties; climatic conditions; control of weeds, insects, and diseases; harvesting methods; and other crop management practices.

Some farms, it appears, are located on the type of soils and in a climate where yields from crops produced organically may be as economical as crops produced conventionally. In some areas or for some farmers, crop production without the use of chemical fertilizers, pesticides, or insecticides may greatly reduce yields and, consequently, income. Unless production costs are greatly reduced, low crop yields can impact heavily on the farmer's net income.

Some farmers who have more available labor than capital, especially those on small farms, may be able to take advantage of organic farming practices. Small vegetable farmers, with proper use of organic waste and nonchemical control methods, are obtaining fairly high yields. Their success, however, depends on whether net income continues to cover their minimum cost of living.

More than half of the organic farmers visited for this study believed that their average yields were about the same as average yields on the other farms in their respective areas. About an equal number of organic farmers reported their yields were higher or lower than yields of conventional farmers nearby.

The response of strictly organic farmers in the Rodale Press survey was the same as mentioned above. Thirty-eight farmers believed average yields on their farms were the same as average yields on other farms in their county. Twenty-three organic farmers believed yields were higher, and 20 organic farmers believed their yields were lower. Among the combination respondents, 113 farmers reported average yields were the same as the average yields of other farms in their respective counties. Forty-six combination respondents reported that their yields were higher. Only 23 respondents reported that their yields were lower than the yields on other farms in their county.

From the above review, it is apparent that general statements concerning yields expected with organic farming are restricted by the great range of soils, crops, climatic conditions, livestock enterprises, and management levels present in U.S. agriculture, and also by the general lack of research results from well-designed, replicated, experimental plots comparing long-term yields from organic farming and conventional farming. Such comparisons are complicated by the large number of possible variables involved, the great range of organic and conventional farming practices in use, and the necessity that comparisons must be conducted over a time period of sufficient length to accurately assess the stability of the systems. Research has been conducted either as:

1) Replicated small-plot comparisons of individual treatments, which are open to the criticism of not adequately representing organic farming per se; or as

2) Small numbers of large-scale, field- or farm-sized, short-term comparisons, with substantial but undetermined errors due to problems inherent in matching soil and climatic conditions encountered on these farms and in accurately measuring yields on such large units.

REFERENCES

1. Lockeretz, W., R. Klepper, B. Commoner, M. Gertler, S. Fast, and D. O'Leary. "Organic and conventional crop production in the Corn Belt: a comparison of economic performance and energy use for selected farms." Center for the Biology of Natural Systems, Rep. No. CBNS-AE-7, Washington University, St. Louis, Missouri. 1976.

2. Berardi, G. M. "Organic and conventional wheat production: examination of energy and economics." Agro-Ecosystems, Vol. 4, (1978), 367-376.

3. Kraten, S. L. "A preliminary examination of the economic performance and energy intensiveness of organic and conventional small grain farms in the Northwest." Unpublished M.S. thesis, Washington State University, Pullman, Wash., 1979.

4. Lockeretz, W. "Testimony presented at hearings on Agricultural Productivity and Environmental Quality." Washington, D.C., July 25, 1979.

5. Roberts, K. J., P. F. Warnken, and K. C. Schneeberger. "The economics of organic crop production in the Western Born Belt." Agri. Econ. Paper No. 1979-6, Dept. of Agricultural Economics, Univ. of Missouri, Columbia, 1979.

6. Klepper, R., W. Lockeretz, B. Commoner, M. Gertler, S. Fast, D. O'Leary, and R. Blobaum. "Economic performance and energy intensiveness on organic and conventional farms in the Corn Belt; A preliminary comparison." Amer. Jour. Agri. Economics, Vol. 59, (1977), 1-12.

7. Lockeretz, W., G. Shearer, R. Klepper, and S. Sweeney. "Field crop production on organic farms in the Midwest." Jour. Soil and Water Conservation, Vol. 33, (1978), 130-134.

4.8 LABOR INTENSIVENESS ON ORGANIC FARMS

The nature and intensity of labor used in agricultural production systems depend on soil type and topography, types of crops and livestock, type and size of machinery and equipment, and overall labor and management efficiency. Consequently, labor use may vary significantly among organic farms, or between organic and conventional farms.

In a paired comparison of 14 organic farms with 14 conventional farms, Klepper et al. (1) found that labor requirements for crop production were only slightly higher for organic farms than for conventional farms (3.3 hours/acre for organic and 3.2 hours/acre for conventional). However, when expressed as labor input per dollar of crop output, the use of labor was much higher for the organic group because the value of crop output per acre was lower. The organic farmers spent 19.8 hours per $1,000 of crop output compared with 17.8 hours for the conventional farmers. The organic farmers' labor requirements were similar to those of the conventional farmers for corn and small grains but higher for soybeans.

In a comparison of two organic farms with two conventional grain farms in Washington State by Eberle and Holland (2), it was found that one of the organic farms used 5.65 hours per acre compared to only 0.59 hours per acre for the conventional farm. An explanation for such a large difference was that the organic

farmer was controlling potato pests with hand labor. The other organic farm averaged 1.9 hours/acre for crop production compared to 1.3 hours on the conventional farm.

Roberts et al. (3) compared the labor costs of organic farms in the western Corn Belt with data representative of comparable conventional farms. Labor costs for the production of corn, oats, and wheat, in most cases, were less on organic farms than on conventional farms. However, the labor cost for soybean production on organic farms was greater than on the conventional farms because of the additional labor required for weed control.

In a study comparing organic and conventional wheat growers in New York and Pennsylvania, Berardi (4) found that the organic farmers required 8.5 hours/acre to produce wheat compared to 3.6 hours/acre for conventional farmers. By excluding one Amish farmer in the organic group, who was using horses, the labor requirements for the organic group averaged 5.3 hours/acre.

Oelhaf (5) found that labor requirements for vegetable production on organic and conventional farms varied widely. He concluded that, except for intensive tomato cultivation for the fresh market, organic vegetable production requires more labor than conventional production.

In a study of 31 small organic farms in Maine, Vail and Rozyne (6) found that 12 could not fulfill their labor requirements because of high labor costs. Nine farmers reported that labor shortages were a major obstacle to making a living on small farms. More than half of the farmers in the survey who hired farm labor described problems with recruitment, poor work habits, absenteeism, or high turnover. Because of the diversity of enterprises on small farms, a large number experienced excessive labor problems because the farm had not been sufficiently mechanized.

Most of the organic farmers in the USDA case studies believed that labor requirements on their farms were higher or similar to labor requirements on nearby conventional farms. Very few of the organic farmers reported them to be lower. Five farmers had even reduced or modified their organic practices because of high labor requirements. In the Rodale Press survey, 24 of the 95 totally organic respondents reported that their labor requirements were higher than on conventional farms, 28 reported them to be similar, while 23 reported them to be lower.

Based on this rather limited information, it would appear that organic farms generally require more labor for their operation than conventional farms, but that exceptions occur. Labor requirements on organic farms depend to a large extent on how effectively weeds, insects, and diseases are controlled with mechanical or nonchemical methods. If considerable hand weeding or other types of manual labor are required, then organic systems are more labor-intensive than conventional systems.

Organic farms with horses and horse-drawn equipment or old machinery and equipment are highly labor-intensive but less capital-intensive. Consequently, labor efficiency (output per unit of labor input) will be quite low.

The labor required to farm organically is a major limitation to the expansion of some organic farms (especially vegetable farms where hand weeding is required) and an important deterrent to some conventional farmers thinking of shifting to organic farming.

REFERENCES

1. Klepper, R., W. Lockeretz, B. Commoner, M. Gertler, S. Fast, D. O'Leary, and R. Blobaum. "Economic performance and energy intensiveness on organic and conventional farms in the Corn Belt: a preliminary comparison." Amer. Jour. Agricultural Economics, Vol. 49 (1977), 9-10.

2. Eberle, P., and D. Holland. "Comparing Organic and Conventional Grain Farms in Washington." Tilth, Spring 1978, pp. 34-35.

3. Roberts, K. J., P. F. Warnken, and K. C. Schneeberger. "The economics of organic crop production in the Western Corn Belt." Agricultural Economics Paper No. 1979-6. Dept. of Agricultural Economics, Univ. of Missouri, Columbia, 1979, pp. 95-99.

4. Berardi, G. M. "Organic and conventional wheat production: examination of energy and economics." Agro-Ecosystems, Vol. 4 (1978), 367-376.

5. Oelhaf, R. C. Organic agriculture: economic and ecological comparisons with conventional methods. Halsted Press, New York (1978), pp. 206-208.

6. Vail, D., and M. Rozyne. "Appropriate technology for small farms: Lessons from 31 organic farms in Maine." Idea Paper No. 11, Maine Small Farm Management and Technology Project. Dept. of Economics, Bowdoin College, Brunswick, Maine, 1978, 28 pp.

4.9 WATER CONSERVATION

Many practices frequently employed by organic farmers are known to increase water infiltration and storage but will not necessarily conserve water for subsequent crops. Moreover, these practices are not as effective for conserving water as some practices used in conventional farming.

4.9.1 Tillage

The organic farmers' choice of the chisel plow or offset disk over the moldboard plow, which is used more frequently by conventional farmers, is known to be effective for improving water conservation. Research also indicates that long-term use of the organic farmer's method of shallow tillage, which incorporates crop residues near the surface, may temporarily increase water infiltration compared with moldboard plowing (1). On the other hand, conservation tillage practices, which include some forms of minimum tillage or no-till, are even more effective for water conservation. These systems as yet are not viable options for organic farming because pesticides are required to control weeds and insects harbored in crop residues. Additional pre- or post- plant tillage as a substitute for pesticides would decrease the effectiveness of conservation tillage systems.

4.9.2 Cropping Practice

There are some residual benefits of sod crops, such as increasing water infiltration for a year or so after the sod is plowed out; however, this effect declines rapidly thereafter. Apart from this, sod, especially deep-rooted alfalfa, and cover crops often used in the organic rotation consume large amounts of water, and in lower rainfall areas may contribute to a water deficit for the subsequent crop.

4.9.3 Organic Matter Effects

The infiltration capacity of fallow soils was shown to increase as soil organic matter content increased (2). However, experiments have shown that short-term changes in soil organic matter due to soil management are difficult to measure unless extremely large amounts of organic material are added (3).

REFERENCES

1. Johnson, C. B., and W. C. Moldenhauer. "Effect of chisel versus moldboard plowing on soil erosion by water," Soil Sci. Soc. Amer. Jour., Vol. 43 (1979), 177-179.

2. Wischmeier, W. H. "Relation of field-plot runoff to management and physical factors," Soil Sci. Soc. Amer. Proc., Vol. 30 (1966), 272-277.

3. Lucas, R. E., and N. L. Vitosh. "Soil organic matter dynamics," Michigan State University Agr. Expt. Sta., Research Report No. 358., East Lansing, Mich., 1978.

4.10 IMPACT OF ORGANIC AGRICULTURE ON ENVIRONMENTAL QUALITY

Differences between organic farming and conventional farming without adequate conservation practices are such that conventional farms are more likely to adversely affect the environment through increased soil erosion and plant nutrient and pesticide runoff.

