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Charles L. Mohler and Sue Ellen Johnson, editors
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Crop Rotation on Organic Farms

A PLANNING MANUAL

Charles L. Mohler & Sue Ellen Johnson, editors

Sustainable Agriculture Research and Education (SARE)
Natural Resource, Agriculture, and Engineering Service (NRAES)

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CROP ROTATION ON ORGANIC FARMS

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CHARLES L. MOHLER AND SUE ELLEN JOHNSON, EDITORS

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CONTENTS

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1
INTRODUCTION

Charles L. Mohler

Crop rotation is a critical feature of all organic cropping systems because it provides the principal mechanism for building healthy soils, a major way to control pests, and a variety of other benefits. *Crop rotation* means changing the type of crop grown on a particular piece of land from year to year. As used in this manual, the term includes both cyclical rotations, in which the same sequence of crops is repeated indefinitely on a field, and noncyclical rotations, in which the sequence of crops varies irregularly to meet the evolving business and management goals of the farmer. Each field has its own rotation, and, consequently, each farmer manages a set of rotations.

Good crop rotation requires long-term strategic planning. However, planning does not necessarily involve identifying which crop will be grown on a field years in advance. Indeed, such specificity may prove futile as plans become disrupted by weather, changes in the market, labor supply, and other factors. Lack of planning, however, can lead to serious problems—for example, the buildup of a soilborne disease of a critical crop, or imbalances in soil nutrients. Such problems can result in an inability to meet the demands of a carefully cultivated market or in additional labor and expense. Problems caused by faulty rotation often take several years to develop and can catch even experienced growers by surprise. In fact, rotation problems usually do not develop until well after the transition to organic cropping. Since the crops grown by organic farmers are often different and more diverse than those grown in the preceding conventional system, the organic transition itself often rotates away from the previous crops and their associated problems. Most farmers are greatly tempted to plant excessive acreage of the most profitable crop or to overuse certain fields for one type of crop. Such practices can lead to costly problems that take many years to correct. The purpose of this book is to help growers and farm advisors understand the management of crop rotations; avoid crop rotation problems; and use crop rotation to build better soil, control pests, and develop profitable farms that support satisfied families.

"The purpose of this book is to help growers and farm advisors understand the management of crop rotations; avoid crop rotation problems; and use crop rotation to build better soil, control pests, and develop profitable farms that support satisfied families."

Although rotating among a diversity of cash and cover crops has numerous advantages, it poses substantial management challenges. The number of crops (and crop families) grown can be large, particularly on diversified vegetable farms and mixed vegetable-grain operations. Mathematically, this creates a huge number of potential crop sequences from which to choose. For example, if a farm produces ten different crops, these can be arranged in 90 two-year sequences, since each of the ten crops could be followed by any of the other nine. The same ten crops can be arranged in any of 5,040 unique four-year sequences! Of course, some sequences can be easily eliminated from the list of possibilities, based on experience

or general rules of thumb, like avoiding successive vegetable crops in the same plant family, but the number of possibilities is still enormous. Further complications arise because, for market reasons, some crops are grown on a larger acreage than others. Large-acreage crops necessarily occur in multiple sequences with different small acreage crops. Moreover, since certain crops grow well only on particular fields due to soil type, availability of irrigation, topography, etc., the problem of choosing effective crop sequences and allotting them to particular fields becomes even more complex.

This manual is intended to assist growers in plotting a course through the maze of decisions involved in planning crop rotations. The idea behind the manual is not to provide a list of rigid dos and don'ts. Rather, the intent is to provide perspectives on how to approach the challenge of planning effective crop rotations and to provide current information on which to base decisions.

How This Manual Was Constructed

To ensure that this rotation planning manual reflects the realities of crop production on actual farms, the New England Small Farm Institute, on behalf of the Northeast Organic Network (NEON), assembled a panel of 12 expert organic farmers. The panel met for three days and worked through a formal facilitated process that produced a detailed analysis of how experienced organic farmers plan their cropping sequences. This process is discussed in chapter 2 (pages 3–20). Each expert farmer also detailed a highly successful crop rotation that they use, along with problems that sometimes occur with that rotation and how they meet such contingencies. These sample rotations are presented in chapter 4 (pages 47–57) and are supplemented with rotations from several farms that have been intensively studied by NEON. These sample rotations may not work well on farms that have different soil conditions, climates, financial resources, or types of crops, but they are intended to provide inspiration and insight in planning crop sequences.