4.10.1 Soil Erosion Control with Organic Farming

Effective erosion control methods practiced by organic farmers include the use of grass, legume, and small grain crops which decrease the percentage of row crops in the rotation, use of cover crops, green manure crops, and tillage methods that conserve surface crop residues. Organic agriculture also strongly emphasizes the application of manure and other organic materials to maintain or increase the soil organic matter content which, in turn, increases water infiltration and storage, decreases nutrient and pesticide runoff, and reduces soil erosion.

The effect of soil and crop management practices on soil erosion by water can be evaluated with the cover and management factor, or C factor, in the Universal Soil Loss Equation (1). The C factor, which ranges in value from a minimum of about 0.001 for well-managed woodland to a maximum of 1.0 for continuous fallow, is directly proportional to soil loss on a given site and reflects only differences in soil and crop management.

4.10.1.1 Crop Rotations -- Many organic farmers maintain from 25 to 40 percent of their cropland acreage in sod crops, such as grass and legumes, whereas the chemical-intensive (conventional) farmer often grows mostly row crops, such as corn and soybeans, with little or no grass or legume crops in the rotation and uses conventional planting and tillage practices.

The first column of table 4.10.1 shows that, with conventional tillage, as the percentage of row crops in the rotation is decreased, the potential for soil loss decreases markedly. These data show that where sod crops comprise 25 to 40 percent

Table 4.10.1 Effect of rotation and tillage on relative soil loss.

Rotation	Conventional tillage	No-till corn[1]
	C factor[2]	
C	0.35	0.11
C-B	.43	.18
C-C-C-W-M-M	.14	.061
C-C-W-M	.12	.068
C-C-W-M-M	.087	.051
C-W-M	.055	--
M	.044	--

C = corn; B = soybeans; W = wheat; and M = meadow.

1 The 2nd and 3rd crop of corn were planted no-till and the first crop was not.

2 C is the cover and management factor in the Universal Soil Loss Equation (1). This factor is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow. The numbers in the table are directly proportional to soil loss for a given site. The C factors for these rotations were taken from Stewart et al. (7).

of the rotation, the average annual soil loss is only one-third to one-eighth of that which occurs with conventional tillage and continuous row cropping.

Cover crops used by organic farmers may also reduce soil erosion by up to 50 percent when they follow crops that leave only small amounts of residue after harvest, such as potatoes, most vegetables, and corn harvested for silage.

4.10.1.2 Tillage -- Many of the organic farmers in our case studies had already shifted from the moldboard plow to the chisel plow and disk-type implements which would provide even greater erosion control compared with conventional methods. Studies conducted in the Midwest showed that when chisel and disk implements were used in primary tillage operations, soil loss was reduced by 20 to 75 percent of that which occurred from conventional tillage. The favorable results from chisel and disk implements are mainly due to effective placement of residues at or near the soil surface. This type of tillage, which is not unique to organic farming, is becoming well accepted in wide areas of the Corn Belt and in parts of the Pacific Northwest.

One of the most effective erosion control methods that could be adopted in chemical-intensive systems is conservation tillage, which includes minimum tillage and no-till methods. Conservation tillage systems are generally not a viable option for organic agriculture because they require pesticides to control weeds and insects. With no-till planting, soil erosion losses from a corn-soybean sequence are one-third to three times greater than with sod crops in the rotation (table 4.10.1). No-till continuous corn has a C factor value more comparable to that of meadow rotations with conventional tillage. Conservation tillage systems, though not yet extensively used in the United States, are gaining popularity among some farmers.

4.10.1.3 Organic Matter -- Increases in soil organic matter that are associated with organic farming practices could also significantly decrease erosion. Differences in the content of soil organic matter from manure applications and crop rotations may range from a fraction to several percentage points. For example, at Rothamsted, England, soil cropped with barley and treated continuously since 1852 with NPK fertilizers had an organic matter content of 1.90 percent, while soil treated continuously with manure had an organic matter content of 4.85 percent (2). This research also showed that grass and legumes in the rotation tend to maintain soil organic matter at higher levels (0.5 percent or more) than continuous arable cropping.

The effect on soil erosion of increased soil organic matter content is quantified by the soil erodibility factor, K, in the Universal Soil Loss Equation (1). The change in the K factor, which results from a change in organic matter, can be estimated for many soils from a soil erodibility nomograph (1). This nomograph shows that an increase in the organic matter content of 1 percent (e.g., changing the organic matter content from 3 to 4 percent) of some soils will decrease the K factor by 10 percent and would, in turn, decrease the potential for soil erosion loss by this amount. This does not take into account changes in the structure index and permeability class, which also might be improved by increasing the organic matter content.

4.10.1.4 Use of Supporting Practices -- Our case studies showed that organic farmers have made good use of erosion control support practices, such as terraces, contour stripcropping, contour farming, and grassed waterways. However, we were not able to assess whether they used these practices to a greater extent than their conventional neighbors.

4.10.2 Nutrient Loss with Organic Farming

Nutrient losses contributing to environmental pollution would appear to be less with organic farming than with conventional farming where land is not adequately protected by conservation practices.

Nutrient losses are minimized by use of organic nutrient sources, inorganic nutrient sources of limited solubility, and the use of practices that control runoff, leaching, and erosion. The plant nutrients that are of greatest concern with respect to water pollution are N and P.

4.10.2.1 Excessive Fertilization -- There is considerable evidence that excessive use of chemical fertilizers can contribute significantly to the pollution of surface and groundwaters with plant nutrients (3, 4). Some growers have tended to apply N and P in excess of that actually needed because existing technology can not accurately predict the crop's fertilizer requirements. A portion of this unused fertilizer, especially N, can become a potential environmental pollutant.

Organic agriculture uses chemical fertilizers only sparingly and selectively, if at all, and relies mainly on nutrient sources that are not readily susceptible to loss even when applied in excess of crop needs. Moreover, analysis of the nutrient budget on organic farms indicates that some operate at nutrient levels that might be considered too low for maximum yields (Section 4.1). Therefore, this system largely eliminates the potential pollution hazard from excessive fertilization.

4.10.2.2 Control of Leaching Loss -- There is evidence that N from application of chemical fertilizer sources can pollute groundwater under some conditions (3, 4). This problem is associated with high rates of fertilizer application, high rainfall or irrigation, sandy soils, and shallow-rooted crops.

Besides avoiding excessive fertilization, organic farmers utilize practices that effectively control nutrient leaching losses. These include use of animal manure and other organic nutrient sources, crop rotations, and green manure and winter cover crops. Nitrogen is released slowly from organic nutrient sources, and with plant uptake, less nitrate-nitrogen is available for leaching. However, if N release continues after crop harvest, the nitrates may be subject to leaching later on.

Rotating crops that require little or no N fertilizer (soybeans and alfalfa) with crops requiring high N levels (corn, wheat), as practiced by many organic farmers, will reduce the long-term average amount of N available for leaching (5). Moreover, alfalfa may reduce nitrate leaching because its deep-rooting characteristics enable it to absorb nitrates from below the soil root-zone of most crops. Winter cover crops may also reduce nitrate leaching through plant uptake of nitrate and by extracting soil water so that less is available for percolation. Nonleguminous crops, such as oats, timothy, and rye, have been shown to reduce leaching losses from 40 to 60 percent (5). A legume may be less effective because it fixes nitrogen, thereby increasing the concentration of nitrate in the soil.

There is evidence that the use of N fertilizer can actually reduce nitrate leaching by increasing plant growth (5). Moreover, low amounts of P and K, relative to the N supply, may result in considerable amounts of unutilized nitrate in the root zone. Singh and Sekhon (4) showed that after wheat harvest in a wheat-corn rotation, much nitrate remained in the soil profile where no P and K were applied with 120 kg N/ha. When P was applied at 26 kg/ha and K at 25 kg/ha, little nitrate was found in the soil profile to a depth of 2 meters. This suggests that an adequate and balanced supply of nutrients for the crop can also be highly effective in reducing nitrate leaching losses.

4.10.2.3 Nutrient Losses from Runoff and Erosion -- Excessive erosion and runoff can contribute significantly to the pollution of surface waters by plant nutrients. Sediment from soil erosion is not only a major pollutant in itself, but it is the principal means of transporting inorganic P and organic N from watersheds.

The use of sod and cover crops in organic farming systems would also reduce the potential for nutrient runoff losses. For example, Stewart et al. (5) reported that N and P losses from runoff were threefold to sixfold less in a corn-wheat-clover rotation compared with continuous corn. Similarly, there was a 50-percent reduction in runoff and a 40-fold reduction in the loss of sediment, total N, and total P when corn was planted in a ryegrass cover crop.

The use of organic materials in the farming system does not necessarily eliminate the potential for water pollution. Manure and certain other organic materials, such as domestic and industrial sludges, can create a pollution hazard as high or higher than that from commercial fertilizer if improperly applied, or if the materials contain substances that are potentially toxic to plants, humans, or animals. The most serious problems would involve nutrients and other chemicals in runoff and contamination of soils with heavy metals or toxic organic chemicals. Nutrients can be readily lost if runoff occurs before manures or sludges are incorporated in the soil. Runoff from rains and snow melt can remove 10 to 20 percent of the N and P in manure applied on frozen or snow-covered fields (5).

4.10.3 Pesticide Pollution

Organic farming strongly encourages that the use of synthetic pesticides be avoided in crop production. Use of pesticides has increased 40-fold in the last

three decades. Herbicide use continues to increase, but insecticide use has stabilized. Cotton, corn, and fruits and vegetables receive the greatest amounts of insecticides, herbicides, and fungicides, respectively. Agricultural pesticides have the potential to cause adverse biological effects throughout the environment because of the continuous exchange of pesticides between soils, living organisms, water, and air.

4.10.3.1 Pesticides in runoff -- A summary of studies on pesticides in runoff shows that with recommended rates of application, losses of some chemicals ranged from undetectable amounts to 5 percent of the amount applied (6). The highest potential for loss was in the early weeks following application, when heavy precipitation and runoff could remove up to 20 percent of the amount applied. In the case of short-lived pesticides, to which we are now shifting, the concentration in runoff will depend on the probability of rainfall and runoff occurring soon after application. Thus, the acute effects of these short-lived pesticides will become more important than chronic effects in determining potential environmental hazards.

Aerial losses of pesticides (i.e., losses during application and post-application volatilization) are sometimes greater than runoff losses and may contribute greater amounts to aquatic environments than runoff. Nevertheless, runoff losses have received more attention and are of greater concern because of the direct input to natural surface waters and because of publicity from fish kills, decreased fish productivity, and contamination of other aquatic species.

4.10.3.2 Effect of Erosion and Runoff Control on Pesticide Pollution -- Erosion control practices should reduce loss of pesticides transported by sediment. However, the distribution of most pesticides in runoff is such that the bulk of the pesticide is transported in the water phase because of the greater volume of water relative to sediment. Thus, conservation practices that reduce runoff volume may be more important than those designed to reduce erosion and sediment yield.

How effective will no-till systems be for reducing nonpoint pollution by pesticides? The absence of tillage usually requires increased use of herbicides for weed control and possibly increased use of insecticides. Unfortunately, the effect of no-till systems on the potential for pesticide pollution cannot be readily assessed at this time.

REFERENCES

1. Wischmeier, W. H., and D. D. Smith. Predicting rainfall erosion losses. AH 537. U.S. Dept. Agr., 1978, 38 pp.

2. Cooke, G. W. "The roles of organic manures and organic matter in managing soils for higher crop yields: A review of the experimental evidence." In Proceedings of the International Seminar on Soil Environment and Fertility Management in Intensive Agriculture. Tokyo, Japan, (1977), pp. 53-64. (G. W. Cooke, Ministry of Agriculture, Agricultural Research Council, London, England).

3. Parr, J. F. "Chemical and biochemical considerations for maximizing the efficiency of fertilizer nitrogen," J. Environ. Qual, Vol. 2 (1973), 75-84.

4. Singh, B., and G. S. Sekhon. "Nitrate pollution of groundwater from farm use of nitrogen fertilizers--A review," Agriculture and Environment, Vol. 4 (1978), 207-225.

5. Stewart, B. A., D. A. Woolhiser, W. H. Wischmeir, J. H. Caro, and M. H. Frere. "Control of Water pollution from cropland." U.S. Dept. Agr. and Environ. Prot. Agency, Vol. II (1976), 187 pp.

6. Wauchope, R. D. "The pesticide content of surface water draining from agricultural fields," J. Environ. Qual., Vol. 7 (1978), 459-472.

7. Stewart, B. A., D. A. Woolhiser, W. H. Wischmeier, J. H. Caro, and M. H. Frere. "Control of water pollution from cropland." U.S. Dept. Agr. and Environ. Prot. Agency, Vol. I (1975), 111 pp.

4.11 NUTRITIONAL QUALITY AND FOOD SAFETY

4.11.1 Background and Terminology

Many organic farmers believe that organically produced foods are more healthful than similar products from conventional farms. Such superior healthfulness could presumably arise from greater amounts or better proportions of beneficial nutrients in the food, for example, more or better quality of protein, more nutritionally important trace elements, more important vitamins, or more of some other known or unknown but nutritionally important constituent. The organic food would thus have better "nutritional quality." Superior healthfulness could also arise from a lower content in the food--or a complete absence from it--of health-harmful residues of pesticides, antibiotics, hormones, or accidental contaminants or pollutants. If the detrimental health effects of such extraneous chemicals in the conventional food were real, the organic food might then have superior "health safety".

Some organic farmers also believe that not only foods but also forages and feeds from their farms have superior nutritional quality and health safety and that this is, at least in part, the cause of the superior health which they believe to be seen in the animals on their farms.

4.11.2 Nutritional Quality

4.11.2.1 Foods -- Several nutritionists and other research scientists have examined the evidence available on the comparative nutritional quality of foods from organic and conventional farms. Seven are known to have published statements of their findings on this subject (1). In each case, the authority involved has denied the validity of claims for nutritional superiority made by others for organic foods. To some degree, nutritionists' statements on this subject may represent skeptical responses to certain previous claims by others to the effect that a diet of organic food is helpful in preventing poor health.

Claims for nutritional superiority of organic foods with respect to trace element composition seem not to be accompanied by credible supporting evidence. Studies relating to trace elements in food sources have been made by many nutritionists and other scientists. No clear evidence has been found in the literature, however, that plants grown with inorganic fertilizer amendments to the soil regularly take up smaller amounts of trace elements or accumulate these elements in lower concentrations than plants grown with organic soil amendments only. Trace element uptake is influenced by many factors. Some organic farming advocates have made claims for special benefits from "organic iron" in organic produce. Iron deficiency is recognized to constitute a problem with many women of child-bearing age, especially during pregnancy. Iron deficiency is also a problem with many infants, but there seems to be no evidence that organic farming practices offer any special help with these matters.

Future research could conceivably uncover previously unsuspected evidence of superior content of beneficial nutrients in organic as compared with conventional produce. But such evidence was not found in the presently available literature during this study.

4.11.2.2 Forages and Feeds -- Many different nutritional problems occur in farm animals, but few if any of these seem to be uniquely related to the use of inorganic fertilizers or organic amendments on soils. Low levels of selenium in soils may result in healthy looking forage but may cause a selenium deficiency in an animal that consumes it. Animals also require sodium, cobalt, and iodine, which forage plants do not, and this can result in nutritional problems in animals eating material from essentially healthy plants. Better health in farm animals on organic farms could well result from better management practices, such as improved rations, a higher level of cleanliness and hygiene, and less strict confinement.

4.11.3 Health Safety

Since the publication of Rachel Carson's book "Silent Spring" in 1962, extraneous chemicals of agricultural origin have come under close scrutiny in the United States with respect to the possibility of their causing adverse effects on health. Such chemicals have consisted principally of pesticides, animal growth promoters (such as diethylstilbestrol, antibiotics, and other antibacterial agents), chemicals coming accidentally into the food chain through animal feeds, and pollutants of agricultural origin in water supply sources. Chemical food additives, also generally avoided by organic farmers, have also been under question as possible causes of health risks.

Residual pesticides in foods were regarded with increasing uneasiness in the mid-sixties. A particular burst of apprehension occurred in 1969 following public release of data reporting experimental stimulation of tumor formation in mice by the insecticide DDT and the herbicide 2,4,5-T. Although these data were recognized at the time to be only doubtfully interpretable into terms of human hazard, the newly formed Environmental Protection Agency (EPA) suspended U.S. agricultural use of both of these pesticides in 1972. Similar data on tumor stimulation in laboratory mice and rats has been to a major degree responsible for successive EPA suspensions of the insecticides chlordane, heptachlor, aldrin, dieldrin, mirex, toxaphene, and the widely used nematacide dibromochloropropane (DBCP).

No information uncovered in the preparation of this report conclusively proves that pesticide residues in foods have caused such health problems as cancer, miscarriages, birth deformities, or nerve disorders. On the one hand, allegations of a causal relationship between the use of 2,4,5-T on forested areas in the Northwest and subsequent miscarriages in the population have been regarded by a committee of experts, including former U. S. Surgeon General Jesse Steinfeld, as being of highly doubtful validity (2). On the other hand, data showing adverse effects of high ingestion levels of pesticides on experimental animals are now extensive and appear to warrant a cautious and watchful attitude in the future with respect to possible effects on humans (3). The USDA has a clear policy of protecting the public in matters of health safety of foods and has cooperated closely with Federal regulatory officials in the Food and Drug Administration (FDA) and EPA.

The animal growth promoter, diethylstilbestrol (DES), used widely until recently in the raising of beef cattle, is now banned by an order from the FDA (4). DES was considered by many reputable scientists to represent a risk of doubtful significance to the beef-consuming public. At the same time, allegations of hazards from the same material in human medical use were the subject of very major attention in the

news media and probably contributed greatly to an adverse public opinion regarding use of DES in animals. The cancer-causing effects of DES in experimental animals were well established. Substitute growth-promoting materials for farm animals, also estrogenic, are currently coming into use.

The antibiotics pencillin and tetracycline, once highly effective in human medicine, have now become much less helpful because of the development of many strains of human disease-causing bacteria much less sensitive to them. Overuse of antibiotics in medical practice is generally regarded as a major cause of the problem, but use of the same antibiotics in animal feeds on the farm has not been totally exonerated from blame as a contributory cause. Food and Drug Administration officials currently tend toward an adverse view of the use of human-medical types of antibiotics in farm animals, in spite of the fact that very little direct incriminating evidence is available. A committee of experts under the aegis of the National Academy of Science is currently undertaking an intensive examination of the matter. The possibility of allergies arising from antibiotics, of adverse human reactions to sulfa residues, and of carcinogenic potentialities from residues of furazolidone in meats is also under review.

The use of nitrites in meat products has been a cause of concern in the Department because of tumor-stimulating possibilities associated with such compounds and especially with nitroso compounds produced from them during cooking. The problem is a complex one, clouded in this case with some uncertainty because of multiple sources of nitrate and nitrite in the diet and other sources of nitroso compounds in the diet and in the environment. A gradual decrease in levels of added nitrite in meats has been suggested while alternative and safer compounds for bacterial control are being developed for commmercial use.

Food additives in the nature of artificial coloring substances and noncaloric sweeteners have been questioned with respect to carcinogenic significance. The FDA has banned the previously common food coloring Red Dye No. 2 as a suspected carcinogen, also the use of cyclamates as sweeteners. Controversy developed in Congress when FDA attempted to ban saccharin, extensively used as a noncaloric sweetener in soft drinks; this matter still awaits resolution.

PCB's, used in a great number of applications and already widespread in the environment, have found their way on some occasions into animal feeds and thus into the food chain. High level policy in USDA has again mandated strong protection of the public health interest and ordered a tightening of monitoring for these materials in feeds and foods.

Federal agencies generally are now actively attempting to prevent potentially harmful extraneous chemicals of agricultural and other origins from finding their way into the food supply of the Nation. In many cases, it is not possible to know with certainty whether a particular chemical is or is not a health risk. Nevertheless, present Federal policy seems to be moving strongly toward exclusion of all substances about which there is some doubt concerning safety (3, 6). Currently, low-level or infrequent contamination of conventionally produced foods may be found in the food store, and a plausible case can probably still be made for the buying behavior of the consumer who purchases an organic product to guarantee an extra margin of health safety.

REFERENCES

1. Marsh, P. B., and J. M. Kla. "Nutritional quality and health safety of organic and conventionally produced food and feed." (In press).

2. Anon. "Dispute resolution conference on 2,4,5-T." American Farm Bureau Fed., Park Ridge, Il., 1979. 101 pp.

3. Khera, K. S. "Distribution, metabolism, and perinatal toxicity of pesticides with reference to food safety evaluation: a review of selected literature." Advances in Modern Toxicology 1, 1976, pp. 369-420.

4. Kennedy, D. "Diethylstilbestrol (DES) in edible tissues of cattle and sheep; Revocations." Federal Register, 44(131):39387-39388, 1979.

5. Costle, D. M. "Proposed health effects test standards for Toxic Substances Control Act." Federal Register, 44(145):44054-44093 (Part IV), 1979.

6. King, S. B., D. M. Costle, D. Kennedy, and C. T. Foreman. "Scientific bases for identification of potential carcinogens and estimation of risks." Federal Register, 44(131):39858-39879, 1979.

4.12 PUBLIC POLICY AND ORGANIC FARMING: SELECTED ISSUES AND POLICIES

4.12.1 Introduction

Little public policy at either the Federal or State levels pertains directly to organic farming. For example, no laws on organic agriculture exist at the Federal level. Similarly, agency guidelines and regulations designed specifically for organic farming practices, technology, or marketing systems are rare. Instead, one finds a number of existing agricultural policies, some of which are favored by organic proponents (the Rural Clean Water Program) or which contain elements unfavorable to organic agriculture. In either case, however, organic farming would not (a) appear to have been the driving force behind the legislation or (b) provide the direct, continuing stimulus for its implementation.

In general, State-level policy appears to relate more directly to organic farming. State-level fertilizer legislation is, for example, a major issue within organic farming circles. Moreover, at least three States now have organic grower certification legislation in place. A number of other States are considering such legislation.