Chapters 2 (pages 3–20) and 4 (pages 47–47) convey the practical experience of expert growers. In contrast, chapter 3 (pages 21–46) emphasizes the theoretical underpinnings of crop rotation. Five researchers who have extensive experience with organic agriculture provide their views on what crop rotation contributes to particular biological and physical aspects of organic cropping systems, including management of soil health, crop nutrition, diseases, insects, and weeds. An important aspect of these contributions is that they clarify what crop rotation cannot accomplish, as well as what it can do to solve various production problems.

Chapter 5 (pages 58–90) outlines procedures for sorting through the diverse types of data to arrive at decisions about crop rotation. These procedures distill the wisdom derived from the panel of expert growers into a method that can be applied to any farm. Step-by-step examples are provided.

Although this manual is primarily intended for organic farmers and the extension personnel who work with them, we hope it will also be useful to other growers. To this end, chapter 6 (pages 91–94) provides a brief discussion about crop sequences that can be used for transition from conventional to organic production.

Intercropping is not a necessary part of crop rotation, but intercropping greatly affects crop rotation planning. Consequently, chapter 7 (pages 95–100) discusses the basic principles of intercropping and how these interact with other aspects of crop rotation.

Finally, a series of appendices provide biological data relevant to planning crop rotations. These data have been assembled from a variety of sources, including scientific literature, extension publications, and farmer experience.

This manual is most applicable for farms from Maryland to Ohio and north through southern Canada. Most of the principles of crop rotation and methods for choosing among potential crop sequences are widely applicable beyond this region. Data tables on crops, weeds, insects, and diseases, however, are likely to be inadequate in areas far from the northeastern US.

How to Use This Manual

This manual can be used in several ways. First, it can be used simply as a reference. For example, one can check for possible pest or soil problems that may occur in a cropping sequence, or determine how long to leave a field out of a particular crop to avoid pest problems. Second, the manual can be used to see how experienced growers think about crop rotations, and how they manage particular crop sequences on their farms. Reading about what researchers have discovered about how crop rotation affects soil and pests will further increase one's understanding of crop rotations. Finally, the manual provides a method for systematically planning the crop rotations on a farm.

2

HOW EXPERT ORGANIC FARMERS MANAGE CROP ROTATIONS

Sue Ellen Johnson & Eric Toensmeier

Crop rotation is central to the success of organic farms. So how do successful farmers plan and execute crop rotations?

We asked twelve expert organic farmers this question when they gathered at a farmhouse in upstate New York for three snowy days in 2002. Between homemade organic meals, they detailed how they plan and execute crop rotations on their farms. The expert farmers, who together have over 200 years of experience, shared many concepts and insights about crop rotation management. Twenty other organic growers have since reviewed and added to the panel farmers' conclusions. Their cumulative knowledge and common practice are summarized in this chapter. Their specific actions and decisions related to crop rotation are outlined in the chart "Managing a Crop Rotation System" on pages 12–13. The chart delineates the key "responsibilities" and the necessary "tasks" that need to be executed to fulfill each key responsibility.

Why Rotate Crops?

Effective crop rotations are a foundation of organic cropping systems. Organic farmers recognize that crop rotation is necessary to maintain field productivity. Expert farmers design their rotations to (1) earn income and (2) increase soil quality or build "soil capital" (sidebar 2.1). Crop rotation and a crop rotation plan and records are required for organic certification of a field or farm.