4.12.2 National Policies and Issues

Title XIV of the Food and Agriculture Act of 1977 (P.L. 95-113) contains a number of provisions which relate indirectly to organic agriculture. For example, among other things, section 1402 calls for "research to find alternatives to technologies based on fossil fuels; . . . research to find solutions to environmental problems caused by technological changes in food and agricultural production; . . . research and extension directed toward improving the management and use of the Nation's natural and renewable resources, . . . extension programs in energy conservation, . . more intensive agricultural research and extension programs oriented to the needs of small farmers . . . development . . . of more efficient, less wasteful, and environmentally sound methods of producing, processing, marketing, and utilizing food, fiber, waste products, other nonfood agricultural products, and

forest and rangeland products; . . . investigation and analysis of the practicability, desirability, and feasibility of using organic waste materials to improve soil tilth and fertility, and extension programs to disseminate practical information resulting from such investigations and analyses; . . ." This latter provision already has been partly implemented by a 1978 USDA report entitled, Improving Soils with Organic Wastes (See section 4.3.1). The provisions in this legislation indicate that the U.S. Congress shares at least some of the policy goals of organic farmers.

Federal policy regarding the regulation of organic food claims has direct consequences for organic agriculture; it affects potential markets for organic products and also affects methods of production which legally may be considered organic. The USDA and two Federal regulatory agencies, the Food and Drug Administration and the Federal Trade Commission (FTC), regulate food claims and often take different approaches in so doing. For example, with respect to the labeling of organic and natural foods, the "FDA does not attempt to restrict such claims because it believes that the development and enforcement of standards in this area would be difficult and might unjustifiably imply to consumers that foods labeled 'organic' or 'natural' are inherently superior to other foods in nutrient content and safety. USDA, on the other hand, does attempt to control the use of 'natural' and 'organic' claims on meat, poultry, and egg products because it believes such claims are generally misleading. USDA enforces this approach through its prior label review program" (1).

The FTC has the responsibility for regulating food claims in advertising. In 1974 the agency began a full-scale review and analysis of organic and natural food advertising claims. Included in this review was a proposal to prohibit use of the terms organic and natural (2), as well as hearings in which industry spokesmen, consumer advocates, nutritionists and other experts testified on the scientific validity and public understanding of these terms. As a result, the staff of the Division of Food and Drug Advertising altered its original position, which called for the banning of these terms, and instead recommended that use of the terms be allowed provided the foods in question meet specific criteria. With respect to the term organic, for example, the staff recommended that:

". . (c) Advertising shall not represent that a food is organic, an organic food, or has been organically grown if:

(1) The soil in which such food was grown was subjected to fertilizers other than organic materials and/or minerals extracted by the application of physical processes.

(2) Any artificial or synthetic pesticide, herbicide, or other such chemical has been directly applied in the production of such food.

(d) Where a food is represented in advertising as organic, an organic food, or as having been organically grown in accordance with paragraph (c) of this section:

(1) Such advertising shall not further represent that such food is superior to any other food(s) in terms of nutrient content or safety because it is organic, an organic food, or has been organically grown.

(2) Such advertising shall disclose that such representation means that such food has been grown (i) with organic fertilizer and (ii) without the direct application of artificial fertilizers or pesticides" (3).

What are the implications of this action? If adopted, Federal regulatory policy will begin to define what the terms natural and organic mean. Given the widespread degree of public confusion over the meaning of such terms (4), progress toward clarifying these issues could benefit the organic and natural food industries. Finally, the similarity between the FTC definition and those definitions which have been adopted by California, Maine, and Oregon for the purpose of State certification of organic growers may lead to a more uniform formal definition of organic and natural foods.

Proponents of organic agriculture oppose a number of existing policies of USDA's Agricultural Stabilization and Conservation Service (ASCS). First, some organic producers object to certain aspects of that agency's cost-share program. Presently, in order to qualify for various cost-share programs pertaining, for example, to permanent pasture, seed, lime, and certain tillage practices, producers must apply various commercial fertilizers depending upon the results of mandatory soil tests. This commercial fertilizer requirement prevents participation of organic farmers in such programs. They would prefer to fulfill this requirement with mineral fertilizers of limited water solubility, such as rock phosphate, granite dust, and greensand, or by plowing under green manure crops. Organic producers complain that ASCS has never seriously considered these kinds of alternative policies.

Certain aspects of the ASCS price support system appear to run counter to conservation goals, thereby discouraging program participation by conservation-minded farmers in general and organic farmers in particular. For example, according to Risser (5), ASCS refusal to count "protected grasslands" as normal crop acreage penalizes conservation farmers by reducing the number of acres eligible for price-support payments.

Organic growers also oppose certain aspects of USDA marketing order policy. They are, for example, in opposition to the so-called "cosmetic" requirements included in most marketing orders contending that such factors as size, shape, and general appearance are invalid indicators of quality. The industry position has been summarized by Andrew Rock, president of a Florida organic distributing company. For example, he asserts: "Organic citrus has extremely high quality as far as sweetness, juiciness and ripeness are concerned, but is not 'pretty' enough for the American commercial market" (6).

The USDA, on the other hand, sees marketing orders as essential elements in assuring that consumers are given a dependable supply of fresh farm products. Moreover, the so-called "cosmetic" aspects of marketing orders are viewed as valid and reasonable indicators of product quality rather than as a deliberate obstacle to the marketing of organic produce. According to the Agricultural Marketing Service (AMS), those quality requirements, which are written into nearly every marketing order, have this purpose: "This keeps the less acceptable qualities and less desirable sizes of a crop off the market. In other words, the big, juicy pear that makes customers happy goes to market, and the poorly shaped, overripe, shriveled, and damaged pear with a lot of waste stays at home" (7). Moreover, in the words of D. S. Kuryloski, Acting Director of the Fruit and Vegetable Division of the Agricultural Marketing Service, "in many instances the external (sometimes called 'cosmetic') defects reflect internal problems" (8).

Although resolution of this basic dispute must await further analysis, the recent protests of organic citrus growers in Florida did result in certain modifications in the Florida Citrus Marketing Order. Prior to these changes, it was illegal to send organic citrus out of Florida. Because the organic citrus was often marked by rust mites, it did not meet the standards imposed by Marketing Order 905 (9).

Amendments to M.O. 905 do, however, establish "lower grade requirements applicable to the handling of 'organically produced' fresh Florida citrus fruits" (10). According to the AMS, "this action established appropriate grade requirements for such fruit in recognition of the quality of fruit produced under cultural practices employed and the specific demand in outlets to which such fruit is shipped."

As this selective overview illustrates, public policies can either promote or impede the goals of organic farmers. Subsequent publications will contain a far more comprehensive analysis of the relationship between various public policies and their consequences for organic agriculture.

REFERENCES

1. Federal Register, Vol. 44, No. 247 (1979), 76012.

2. "Federal Trade Commission Proposed Trade Regulation Rule on Food Advertising, Staff Report and Recommendations," 16 CFR Part 437, Phase I (1978), p. 206.

3. ____, pp. 207-208.

4. ____, pp. 215-216.

5. James Risser, "Conservation Schizophrenia Frustrates Soil Experts," The Des Moines Register, September 12, 1978.

6. Letter from Andrew Rock, May 11, 1979, p. 2.

7. U.S. Dept. Agr., Agr. Marketing Serv., "Federal Marketing Orders for Fruits and Vegetables--In brief". AMS-563, March 1978, p. 1.

8. Memorandum from D. S. Kuryloski, January 11, 1980.

9. Letter from Andrew Rock, May 11, 1979, p. 2.

10. Federal Register, Vol. 43, No. 225 (1978), 54217.

CURRENT RESEARCH AND EDUCATION PROGRAMS THAT RELATE TO ORGANIC FARMING

This study has shown that the U.S. Department of Agriculture and the land-grant universities and State agricultural experiment stations have few research and education programs directed exclusively to the needs and problems of organic farmers. However, a considerable number of their programs do relate to various aspects of organic farming. For example, although few programs deal with farming practices that would completely avoid the use of synthetic chemicals in agricultural production, some do deal with practices or alternatives that would reduce the usage of such chemicals.

Because of limits on resources, space, and time, the study team has described only those research activities in crop production and associated areas which relate to organic farming or to practices used by organic farmers. Further justification for this approach is that the soil and soil management practices are central to the whole concept of organic farming.

5.1 CURRENT RESEARCH ON CROP PRODUCTION THAT RELATES TO ORGANIC FARMING

5.1.1 Introduction

Research activities included here are those which bear directly on organic farming, such as biological nitrogen fixation, use of municipal organic wastes (sewage sludge) on crop lands, soil fertility, food safety and quality, pest control, and the economic viability of organic practices. A summary of the State and Federal funds expended and scientific contributions during fiscal year 1978 is shown in table 5.1. The figures shown in this table do not represent the total research effort in each area, since only those activities which are related to organic farming were included. As previously noted, few research and education programs in progress are directed exclusively toward the needs of organic farmers. Only a small percentage of the amounts shown in table 5.1 are estimated to be directed to organic farming practices as such, since probably less than 1 or 2 percent of all the land currently farmed in the United States can be categorized as being organically farmed. Although the information in table 5.1 does give some indication of how public funds are currently used for crop production research related to organic farming practices, it does not reflect past research that is still applicable to organic farming. For example, USDA and the State agricultural experiment stations have conducted considerable research on crop rotations and the utilization of animal manures as sources of plant nutrients which is still relevant to organic farming. Nevertheless, ongoing research as well as new research is as vital to the interests of organic agriculture as it is to conventional agriculture.

5.1.2 Biological Nitrogen Fixation

Biological nitrogen fixation is essential to the success and profitability of organic farming. Currently about three-quarters of the world's production of fixed nitrogen is by natural biological processes; about a quarter comes from commercial processes. The U.S. Department of Agriculture and the State agricultural experiment stations have been involved in biological nitrogen fixation research since the twenties.

Currently, major studies, on basic and applied aspects of nitrogen fixation by soybeans, alfalfa, clovers, and grasses, are being conducted by USDA scientists and at many of the State agricultural experiment stations and 1890 land-grant institutions.

Table 5.1 Funds and scientist-years decicated to research activities related to organic farming practices carried out by the U.S. Department of Agriculture and the State agricultural experiment stations from October 1977 to September 1978.

Research Area	USDA/SEA	Other Federal	Non-Federal	Total	Scientist-years
			Dollars		
Biological Nitrogen Fixation[1]	2,045,000	1,373,000	1,876,000	5,294,000	54.5
Application of Sewage Sludge to Land	1,747,000	369,000	1,321,500	3,437,500	35.0
Application of Animal Manure to Land	1,150,000	417,000	1,271,000	2,838,000	23.0
Soil Fertility	271,000	43,000	469,000	783,000	12.9
Tillage	135,000	22,000	140,000	297,000	3.5
Food Safety and Quality	28,800	39,800	16,600	85,200	1.9
Economic Evaluations	36,600	9,800	85,700	132,100	2.2

[1]The USDA figure includes both the SEA/CR and SEA/AR programs. Estimates based on data for fiscal year 1977. Totals do not include about $2 million currently expended each year under the SEA/CR competitive grants program initiated during 1978.

5.1.3 Application of Municipal and Industrial Waste to Land

A number of ongoing research programs are investigating the utilization of municipal (sewage sludge and garbage) and industrial wastes (e.g., papermill wastes) on land as sources of plant nutrients and as soil conditioners. The purpose of these studies is to develop safe, efficient, and practical methods for the application of these materials to land without adverse environmental consequences.

5.1.4 Application of Animal Manure to Land

Many studies have been conducted over the years to determine rates of decomposition, nutrient availability, optimum rates of application, and, only recently, to assess the possible adverse consequences of the application of animal manures to land. Table 5.1 shows that there is a substantial ongoing research effort on aspects of manure application on land.

5.1.5 Soil Fertility

Current research programs on soil fertility deal primarily with nutrient transformations in soils, the capacity of soils to supply nutrients to crops, limitations of natural fertility, and the management of chemical fertilizers to increase their efficiency. Much of the research reported under "Applications of Sewage Sludge and Industrial Waste to Land" and "Application of Animal Manure to Land" also includes studies on organic wastes as sources of plant nutrients.

5.1.6 Economic Evaluations

Several studies have been initiated in recent years to evaluate the economic viability of organic farming systems. Aspects considered in these studies are energy requirements, yields, costs, and net returns.

5.1.7 Food Safety and Quality

Food safety and quality are important considerations in judging the viability of organic farming systems. The effort devoted to this activity is small but probably should be increased. The effect of organic farming methods on food quality as measured by a variety of standards, including visual appearance and chemical composition, has not been studied in a definitive manner.

5.1.8 Pest Control

This category, not listed in table 5.1, includes research related to nonchemical control of weeds, insects, and plant diseases. Research on the use of limited amounts of chemicals in pest control is also included. Of the estimated expenditures by USDA/SEA Cooperative Research and State agricultural experiment stations for research activities related to the control of plant and animal pests, approximately 50 percent is for research on nonchemical pest control methods. These amounts do not include expenditures by USDA/SEA Agricultural Research.

5.2 EDUCATION PROGRAMS IN ORGANIC FARMING

5.2.1 University Programs

Information on academic courses in organic farming was requested from all of the 1862 and 1890 land-grant universities and from three other State institutions that have significant agricultural programs.

Responses were received from 43 of the 50 State land-grant universities, 3 of the 16 land-grant universities of 1890, and 2 other State institutions. A response was also received from Puerto Rico. For some institutions, separate responses were received from as many as nine academic departments. The questions used are followed by a summary of the responses:

5.2.1.1 Course Directly Related to Organic Farming --

Question (1). This Department has the following undergraduate courses that relate directly to organic farming. If none, so state. (List course name, number, and brief description).

Nineteen institutions listed courses considered directly related to organic farming. Courses were offered at five universities on the specific topics of organic farming and gardening or organic gardening. One special topics course was given on organic agriculture.

Organic farming has been offered as a special topics course at two additional institutions. A number of institutions listed courses on biological control, waste management, pest management, host plant resistance, and ecology as being relevant. Courses on biological control were listed most frequently. Similar courses are probably offered at most land-grant colleges, although most respondents did not list

them in this category. Information presented on the biological control of pests is obviously equally applicable to organic and conventional farming.

5.2.1.2 Short Courses --

Question (2). This Department has the following short courses that directly relate to organic farming. If none, so state. (List course name, number, and brief description.)

The intent was to obtain information on short courses sponsored by Cooperative Extension Services. Short courses were listed on the topics of aquaculture, crop scout training, practical beekeeping, home food production, organic gardening, host plant resistance, and farm insects. None of these short courses are designed specifically for the organic farmer. Generally, the information presented would be equally applicable to organic and conventional farming. The response from one Department of Horticultural Sciences stated: "All Extension short courses and county meetings stress use of disease-, insect-, and nematode-resistant varieties; use of mulch, stakes, and other supports to keep plants off of the ground; use of compost and manure; and specialized cropping practices including rotations to reduce use of pesticides and improve quality of produce."

5.2.1.3 Courses in Which Organic Farming is Discussed to Some Extent --

Question (3). Organic farming is discussed to some extent in the following courses (i.e., one or more lectures devoted to organic farming principles or practices). (List course name, number, and brief description.)

All except 5 of the 51 academic institutions that responded listed courses in which organic farming principles or practices are discussed. A broad range of courses was listed, such as Ecology of Agronomic Crop Plants; Pastures and Pasture Problems; Forage Management and Production; Weed Control; Principles of Plant Breeding; Introductory Soils; Soil Microbiology; Man and Food; Soil Fertility and Management; Vegetable Production and Gardening; Environmental Horticulture; Agriculture, Society and the Environment; Farm Power and Machinery; Applied Entomology; Insect Pest Management; and Economics of Production and Distribution. As many as 23 courses in a single department were listed. Among topics discussed are key pests and factors affecting outbreaks; identification and control of plant diseases; principles of plant nutrition; biological control of insects; utilization of crop residues, animal manures, and sewage sludge; and decomposition of organic residues and release of plant nutrients.

5.2.1.4 Courses at Other Institutions and "Free-Universities" --

Question (4). If you are aware of courses on organic farming that are offered by other institutions in your State, or by "free universities," please provide details below.

Twelve responses were received. Courses on organic farming apparently have been taught by several colleges and universities other than those contacted. Several other colleges throughout the United States offer courses on organic and home gardening. However, the accuracy of these statements was not checked.

5.2.2 Cooperative Extension Service Educational Programs

5.2.2.1 Survey of State Program Directors -- Responses to the survey on current educational programs on organic agriculture were received from 44 States, plus the Virgin Islands and Puerto Rico. The five questions used in the survey are followed with a summary of the answers and comments received.

(A) Numbers of information requests

Question (1). Estimated number of requests for information and assistance on organic farming in 1978 made to State and county Extension offices.

- None.
- Much less than conventional farming.
- Somewhat less than conventional farming.
- More than conventional farming.

If you checked "none" or "much less than conventional farming," is the low relative number of requests for information by organic farmers due to (please check all that apply):

- Very low number of organic farmers relative to conventional farmers.
- Organic farmers do not request any information.
- Organic farmers very seldom request information.
- Other; please explain:_____

Summary of Anwsers: The estimated number of requests for information from local and State Extension offices is much less than conventional farming in 44 cases and somewhat less in 2 cases. The relatively small number of responses is considered to be a result of the "very low number of organic farmers relative to conventional farmers" in almost all cases. One-quarter of the responses indicated that organic farmers did not view the university or Cooperative Extention Service as being willing or able to provide assistance to them. One indicated that organic farmers derived most of their information from other sources.

(B) Interest in organic farming

Question (2). Compared with 5 years ago (1974), interest in organic farming is:

- Increasing.
- No change.
- Decreasing.

Summary of Answers: In comparing current interest in organic farming with interest of 5 years ago, more than 3 times as many respondents considered interest in organic farming to be increasing (24) as considered it to be decreasing (7). Geographically, States in the Northeast, Pacific Northwest, northern Great Plains, and in three of the Gulf States said that interest in organic farming was increasing. Scattered States said interest was decreasing. In the Southwest "Sunbelt" States, interest was either constant (no change) or decreasing. Eight States indicated that most or much of the interest was centered in organic gardening.

(C) Education activities

Question 3. The estimated number of short courses, workshops, and demonstrations on organic farming conducted in 1978 in this State was:

- On campus.
- Off campus.

Summary of Answers: Of 46 responses, only 9 indicated that short courses, workshops, or demonstrations on organic farming were held on campus, and 22 indicated that such were held off campus. Several of the States' responses may have referred to integrated pest management or organic gardening instead of organic farming. The greatest concentration of States with workshops was in the Northeast and Southwest.

(D) Need for establishing or increasing Extension programs in organic farming

Question 4. Do you believe there is need for establishing or increasing Extension programs on organic farming (including mass media, county meetings, and educational materials)?

- Yes.
- No.
- Undecided.

Summary of Answers: Of 46 responses, an equal number (18) of States gave positive and negative responses concerning the need for establishing or increasing Extension programs in organic farming (10 were undecided). Regions with positive responses were the Northeast, the Pacific Northwest, and the western Corn Belt. All of the Southern States responded negatively, except for two. Eight States indicated that they would establish programs if interest developed.

(E) Plans to expand educational programs in organic farming in 1980

Question 5. Do you plan on expanding programs for organic farming in 1980?

- Yes.
- No.

In subsequent years?

- Yes.
- No.

Summary of Answers: Of 45 responses, one-third (15) indicated plans to expand organic farming education programs in 1980. After 1980, 28 of the 45 either plan to expand their educational programs or indicated that they will do so if needed, if sufficient interest is shown. States in the Northeast generally plan to expand their information programs after 1980. Other States planning to expand their programs were distributed throughout the country.

5.2.2.2 Staffing and Funding Levels Committed to Educational Programs Supporting Organic Agriculture -- We were not able to identify funding of positions in the Cooperative Extension Services, which have the specific purpose of providing direct support to organic farming. Several of the Cooperative Extension Service programs in crop production, crop protection, and land and water resources relate to certain objectives and practices used in organic farming. However, organic farmers represent only a very small portion of the general agricultural clientele reached by these programs and would not, in general, be treated as a separate group. Examples of programs which appear to be helpful to organic farmers are listed in table 5.2.

Table 5.2 Staffing and funding of Cooperative Extension Service programs relating to practices used by organic farmers.

Item	Approximate 1979 levels for Cooperative Extension Service	
	Positions[1]	Total budget[2]
	No.	Mil. dollars
Crop Production Forage and Pasture	200	6.5
Land and Water Resources, Appraisal of Soils and Environmental Quality	400	12.1

[1]FTE-Full time equivalents--professionals.

[2]Federal and State contributions.

FACTORS AFFECTING THE FUTURE OF ORGANIC FARMING

The future of organic farming as a viable option for food and fiber production will depend on the future goals of U.S. agriculture and on public policy on matters concerning energy conservation, natural resources conservation, and environmental protection. It will also depend on the development and implementation of successful organic farming systems that can effectively overcome certain barriers and constraints to soil productivity, crop and livestock production, and marketing.

There are large ranges in climatic conditions and crops grown, great variations in soils and their characteristics which affect crop production, and large differences in the nature and importance of livestock enterprises both within and between regions in the United States. These differences must be considered in evaluating the effectiveness of any farming system, including organic farming, or of any particular practice, such as crop rotation and the use or nonuse of a particular soil amendment. Such detailed analysis is clearly outside the scope of this report; however, specific examples have been cited where appropriate. It is apparent that some crop, soil, climatic, and livestock conditions are especially favorable to the successful implementation of organic farming, but other conditions make it very difficult to implement successfully, if at all.

6.1 FACTORS WHICH SUPPORT SUCCESSFUL ORGANIC FARMING OPERATIONS

A large number of the organic farmers in our case studies were farming successfully and appeared to be deriving an acceptable net return from their operations. Success was determined by personal judgment of the interviewer; that is, we did not analyze the farmers' financial records. Judgment was based on the farmer's testimony and the general appearance of the farm operation, including the condition of the buildings, equipment, crops, and livestock. This assessment was supplemented whenever possible by contacting the County agricultural Extension agent and, in several cases, local Soil Conservation Service personnel. We list here what we consider to be the main reasons contributing to successful organic farming.