Numerous books and articles outline the goals and benefits of crop rotations (see sidebar 2.2, page 4). The contribution of our panel of expert farmers is interesting in (1) the emphasis they give to business management decisions in crop rotation planning; and (2) the flexibility of their crop rotations, specifically the absence of fixed, long-term crop rotations. Their rotation planning is an ongoing annual process that incorporates information and objectives for multiple years. Many expert farmers do not have standardized, cyclical crop rotations for every field, yet our experts share an overall approach to designing, implementing, and adapting crop sequences on their farms. The tools in chapter 5 (pages 58–90) are designed to help readers develop their own expertise.

Sidebar 2.1

The Concepts of Soil Quality, Soil Capital, Soil Health, and Soil Life

The expert farmers used many terms interchangeably as they discussed rotations and their farm goals. Organic agriculture revolves around the concepts of soil life and soil biology. Organic practices, including crop rotation, are expected to enhance soil life and soil health. A basic tenet of organic agriculture is that biological diversity and soil organic matter are drivers of productive organic farming systems. Farmers believe that a soil high in organic matter leads to a healthy, biologically active soil that will have fewer crop fertility, pest, and disease problems. Farmers also use the term *soil capital* to express how soil building practices are an investment in long-term soil productivity.

Sidebar 2.2

What Some Good Books Say about Crop Rotation

Numerous books and articles do an excellent job of outlining rotation theory, guidelines, and practice. Many present crop-by-crop rotations. These may or may not reflect the real complexity of modern organic farming operations and successful farm management, but a sampling of the advice is listed below.

From *Cyclopedia of American Agriculture* (1907; L. H. Bailey, ed.), chapter 5, "Crop Management," pp. 85–88:

a. The rotation must adapt itself to the farmers business.
b. It must adapt itself to the soil and fertility problem.
c. The fertilizer question often modifies the rotation.
d. The kind of soil and the climate may dictate the rotation.
e. The labor supply has an important bearing on the character of the rotation course.
f. The size of the farm and whether land can be used for pasturage are also determinants.
g. The rotation must be planned with reference to the species of plants that will best serve one another, or produce the best interrelationship possible.
h. The rotation must consider in what condition one crop will leave the soil for the succeeding crop, and how one crop can be seeded with another crop.

From *Organic Farming* (1990; Nicolas Lampkin), chapter 5, "Rotation Design for Organic Systems," pp. 131–32:

"Usually a rotation contains at least one 'money crop' that finds a direct and ready market; one clean tilled crop; one hay or straw crop; one leguminous crop. . . .

The starting point for the design of a rotation should be the capabilities of the farm and the land in terms of soil type, soil texture, climatic conditions."

Basic guidelines:

Deep rooting crops should follow shallow rooting crops. . . .
Alternate between crops with high and low root biomass. . . .
Nitrogen fixing crops should alternate with nitrogen demanding crops. . . .
Wherever possible, catch crops, green manures, and undersowing techniques should be used to keep the soil covered. . . .
Crops which develop slowly and are therefore susceptible to weeds should follow weed suppressing crops. . . .
Alternate between leaf and straw crops. . . .
Where a risk of disease or soil borne pest problems exists, potential host crops should only occur in the rotation at appropriate time intervals. . . .
Use variety and crop mixtures when possible. . . .
Alternate between autumn and spring sown crops. . . .

Also consider:

suitability of individual crops with respect to climate and soil
balance between cash and forage crops
seasonal labour requirements and availability
cultivation and tillage operations

From *Building Soils for Better Crops* (2000; Fred Magdoff and Harold van Es), chapter 11, "Crop Rotation," pp. 102–3:

General Principles:

1. Follow a legume crop . . . with a high nitrogen demanding crop.
2. Grow less nitrogen demanding crops . . . in the second or third year after a legume sod.
3. Grow the same annual crop for only one year . . . .
4. Don't follow one crop with another closely related species. . . .
5. Use crop sequences that promote healthier crops.
6. Use crop sequences that aid in controlling weeds.
7. Use longer periods of perennial crops on sloping land.
8. Try to grow a deep-rooted crop . . . as part of the rotation.
9. Grow some crops that will leave a significant amount of residue.
10. When growing a wide mix of crops . . . try grouping into blocks according to plant family, timing of crops, (all early season crops together, for example), type of crop (root vs. fruit vs. leaf), or crops with similar cultural practices. . . .