6.1.1 Skilled Management

Successful organic farmers appeared to be highly skilled managers. Most had systematically, and largely through their own efforts, developed crop and/or animal management systems well adapted to their specific conditions, including climate, soils, available capital, and organic materials for recycling. They had built sufficient flexibility into their management systems to adjust for weather fluctuations and for soil differences. Most of the farmers had previous experience in chemical-intensive farming.

6.1.2 Available Sources of Nutrients

Most of the organic farmers that we interviewed were depending largely on their own crop residues, green manure crops, legumes, and animal manures as sources of plant nutrients. In some cases, farmers used mineral sources of P and K, such as rock phosphate and greensand (glauconite). A few farmers had access to certain off-farm sources of organic wastes (such as animal or poultry manures, paunch manure, sewage sludge, and composts) at little or no cost, which supplied additional plant nutrients and assured a higher crop yield potential.

6.1.3 High Phosphorus and Potassium Status of Soils

The greatly increased amounts of P and K fertilizers applied since World War II have raised the P and K status of many soils (including many that are now farmed organically) sufficiently so that crop production can be sustained at moderate to high yield levels for a number of years without further additions of fertilizer. Where the P and K deficit is reduced further by an animal operation, high crop production levels could be sustained even longer. This situation has allowed many organic farmers to reduce or eliminate P and K fertilizer additions while maintaining past levels of crop production for 5 to 10 years and considerably longer in some cases.

6.1.4 Soils Highly Buffered with Phosphorus and Potassium

A few of the organic farmers claimed that their soils had never received chemical fertilizers of any kind but that moderate to high yields had been maintained. In these cases, it is likely the soils were well buffered with high initial P and K levels that could supply adequate P and K for moderate to high crop yields for long periods. These periods could be greatly extended with mixed crop-livestock operations where most of the crops are fed and manure is returned to the land.

6.1.5 Benefits from Organic Matter Management

Organic farmers tend to take advantage of every opportunity to apply organic materials to the soil. Improved organic matter management can be beneficial to farming operations in several ways, and Cooke (1) advises that farmers should return to the soil "all organic wastes produced on the farm" to the extent that it is practical and economically feasible. There is evidence that farmyard manure may give larger long-term yields than can be obtained with chemical fertilizers only.

6.1.6 Improved Soil Physical Conditions

Organic farmers have generally recognized the importance of improving soil physical properties for increased plant growth and yield. For example, where water limits crop yields, an improvement in soil physical properties may increase infiltration and water storage which, in turn, may increase crop yields.

6.1.7 Farm Ownership

The USDA case studies showed that most of the organic farmers interviewed owned their farms. Consequently most of them were not pressured to farm so intensively as farmers who had to meet mortgage payments.

6.2 BENEFITS, OPPORTUNITIES, AND INCENTIVES THAT LEND SUPPORT TO ORGANIC FARMING PRACTICES

Some features of organic farming have favorable implications for agriculture and could encourage increased future use of certain concepts and practices. These include the following.

6.2.1 Environmental Quality

Reduced pesticide pollution -- Organic farmers avoid or greatly restrict the use of pesticides in their operations. Decreased use of pesticides could help reduce

runoff of agricultural chemicals in some areas and reduce the spread of chemical residues in the environment.

Reduced Soil Erosion -- Practices used extensively by organic farmers, including meadow-based rotations, cover crops, green manure crops, noninversion-type tillage, and organic matter management, all help to control soil erosion. However, as conservation tillage systems (such as no-till) are developed and implemented, the advantage that organic farming methods now have for controlling soil erosion over that of chemical-intensive systems may decrease.

Reduced Nutrient Pollution -- Organic farmers avoid or restrict the use of commercial fertilizers and instead rely more on recycling of nutrients in their farming operations. This reduces the opportunity for residual nutrients in soil which might be subject to leaching. Reduced soil erosion also minimizes nutrient transport from fields.

6.2.2 Food Safety

Despite the present trend toward closer governmental regulation of chemical use in U.S. agriculture, there is no assurance that all conventionally produced food products are free of health-harmful residues. This offers an opportunity for organic farmers to market food products that are certified to have been produced in the absence of such substances.

6.2.3 Energy

Organic farmers use appreciably less total energy for producing most crops than do conventional farmers. Considerable quantities of energy are saved on organic farms by the use of crop rotations and the application of organic wastes in place of chemical fertilizers, especially nitrogen.

6.2.4 Conservation of Natural Resources

Increased Recycling of Organic Wastes -- In addition to the recycling of on-farm organic wastes, some organic farmers utilize off-farm sources of organic wastes, including paunch manure, sewage sludge, and processing wastes, thereby achieving a higher crop yield potential. This reduces the dependence on finite reserves of concentrated plant nutrients and helps to resolve a disposal problem, while contributing greatly to improved soil productivity.

Enhanced Soil and Water Conservation -- Organic farmers make extensive use of crop and soil management practices that effectively protect the soil and improve infiltration. These include sod-based rotations and cover crops for farmers to reduce plant moisture stress. Improved water conservation with organic farming may provide opportunities for farmers in dryland areas. Crop yields in dry years on some Midwestern organic farms were less variable than yields obtained on nearby conventional farms.

Improved Soil Tilth and Productivity -- Many of the practices regularly followed by organic farmers are the best management practices that have been highly recommended to all farmers for almost 50 years by agencies of the U. S. Department of Agriculture and land-grant universities for improving the productivity and tilth of soils. These include recycling organic wastes for plant nutrients and for maintenance of a high level of soil organic matter and using green manure crops, crop rotations, and selective tillage. In the long term, these practices can improve soil physical properties, as evidenced by increased water-holding capacity, increased aeration and

permeability, increased soil aggregation, and decreased soil crusting and compaction. They also encourage the growth and activity of beneficial insects, microorganisms, and earthworms.

6.2.5 Economic Factors

Lower Input Costs -- Organic farmers generally have lower input costs than conventional farmers. Consequently, some farmers, especially those on small farms with cash flow problems, may benefit from organic farming by reducing their cash flow needs. Moreover, if the cost of chemicals and fertilizers continues to increase relatively faster than the cost of other farm inputs, greater economic opportunities to farm organically may become available for farmers, especially farmers on mixed crop-livestock farms.

Premium Price for Products -- Organic farmers may obtain premium prices for certain products that are organically produced.

6.2.6 Technology Development

To Improve Farm Technology in the United States and Developing Countries -- Many of the objectives, problems, and practices of organic farming are similar to those of self-sustaining unit systems which dominate agriculture in many developing countries. Thus, a better understanding of the technological aspects of organic farming in the United States may provide valuable information for increasing the stability and productivity of such systems in developing countries.

Alternative Production Systems -- Organic farming is an alternative production system. In the event that certain pesticides are banned because of their adverse effects on environmental quality or health, it may be necessary to develop farming systems (such as combination conventional - organic systems) that incorporate certain features of organic farming for nonchemical control of a certain pest.

6.3 POTENTIAL LIMITATIONS AND BARRIERS TO ORGANIC FARMING

The following is a compilation of possible barriers that may limit the development of successful and profitable organic farming systems. It is not to be implied here that all existing and potential organic farms would confront all of these problems at any one time, if at all. Moreover, it should be noted that many organic farmers, depending on their particular conditions or circumstances, may not consider some of these to be serious barriers to their ultimate success and profitability in farming organically.

6.3.1 Plant Nutrients

Limiting Phosphorus and Potassium -- Farming systems which have negative P and K budgets and soils with a low P and K supplying capacity generally will not sustain long-term crop production at high yield levels without the input of organic and/or inorganic sources of these nutrients. On most soils, high levels of crop production are not indefinitely sustainable under negative P and K budgets.

Organic Sources of Plant Nutrients are Limited -- America's highly productive agriculture requires large amounts of N, P, and K fertilizers, and large-scale substitution of them with organic sources would be limited by both cost and availability (2). Extensive use of symbiotic N fixation would require large-scale changes in land use.

Restrictions on Symbiotic Nitrogen Fixation as a Source of Nitrogen -- Organic farming systems, which rely heavily on the use of leguminous meadows to provide nitrogen through symbiotic nitrogen fixation, are often less satisfactory than those systems where N is supplied from inorganic sources and may be unsatisfactory under conditions of lower rainfall. In such cases, the yield of the first crop following the leguminous meadow is often reduced because of the severe depletion of subsoil water by deep-rooted legumes.

Low Solubility Nutrient Sources -- Low solubility sources of P and K, which are most commonly used in organic farming, are often of limited value as nutrient sources for high yield levels of many common crops.

6.3.2 Economic Factors

Demand for Organic Food -- The current demand for organically grown food is somewhat limited, but indications are that it may increase in the future. At present, relatively few organic farmers can depend on receiving a premium price for organic products. A large percentage of organically grown produce is now marketed through conventional channels.

Lack of Organized Marketing -- Organic farmers have no concentrated marketing effort. There is little information on kinds of organic products that are available, the location and source of these products, and their price. There is some confusion as to what can be defined as "organically-produced" food. There is also a lack of well-developed alternative marketing strategies available to organic farmers. Lack of certification programs for organic food and poor understanding of certification standards by consumers are often barriers to the marketing of organically grown products.

Increased Transportation Costs -- The geographical dispersion of organic producers and the low volume of organic products increases the cost of transportation and marketing.

Reduced Production -- While individual farmers may find it economically feasiable to adopt organic farming, a full-scale shift to organic practices would probably reduce total farm output. Thus, macroeconomic factors may be a barrier to significant expansion of organic farming, at least in the short term.

Low Income Crops in Rotational Systems -- Because of the need for rotation of crops, organic farming results in greater diversification than conventional farming. Consequently, organic farmers may have to substitute low income crops in place of high income crops. This results in lower income for the organic farmers compared to the conventional farmer whose standard practice is the production of high value crops.

Economic Loss During Transition from Conventional to Organic Farming -- The shift from conventional to organic farming requires a 3- to 5-year transition. During this period, weeds and insects can be serious problems, and significantly lower yields may result.

Greater Risks from Weeds and Insects -- Organic farmers may be subject to greater crop losses from weeds and insects. Controlling weeds and insects is a major problem for some organic farmers, especially those producing fruits and vegetable crops.

Increased Cost of Labor -- The availability and cost of labor, especially hand labor, may limit the success and profitability of organic farming.

The Need to Maximize Economic Return -- Organic farming is sometimes limited because of economic returns. In the short run, the high input costs, especially for land, and low farm prices put continuous pressure on farmers to use practices and methods that provide the greatest return on investment.

Lack of Credit and Financing -- Many organic farmers (or would-be organic farmers) reported difficulties in convincing loan officers that organic farming can be a viable economic operation.

6.3.3 Communmication Problems

Lack of Communication and Understanding -- According to our case studies, lack of communication and understanding between organic farmers and the agricultural research and Extension communities has hindered the transfer and application of research and educational information. The negative attitudes of many conventional farmers and of the agricultural establishment toward organic farming have sometimes limited the acceptance of this method of farming.