Basics of Crop Rotation

Rotations are one dimension of the art and science of farm management. The biological principles of crop rotation intersect with many other aspects of the farm operation and farm business. Crop rotation is both a principle of production and a tool of management (see sidebar 2.3). Expert farmers balance market options and field biology. Labor, equipment, the layout of beds and fields, along with other logistics of planting and harvest, all influence how rotations are designed and executed.

Expert farmers' rotations include key cash crops, "filler" or "break" crops, and cover crops. In every season, farmers must manage production across multiple fields and beds. Variation in the acreage of each crop, variation in field characteristics, and shifting business decisions result in multiple rotations or crop sequences on most organic farms. Consequently, farmers manage numerous crop rotations on the same farm.

"Model" rotations may suggest that every crop is grown on a fixed schedule on every field, with each crop rotating field to field around the entire farm. In reality, expert farmers in the northeast US rarely cycle every crop they grow through every field on any regular schedule. Instead, each field tends to have its own distinct sequence of crops, tillage, and amendments. Thus, each field tends to have a unique cropping history. On some farms, a few fields do follow an established, fixed rotation. Through trial and error the managers of these farms have settled on a cyclical rotation that works well for a particular field (see chapter 4, pages 49–54 for real field examples).

The challenge of a good crop rotation system is to grow the type and quantity of crops needed to ensure the farm's profitability while continually building soil quality for long-term productivity. Most vegetable farms grow many different crops and crop families. Every crop is not equally profitable, and some crops are highly profitable but have limited markets. The rotation of botanical families of crops prevents the buildup of pest populations, by (1) interrupting pest life cycles, and (2) altering pest habitats. Alternatively, fields (or beds) may be deliberately rotated through a fallow to manage a weed or pest problem. Sometimes tillage, the use of mulch, or compost applications are also integrated into a field's rotation plan (see chapter 4, pages 49–54 for examples). Cover crops are often used for building soil fertility and health but make no direct contribution to cash flow. Farms with limited acreage may rely on compost or other soil amendments rather

Sidebar 2.3

Expert Farmers' Definitions of Crop Rotation

The NEON expert panel did not formally define crop rotation, but individual farmers provided their own working definitions:

- Don Kretschmann—"Rotation is the practice of using the natural biological and physical properties of crops to benefit the growth, health, and competitive advantage of other crops. In this process the soil and its life are also benefited. The desired result is a farm which is more productive and to a greater extent self-reliant in resources."
- Roy Brubaker—"[Rotation is] a planned succession of crops (cash and cover) chosen to sustain a farm's economic and environmental health."
- Will Stevens—"I've come to view crop rotation practices as a way to help me use nature's ecological principles in the inherently non-natural world of agriculture. Striving to have as much 'green' on the ground as possible throughout the year is one step in that direction. I view crop rotation as a series of 'rapid succession' cycles, (ideally) minimally managed. Through this approach, the power and sustainability of natural systems can be expressed through the health and prosperity of the farm system."
- Jean-Paul Courtens—"Rotations balance soil building crops (soil improvement crops) and cash crops, and can allow for bare fallow periods to break weed cycles and incorporate plant matter into the soil."

than cover crops (see sidebar 2.4).

Farmers with large land bases often include longer-term, soil-restoring perennial cover or hay crops in their rotations. After a period of intensive cropping, fields cycle out of annual production and into perennial hay or green manure cover crops. During the intensive cropping period, the season-to-season sequences vary with contingencies, and biological principles may be neglected. The perennial hay or cover crop is then expected to correct problems that may have built up during intensive cropping. These cycles often run six to ten years or more.

On many successful farms, long-term, fixed, cyclical rotations are far less common than simple two- or three-year crop sequences. Expert farmers frequently rely on numerous "trusted" short sequences or crop couplets to achieve their crop rotation objectives. Instead of planning long, detailed cyclical rotations, experts use a suite of interchangeable short sequences to meet their farm's goals for cash flow and soil quality. Biological principles are the main determinants of these short sequences. Samples of short sequences are shown in the "Real Fields on Real Farms" chart in chapter 4 (pages 49–54).