Attitudinal Barriers and Inadequate Knowledge About the Benefits of Organic Farming -- Many agricultural scientists, Extension workers, and farmers strongly believe that organic farming is impractical or inteasible. To some extent, these views are the result of misperceptions and misunderstandings about the contemporary character of organic farming. Similarly, agricultural policymakers are not fully aware of the environmental, conservation, and energy-related benefits of organic farming. Educational programs could help to overcome these attitudinal and institutional barriers.

Ambiguity of Organic Farming Concepts -- The ambiguity of certain basic concepts of organic farming prevents their use as a firm basis for decisionmaking. For example, the concept of "feeding the soil" rather than the plant is unclear and is difficult to interpret in physically meaningful terms and difficult for scientists to relate to soil physical and chemical characteristics. This barrier can be overcome by mutual education and understanding.

Lack of Information on Organic Farming -- Little research and published information are available to help organic farmers resolve the problems they encounter in the development and implementation of organic production methods.

6.3.4 Farm Ownership Patterns

Organic farmers tend to own a large portion of the land they farm. Thus, they are in a unique position to experiment, to conserve, and to take less than optimum yields if necessary. Absentee landlords, and local landlords as well, may not be so willing to allow their tenants to practice organic farming.

6.3.5 Crop Varieties

Lack of Adaptable Crop Varieties -- Organic farmers generally grow recommended crop varieties. However, these varieties are most often selected for their response to a high soil fertility regime and may not respond well when grown in organic systems. Thus, the lack of adaptable crop varieties may limit successful organic farming.

6.4 FUTURE PROSPECTS

The future expansion of organic farming in the United States will depend upon such things as the cost and availability of energy and concentrated nutrient sources, demand for food and fiber including organically produced food, and research and education programs. There may be strong incentives for some organic practices in a number of areas including energy conservation, organic waste utilization, food safety, environmental protection, and maintenance of soil productivity (3). These incentives will no doubt continue to give impetus to increased interest in organic farming.

Currently, organic farming is limited in scope. The best opportunities for commercial-scale production are limited to situations where P and K fertilizer requirements are low, because of either lower yield levels or a very highly buffered P and K status of the soil, or where there is large-scale importation of nutrients onto the farms in the form of feed, manure, sewage sludge, composts, or other organic wastes. Most organic farmers do not use organic practices for solely economic reasons. Rather, they are more concerned with protection of human and animal health, protection of the environment, energy conservation, and preservation of soil resources, and will, if necessary, accept some economic loss to achieve these objectives.

The increasing cost of chemical fertilizers, pesticides, and energy inputs and/or their uncertain availability may lead to increased organic farming in the future. As input price relationships change, some farmers, especially the mixed crop-livestock farmers or those operating small farms, may find organic farming just as economical or even more so than chemical-intensive farming. Further impetus to increased interest in organic farming may be brought about by the increasing public concern for the adverse effects of conventional agriculture on the environment (4,5). A large number of chemical pesticides have already been banned from use in agriculture. The use of pesticides and their effects on human life are highly controversial issues. If more agricultural chemicals used in conventional agriculture are banned and not replaced with effective and less toxic compounds, many farmers may have to shift to an alternative production system, including the use of organic methods.

There is widespread concern about the possible decline in long-term soil productivity in large areas (6). This may also encourage expansion of organic farming or at least of some practices advocated by organic farmers. These include more efficient return of all suitable organic wastes to the land and application of soil and crop management practices to control soil erosion. Much can be learned from organic farming to reduce soil erosion and nonpoint source pollution. Other factors which might widen the scope of organic farming in the future are increased public support for research and education programs, which address organic farming problems and concerns, and increased demand for organically grown food.

Small farms, many of the mixed-crop/livestock farms, and farms with access to ample quantities of organic wastes could be shifted to organic farming methods in the future without having a large effect on total production. However, the aggregate adverse affect on the economy could be significant if farmers who are producing large acreages of major crops must shift abruptly to organic farming.

Organic agriculture greatly depends on the recycling of plant nutrients in the production system. Major increases in the recycling of nutrients in the U.S. agricultural production system may be difficult to achieve because of the large amount of grain exported or concentrated in large-scale livestock feeding operations that are far removed from the crop production area. Increases in recycling of nutrients through conversion of cash grain farming to increased regional livestock production,

with an associated increase in legume production, would require major changes in U.S. agriculture. Organic farmers would need to be close to an economical source of acceptable organic waste. A change in input mix would also result in a major change in the output mix. Consequently, the future prospects for large-scale shifts to organic farming are limited unless significant changes are brought about in public policy and in the overall structure of U.S. agriculture.

REFERENCES

1. Cooke, G. W. "The role of organic manures and organic matter in managing soils for high crop yields: A review of the experimental evidence," Proceedings of the International Seminar on Soil Environment and Fertility Management in Intensive Agriculture. Tokyo, Japan (G. W. Cooke, Agr. Research Council, London, England), 1977, pp. 53-64.

2. U.S. Department of Agriculture. "Improving Soils with Organic Wastes." Report to the Congress in response to Section 1461 of the Food and Agriculture Act of 1977 (P.L. 95-113), 1978, 157 pp.

3. Brown, L. R. "The Worldwide Loss of Cropland." World Watch Paper 24, World Watch Inst., Wash., D.C., 1978, 48 pp.

4. Risser, J. "Environmental Crisis Down on the Farm," The Des Moines Register. Sept. 10-16, 1978.

5. Carter, L. J. "Soil Erosion: The Problem Persists Despite the Billions Spent on It," Science, Vol.196 (1977), 409-411.

6. Brink, R. A., J. W. Densmore, and G. A. Hill. "Soil Deterioration and the Growing World Demand for Food," Science, Vol. 197 (1977), 625-630.

RECOMMENDATIONS FOR ACTION

A consensus of the study team was that research and educational programs should be developed and implemented to address the needs and problems of organic farmers and to enhance the success of conventional farmers who may want to shift toward organic farming, adopt some organic methods, or reduce their dependency upon agricultural chemicals. Accordingly, the following research and education programs should be considered.

7.1 RESEARCH RECOMMENDATIONS FROM AN EARLIER REPORT

All of the research recommendations listed in the 1978 USDA report Improving Soils With Organic Wastes (1) directly support the goals and objectives of organic farming. Because of their relevance to the present report and because they have not yet been implemented (except for limited action on recommendations 2,5, and 7), they are listed here as follows:

1. Conduct a national survey to obtain a complete listing of the kinds and amounts of organic wastes available now and in the future.

   Current data are incomplete with respect to the quantities of wastes from food processing industries, industrial organic materials, logging and wood manufacturing wastes, and sewage sludges and effluents. Knowledge of the chemical composition of these wastes is essential for future planning. These data could be obtained in the 1984 survey to be conducted under the Resource Conservation Act of 1977.

2. Assess the effects of various processing methods on the value of wastes for soil improvement.

   Some wastes are processed in ways that may reduce their potential value for land application. There is a need to evaluate currently available processes as they might affect use-value relationships. New methods might be developed to preserve and improve the value of organic wastes as fertilizers and soil amendments. Improved methods are needed, for example, to collect, store, and process animal manures and sewage sludges to minimize losses of ammonia nitrogen. Existing machinery might be modified or new machinery designed to maximize the effectiveness of crop residues as mulches or for erosion control. Composting processes could be devised to improve the nutrient and tilth value of high carbon-low nitrogen municipal refuse and many industrial wastes. Systems are needed to blend wastes, such as sewage sludges and municipal refuse, at the time of soil incorporation to improve their value. Also needed are studies to estimate the value of organic additions to various soils in improving soil tilth, increasing the soil's cation exchange capacity, and determining the physiological effects on plant growth from additions of organic wastes and residues. High priority should be given to research which would provide such data for soils of varying chemical and physical properties.

3. Conduct research to determine how organic wastes differ in their ability to improve soil tilth and fertility.

Information is limited on the extent to which one particular organic waste can be substituted for another to achieve a desired level of soil improvement. Criteria should be developed by which the relative effectiveness of different organic wastes can be compared. For example, studies are needed to determine (a) the rate of loss (or increase) of soil organic matter under different cropping systems as influenced by different organic residues, (b) rates and effectiveness of recycling nutrients from residues for subsequent crops, and (c) impact of organic residue management on the control of insects and diseases. Each type of organic residue or waste has unique opportunities for research.

4. Determine the effect on soil erosion and productivity of a major diversion of crop residues to energy recovery systems.

The availability of some organic wastes that are currently used for soil improvement may be reduced if these wastes are diverted into energy recovery systems. A thorough evaluation of the consequences of such actions on soil properties and erosion is therefore essential. For example, where crops are grown for biomass production, what would be the initial and long-term environmental impact of total crop removal? How much of the biomass must remain on the land to ensure adequate erosion control? To what extent could other wastes be utilized to maintain soil productivity, thereby allowing total removal of the biomass crop for energy production?

5. Conduct research on the utilization of organic wastes on small farms to improve soil productivity and control erosion.

Many small farms in the United States are located in areas of sloping topography and marginal soils. Unfortunately, conservation measures are not often conducted according to recommended practices, and the result is low productivity and serious soil erosion. The economic, social, and environmental effects of organic recycling on small farms should be thoroughly investigated. Where necessary, conservation plans and practices should be implemented to achieve a more effective and efficient use of available organic wastes to (a) improve soil productivity, (b) minimize soil erosion and runoff losses, and (c) improve the standard of living and self-sufficiency of the farm enterprise.

6. Conduct a thorough study of the economic, social, and environmental results of organic farming systems vs. conventional agriculture.

Such studies should be conducted at several State Agricultural experiment stations by multidisciplinary teams of scientists over a minimum of 5 years. Included in the experimental design should be plans to determine the most practical and workable balance between the use of organic wastes and inorganic fertilizers. A thorough study of the energy and nutrient budgets for the two farming systems should be concluded.

7. Develop educational programs to increase public awareness of the value of recycling organic wastes on soils.

Educational programs should be developed and implemented by such agencies as the State Extension Services and SEA-Extension, the National Park Service, the Soil Conservation Service, the Forest Service, and the Environmental Protection Agency. Public groups such as the League of Women Voters, the Sierra Club, and the National Wildlife Federation should be encouraged to develop educational programs. Information should be disseminated by way of pamphlets, brochures, radio, television, and public demonstrations to create a greater awareness of the potential value of recycling good quality organic materials on land.

8. Collect more information on the extent to which the utilization of organic wastes could be improved through relaxation of regulatory restraints or establishment of incentives.

Opportunities may exist to redirect waste application to those kinds of soil which would benefit most from addition of organic wastes. Also, it may be possible to encourage industries, farm operators, or municipalities to increase the reuse of organic wastes for improving soil tilth and fertility and to develop special manure- and sludge-handling systems that would conserve nitrogen. Action agencies such as the Soil Conservation Service should be encouraged to achieve greater and more effective application of established and new conservation practices and systems for utilizing organic wastes. More information is needed on the extent to which the use of organic wastes could be improved through the removal of regulatory restraints, the imposition of regulations, or the establishment of incentives.