During a field season, a bed or field may be planted with a series of different short-season crops. Sometimes, because of market demand or other farm practicalities, growers make multiple plantings of a crop in the same bed within a given growing season, which is more problematic biologically. The same crop or sequence is rarely replanted in the same bed or field the following year, however, due to the likelihood of pest and disease outbreaks. Cover crops are often planted to follow or precede a cash crop and occupy a field only for the winter or a portion of the growing season. In all cases, experts are very conscious that such intensive cropping needs careful biological monitoring and management.

SIDEBAR 2.4

Farm Size, Cover Crops, and Crop Rotations

Farm size affects cover cropping and the management of the crop rotation. Organic farmers plant cover crops to protect the soil, increase soil organic matter, improve soil physical properties, and accumulate nutrients. Cover crops may also provide habitat for beneficial insects or help crowd out weeds.

Most expert farmers integrate cover crops into their fields at every opportunity. Sometimes these opportunities come before or after a short-season crop or during the months between full-season summer crops. Many expert farmers use a full year of cover crops to restore the soil after intensive use. Large farms often have rotations that include multiyear perennial cover crops or hay.

Farmers with limited acreage (<5 acres) find that including cover crops and providing adequate rotation of crop families on a given field is challenging (see chapter 4, pages 47–57). Many smaller farms rely on mulch, compost, and short-term winter cover crops in place of multi-season cover crops and hay rotations. Expert Brett Grohsgal advises that "smaller and more intensively managed farms don't have nearly the cover crop dependence that [larger farms] do, yet these small systems can be extremely efficient, vigorous, and profitable."

Crop Rotation and Farm Management

Crop rotations require multidimensional thinking. Rotation management requires understanding both the whole farm and each individual field and balancing field- and farm-scale decisions (figure 2.1). On successful farms, rotation planning is a rolling, responsive process. Expert farmers are continually balancing annual and multiyear (short- and long-term) decisions. Business decisions must be optimized for annual returns and cash flow. Expert growers indicate that in any given season, market opportunities and logistical needs may override biological concerns.

Experts manage multiple, interacting factors as they implement crop rotations. Organic farmers rely on rotations and long-term soil quality to deal with problems and ensure the productivity of fields more than they rely on fertilizers and pest control products. Their understanding of biological principles sets the boundaries of their management practices. Many expert farmers push and test the

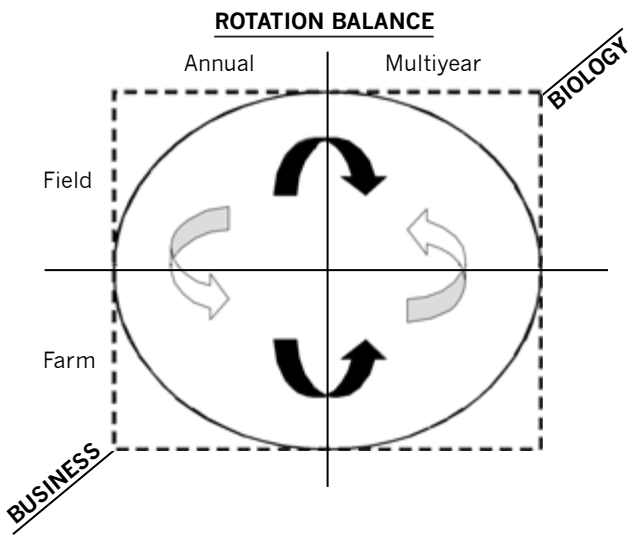

FIGURE 2.1 Rotation planning balances the management of field- and farm-level decisions on an annual and a multi-year basis. Annual farm-level decisions tend to prioritize business concerns. Multi-year decisions tend to prioritize and accommodate biological demands.