7.2 RESEARCH RECOMMENDED BY THE USDA STUDY TEAM

1. Investigate organic farming systems using a holistic approach. The USDA case studies revealed that many organic farmers have developed unique and productive systems of farming which emphasize organic recycling and the avoidance or restricted use of chemical fertilizers and pesticides. It is also likely that these systems are highly complex and involve unknown or poorly understood chemical and microbiological interactions. Much of the research conducted to date that relates to organic farming has been somewhat piecemeal and fragmentary. A holistic research approach, which may involve the development of new methodologies, is needed to thoroughly investigate these interactions and their relationship to organic waste recycling, nutrient availability, crop protection, energy conservation, and environmental quality.

2. Determine the factors responsible for decreased crop yields during the transition from conventional to organic farming systems.

Many farmers report significant decreases in crop yields during the first 3 to 4 years while a rotation is being established

following the shift from a conventional (chemical-intensive) to an organic farming system. This can be a strong deterrent to those farmers who may wish to make such a change. Part of the problem stems from increased weed infestations, but other unknown factors are also involved. Research is needed to determine the underlying causes of yield reduction and to suggest ways that farmers could make this transition without suffering severe economic loss.

3. Determine the long-term effects on the productivity of selected soils from recommended applications of chemical fertilizers and pesticides in conventional farming systems.

   Where current information is inadequate, studies are needed to evaluate the long-term effects of repeated applications of NPK fertilizers and pesticides on the soil organic matter content, the level and activity of soil organisms, soil strength, water infiltration, and root development of crop plants. Changes in soil chemical, physical, and biological properties should be correlated with crop growth and yield. Comparisons should be made with soils where nutrients are recycled through organic wastes and residues.

4. Develop efficient and safe methods for utilization of municipal wastes, especially sewage sludge, as a source of plant nutrients and to improve soil productivity.

   Process technology is needed for conversion of municipal wastes into organic amendments that can be used safely and efficiently on cropland as sources of plant nutrients and to improve soil productivity. Criteria should be established so that the wastes can be applied to achieve the desired level of soil improvement. The feasibility of enriching these organic materials with inorganic nutrient sources to increase their fertilizer value should be investigated. Methods for transporting and applying these materials to agricultural land should be developed. Educational programs are needed to enhance the public acceptability of these materials.

5. Develop methods for more efficient recycling of nutrients in organic wastes for crop production.

   Improved methods are needed for processing and managing organic wastes from agricultural and urban sources for efficient utilization of plant nutrients by crops. Numerical indexes should be developed to predict the nutrient availability of different organic wastes. The nutrient availability index would correlate the rate at which nutrients contained in organic wastes are released to crops for different soil, climatic, and cropping conditions.

6. Determine the availability of phosphorus from rock phosphate and potassium from low solubility sources when applied to soils that are farmed organically.

Research is needed to determine the effect of the rate and frequency of application of different organic wastes and residues on the rate of release of P and K from low solubility mineral sources applied to different soils in organic farming systems. It is possible that a high level of organic intensiveness somehow allows a greater rate of release and availability of these nutrients from sources of limited solubility. The interaction of crop management and climatic factors should be investigated.

7. Develop refined soil test recommendations for nitrogen, phosphorus, and potassium based on crop, soil type, and associated climatic effects.

Correlations of soil tests with crop response to applied P and K fertilizers are often unreliable and imprecise. Research is needed to develop refined soil test recommendations, for both the buildup and maintenance of P and K for major crops at moderate to high yield levels, and to relate these recommendations to specific soil types. Improved correlations would be of great value to both organic and conventional farmers and, in the latter case, would help to prevent overfertilization. Improved methods to predict nitrogen requirements of crops produced both organically and chemically are also needed.

8. Develop new and improved techniques for control of weeds, insects, and plant diseases using biological nonchemical methods.

Methods of pest control using parasites, predator insects and other biological methods to eradicate or control unwanted species should be developed. Breeding programs should be implemented to develop crop varieties that are resistant to insect and pathogen attack and that are more competitive against weeds. These programs should receive continuing and increased emphasis. Improved machinery and tools for mechanical weed management are needed. Allelopathic crops and plants should be investigated as a means of preventing weed seed germination and growth. Crop rotation systems should be developed that compete effectively against weeds, supply symbiotically fixed nitrogen, increase the organic matter content of the soil, and selectively supply nutrients to crops while excluding weeds.

9. Develop through breeding programs crop varieties that are adaptable to organic farming systems.

Breeding programs to develop crop varieties that are more efficient in extracting nutrients from the soil and from sources of limited solubility, and under conditions of

limited fertility, should be implemented. New and improved varieties of legumes and green manure and cover crops are needed for use in organic as well as combination conventional-organic systems.

10. Expand research on biological nitrogen fixation.

Research should be expanded on nitrogen fixation by soybeans, alfalfa, clover, and grasses. Special emphasis should be given to nitrogen fixation by nonleguminous crops. Methods of increasing the effectiveness of nonsymbiotic nitrogen fixation in the soil should be investigated.

11. Determine the effectiveness of organic wastes for improving the efficiency of chemical fertilizers.

There is evidence that higher crop yields are possible when organic wastes and residues are applied in combination with chemical fertilizers than when either one is applied alone. This suggests that the addition of organic amendments may increase the efficiency of chemical fertilizers. Research should be conducted to evaluate the effect of various combinations of organic amendments and chemical fertilizers on crop yields and fertilizer efficiency. The effect of different types of organic wastes and residues on chemical fertilizer efficiency should be evaluated, as well as the potential for enriching (i.e., spiking) organic wastes with concentrated nutrient sources to enhance their fertilizer value.

12. Conduct research on the potential impact of organic farming on the economic viability of small farms.

Farmers on small farms generally depend more on labor than capital and can take advantage of labor-intensive organic farming practices. Many of these farmers have limited funds and could possibly lower their input costs through the use of organic farming practices, such as substituting organic wastes for chemical fertilizers. Research is also needed to develop equipment that is economically feasible for various types and sizes of small farms.

13. Develop procedures to reduce use of antibiotics and chemicals in treatment of mastitis in cattle.[1]

The administration of therapeutic compounds such as antibiotics and chemicals to treat udder infections in cattle is widespread in the United States. This treatment leads to residues in milk, as well as to the development of resistant microorganisms. Research is needed to develop means of utilizing and enhancing the animal's natural defense mechanisms to prevent infections from becoming established.

---

[1]This is not specifically covered in the report but was suggested as a high priority by USDA scientists.

14. Conduct research to investigate the health safety of food products exposed to, and possibly contaminated with, residues of pesticides and other synthetic chemicals in chemical-intensive farming.

Studies in this area should be actively encouraged by the Department of Agriculture by all relevant avenues of approach. This contemplates increased attention especially to critical areas of toxicological and chemical-analytical efforts. There is great public concern about pesticide residues in food and continuing questions as to their real and potential effects on human health. Strategies should be developed to insure the effective and efficient use of pesticides in order to minimize the level of pesticide residues in food.

15. Conduct farm management studies to help individual organic farmers increase their incomes, and develop simulation or other type models to assess the aggregate socioeconomic impact of various combinations of conventional and organic agriculture.

Organic farmers could benefit greatly from research that analyzes the economics of organic farm production systems for various types and sizes of farms. Research of this nature would be extremely helpful in providing needed data to examine in a more rigorous and thorough fashion the aggregate socioeconomic impacts of increased use of organic farming in U.S. agriculture. The social benefits and costs of continued conventional farming versus alternative combinations of conventional and organic farming need to be addressed. The whole issue of how organic farming would affect the structure of agriculture, or what structure of agriculture would be needed to support organic farming, also needs to be researched. Research of this type would require the construction of sufficient data based on organic farming. Currently, little of the data needed for economic modeling and analysis of organic farming exists.

7.3 EDUCATION PROGRAMS

1. Establish courses at land-grant universities on studies of self-sustaining unit systems of farming.

Academic courses should be offered by land-grant universities on self-sustaining unit systems of farming because of their predominance in many developing countries. A study of organic farming systems would be included in such courses, since the self-sustaining unit systems have many things in common with organic farming, including limitations on certain inputs, especially fertilizers and other agricultural chemicals, and emphasis on recycling of nutrients.

7.4 EXTENSION PROGRAMS

1. Develop information materials for county Extension agents to assist them in providing services needed by organic farmers.

   Information is needed to explain the nature of organic farming and organic farming practices to the general public. Extension personnel should have ready access to the latest information on crop rotations, green manure and cover crops, and the utilization of manure and other organic wastes for nutrient recycling that would be applicable to the local areas. Information materials are needed which express the nutrient equivalents (N, P, and K) of organic wastes and residues in terms of their relative availability and suitability for use, and to relate this information to soil test recommendations. Information is needed to explain the suitability of low solubility sources of P and K (e.g., rock phosphate and glauconite) for use in organic systems.

2. Foster the development of direct marketing of organically produced foods.

   Marketing systems and certification programs should be established to assure that organically produced foods are properly labeled and can be efficiently distributed and made available to consumers who desire them. Extension personnel should assist organic producer associations in developing criteria for certification standards and with procedures that would assure that the standards are complied with by organic growers and food processors.

7.5 RECOMMENDATIONS ON ORGANIZATION AND POLICY MATTERS

1. USDA should establish a permanent organic resources coordinator and multidisciplinary advisory committee on organic agriculture.

   Because of the great interest in organic agriculture that has been expressed by both the rural and urban communities throughout this study, it is of utmost importance that USDA develop research and education programs and policy to assist farmers who desire to practice organic methods. At the same time, it is important that USDA continue to learn about all aspects organic agriculture.

   The organic resources coordinator would be responsible for developing liaison between organic farmers, producer associations, and USDA. The coordinator would obtain demographic information on organic growers, and keep USDA informed of the problems and needs of organic growers on matters of information, support, and incentive programs. The coordinator would also, with USDA as the lead agency,

establish an interagency committee on organic agriculture, with representation from EPA, the Food and Drug Administration, Federal Trade Commission, Department of Education, National Science Foundation, State Department, the U.S. Congress, and agencies of the United Nations, such as the Food and Agriculture Organization and the United Nations Environmental Programme. The interagency committee would be responsible for finding ways to reduce the use of chemicals in United States and world agriculture without adversely affecting agricultural production or foreign relations. The advisory committee would serve to provide technical assistance to the coordinator.

Finally, the coordinator would take the lead in examining those public policy issues which affect organic agriculture. For instance, ASCS cost-share arrangements are often cited as one example of public policy which inadequately addresses the needs of organic farmers. Organic farmers and producer groups contend that a number of other policies are also adverse to the goals of organic agriculture. Following a thorough and objective analysis of these policy issues, the coordinator, in consultation with the advisory committee and other appropriate officials, would make recommendations regarding how such policies could be modified to better serve the needs of organic farmers without adversely affecting the interests of conventional agriculture.

REFERENCES

1. U. S. Department of Agriculture. "Improving soils with organic wastes." Report to the Congress in response to Section 1461 of the Food and Agriculture Act of 1977 (P.L. 95-113), 1978, 157 pp.

U.S. GOVERNMENT PRINTING OFFICE 1980 -0- 310-944 /96