FIGURE 2.2 Expert organic vegetable farmer panel, convened January 30 to February 1, 2002. From upper left: Jean-Paul Courtens (NY), Eero Ruuttila (NH), Paul Arnold (NY), David Blyn (CT), Roy Brubaker (PA), Don Kretschmann (PA), Jack Gurley (MD), Brett Grohsgal (MD), Polly Armour (NY), Drew Norman (MD), Will Stevens (VT). Not pictured: Jim Gerritsen (ME).

biological principles of crop rotation to the limit to meet management and business demands.

Expert farmers plan and implement rotations on an annual, seasonal, and last-minute opportunistic basis. Their annual plans are based on clear priorities. Each year the paramount challenge is to grow adequate quantities of profitable crops to keep the farm viable. At the same time farmers are deciding the rotational sequence on each field, they must consider how to rotate equipment and labor efficiently across the entire farm operation. Crop cultural and harvest characteristics—including the logistics of labor-intensive weeding or multiple harvests; vehicle access; and keeping crops like pumpkins or flowers secure from vandals, thieves, and wildlife—have to be managed across farm *and* field. Meanwhile, meeting market demands and maintaining cash flow are farm business issues that must be integrated with field decisions. Inevitably, expert farmers also adapt to the weather conditions of specific years, often by changing their crop mix and, consequently, their rotations.

Most farms have a few key cash crops that generate significant income. Year by year, expert farmers focus on planting their key crops in the most suitable fields for those crops without compromising the soil health and long-term productivity of those fields. Generally, these crop-to-field matches are first made based on market and logistical considerations (see sidebar 2.5, page 8). Then expert farmers review whether there are biological reasons to go in a different direction. They cross-check "what not to do" (see appendix 2, pages 104–123) biologically with both their experience and their knowledge. Farmers take special care to manage the production and soil capital of their best fields. Relying on their knowledge of their fields and the crops they grow, and some general principles (for example, avoid planting related crops in the same field year after year), expert farmers determine the

crop for each field each year.

In any given year, field history, along with the weather, determine the suitability of a field for a particular crop. On many farms in the northeast US, any one field (or bed) is usually not interchangeable with all the others on the farm. Fields, even beds, have unique attributes because of soil parent material and landscape position. Even if soils are similar, microclimates, access to irrigation, and distance to roads or packing facilities cause some fields to be better suited for certain crops. Some fields are simply more productive; others have particular histories or problems that preclude certain crops or rotations.

Expert farmers understand that each field's biological management is central to the long-term success of the overall farm business. They monitor and manage crop rotation to limit negative impacts on any one field. Biological guidelines come into decisions at every convenient opportunity (for example, a field that was too wet for a planned early spring crop is now open for a cover crop). Biological guidelines also enter into decisions when a problem becomes evident and must be addressed (for example, a soilborne disease such as *Phytophthora*).

Frequently, expert farmers design crop sequences to set up for future key crops, in addition to meeting the current season's production needs. For example, for a successful early seeding of a small-seeded crop like carrot the rotation sequence must be planned so that the residue of the previous crop will be fully broken down—providing the proper seedbed for the next season's crop. Other sequences may be designed so that substantial spring growth of an overwintering cover crop precedes a heavy-feeding cash crop. For example, a field could be planted with a summer-harvested crop such as sweet corn in the current year, so that a hairy vetch cover crop has time to establish in the fall and supply nitrogen for a heavy-feeding cucurbit the following spring. High-value crops that are difficult to grow are often pivotal in determining a rotation, because they are the most critical in terms of both the business and the biology of the farm.

Of course, plans don't always go as expected. Market opportunities or weather may dictate a change in a rotation (sidebar 2.5). Seed may not be available or viable. A field may have weed problems or a pest outbreak that is best addressed by rotation. The experts build flexibility and responsiveness into their annual plans.

Expert farmers often need to make decisions for individual fields on the fly, based on their experience and knowledge of each field and the overall farm. They know what can go wrong. They know the limits of their systems. As business managers, they are continually reviewing the farm and its operational capabilities. Many farmers rely on their mental categorization of crops and fields (described in sidebar 2.9, page 15) which makes the quick substitution of crops easier. A tool for crop categorization and allocation of crops to fields is introduced in chapter 5 (pages 58–90).

Expert farmers balance the farm business, farm management, and field biology. Since they manage their systems intuitively, they do not always distinguish farm planning from crop rotation planning. For example, choosing the crop mix is a market-driven business decision, which is coupled with the allocation of crops to fields, which is a biological and logistical decision.

Sidebar 2.5

Opportunistic Decisions: Business Overrides Biology

Unexpected opportunities and circumstances often confront farmers. Expert farmers go through the following steps as they manage these situations:

1. Recognition of a market opportunity or logistical contingency (such as a change in weather, equipment, or labor availability).
2. Feasibility assessment to determine whether the market can be met successfully. Considering the available land, labor, equipment, and irrigation, will the change increase the overall profitability of the farm operation? What is the cascade effect across the farm?
3. Biological cross-check to determine the field or variety. For example, a more disease-resistant variety may be selected if taking advantage of the economic opportunity means that the rotation time between susceptible crops would be decreased. *Biological "rules" may be stretched to meet the market, but they are not repeatedly ignored on the same fields.*

The NEON "Managing a Crop Rotation System" Chart

Our panel of expert organic farmers participated in a structured, facilitated process that was designed to elicit an outline of step-by-step decisions and actions related to their own management of crop rotation (sidebar 2.6). This is summarized in the chart "Managing a Crop Rotation System" (pages 12–13) The content and wording of the chart are those of the expert farmers. The chart reflects both their common practices and how they think about those practices.

The primary purpose of the chart is to provide insight into the decisions and actions followed by experienced organic growers as they manage crop rotations. The responsibilities and tasks outlined in the chart demonstrate how expert farmers integrate crop rotation decisions into the overall planning and operation of their farms. The chart provides a general, overall guide to all of the steps needed to manage crop rotations on an organic farm. Chapter 5 (pages 58–90) presents tools based on the experts' recommendations that will help in executing several priority tasks on the chart.

How to Read the Chart

The left hand column of the "Managing a Crop Rotation System" (pages 12–13) chart represents eight broad "key responsibilities" necessary for managing crop rotations. Each key responsibility is associated with a set of necessary "tasks" described in the boxes that run across the page. These tasks must be completed to fulfill the responsibility. (Note that the tasks associated with a key responsibility sometimes take up more than one row.)

Bear in mind the following when consulting the chart:

- The word *crop* refers to both cash and cover crops unless otherwise specified.
- The responsibilities are listed more or less in the order in which they are performed. Managing a crop rotation, however, is neither a linear nor a cyclical

Sidebar 2.6

The NEON Expert Farmer Rotation Workshop

The New England Small Farm Institute adapted a process called Develop a Curriculum, or DACUM (78a), to understand and present the decision process followed by expert farmers in planning and implementing organic vegetable rotations. The DACUM process was first created at Ohio State University to develop training materials based on the knowledge of experienced workers in business and industry. It was built around the idea that skilled individuals currently performing a job are better able than anyone else to describe the job and how they do it. The approach provided a structured forum for farmers to successfully communicate about management of their farms. The expert farmers created the chart "Managing a Crop Rotation System," which details the key responsibilities for management of successful rotations and the tasks associated with each responsibility. It gave scientists a unique perspective on how farmers manage their systems and how research is used by farmers.

The Expert Growers

Twelve expert organic vegetable growers (figure 2.2, page 7) who farm from Maryland to Maine were nominated by sixteen organic farming organizations and organic certifiers in the northeastern US to participate in the three-day NEON Expert Farmer Rotation Workshop in 2002. Each of them had been farming for eight or more years, and vegetables are the primary crops on all twelve farms. Their operations range in size from 5 acres to 200 acres. They employ an array of marketing strategies, from wholesale to community-supported agriculture (CSA). Twenty other growers with similar qualifications reviewed the chart and other materials produced by the workshop (e.g. lists in sidebars 2.7, 2.8, 2.9, and 2.12, page 11 to page 18). Together, the expert farmers and the reviewers are representative of the best farms in the northeast US. (Farmer profiles are presented in sidebar 4.2, page 48)