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Organic Crop Production Overview

Fundamentals of Sustainable Agriculture

Abstract: *This publication provides an overview of the key concepts and practices of certified organic crop production. It also presents perspectives on many of the notions, myths, and issues that have become associated with organic agriculture over time. A guide to useful ATTRA resources and to several non-ATTRA publications is provided.*

By George Kuepper and Lance Gegner
NCAT Agriculture Specialists
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What is Organic Agriculture?

Over the years, it has become commonplace to understand and define organic agriculture as farming without synthetic pesticides and conventional fertilizers. This should not be considered a definition but a characteristic — only one characteristic of a socially and environmentally conscious approach to agriculture that is currently experiencing rapid growth in the U.S.(1)

A more suitable definition of organic agriculture is provided by the National Organic Standards Board (NOSB) — the federal advisory panel created to advise the USDA on developing organic legislation.

> ***"an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony(2)."***

The NOSB definition, not surprisingly, is similar to many definitions of "sustainable" agriculture. Research on organic farms, done over several decades, has revealed characteristics usually associated with sustainable farming, such as reduced soil erosion (3), lower fossil fuel consumption (3), less leaching of nitrate (4), greater carbon sequestration (4) and, of course, little to no pesticide use.

The Origins of Organic Agriculture in the United States

As close as anyone can determine, the first use of the term "organic" (in this country, anyway) was in 1940. J.I. Rodale coined it in an article for the publication *Fact Digest*.(5) Shortly thereafter, he launched *Organic Farming and Gardening* (OFG) magazine — for many years the flagship publication of Rodale Press. Along with OFG, Rodale Press published (and continues to publish) a large number of books and booklets on organic agriculture. For a long time the publishing house was the most highly visible and accessible source of information about "non-chemical" farming and gardening in the U.S. As such, it was probably the single greatest influence on the shape and underlying philosophy of mainstream organics. J.I. Rodale drew his concept of organic agriculture from a number of sources, including Louis Bromfield (the author of *Malabar Farm* and other books on conservation farming), Dr. William Albrecht (from the Department of Soils at the University of Missouri), and the Biodynamic movement. However, his key ideas about farming came from the British agronomist Albert Howard. Howard worked in the foreign service in India during the first quarter of the 20th century, and much of what he preached about agriculture came from his observations and experiences in that part of the world.

In his landmark books, *An Agricultural Testament* (6) and *The Soil and Health* (7), Howard pointed to emerging problems of animal and plant disease, soil erosion, and similar conditions. He laid the blame for these on mismanagement of soil. Howard specifically cited the failure of modern civilizations to properly return wastes from cities and industries to the farms. Sustainability issues were at the top of the list for this man, now considered the "father of organic agriculture."

Clearly, Howard did not believe that reliance on chemical fertilization could address these concerns. He thought it a misguided approach —the likely product of reductionist reasoning by "laboratory hermits" who paid no attention to how nature worked.

Howard promoted a natural approach to building soil and fertility. He wrote in great detail about the use of deep-rooting crops to draw nutrients from the subsoil, about managing crop residues, and about green manuring. However, Howard gave the lion's share of his attention to composting. The *Indore Process*, which he was responsible for popularizing, is exemplified today by the basic layered, bin composting system that is the standard in organic gardening.

In America, Rodale expanded on Howard's ideas. In his seminal book on organic agriculture, *Pay Dirt* (8), he identifies a number of other "good farming practices" — like crop rotation and mulching — that gave further definition and clarification to what have become accepted organic practices and inputs. This is important because organic farming embodies the elements of a sound agriculture — traditional practices that have been proven over time. In fact, a good, convenient, working definition for organic agriculture is ***good farming practice without using synthetic chemicals.*** This working definition distinguishes organic practice from the general milieu of agriculture that existed in the pre-chemical era, much of which was exploitative and unsustainable. Organic farming was never intended to be a "throwback" or regressive form of agriculture.

A truly significant event in the history of organics took place in 1962, with the publication of Rachel Carson's *Silent Spring*.(9) *Silent Spring* is a strong and dramatic statement about the impact of pesticides on the environment. It was one of the key documents that gave birth to environmental consciousness in the 1960s and 1970s.

When environmentalists and others began looking around for an alternative to pesticides and industrial agriculture, organic farming was there. Not only was it an approach that did **not** use synthetic pesticides, it also had an attractive counter-culture name that grew to signify a philosophy of living as well as a method of farming.

While *Silent Spring* and the environmental movement were not about organic farming per se, they brought it to public consciousness on a vast scale. It is not uncommon, in fact, for some writers to suggest that organic agriculture began with Rachel Carson's book. Though this assertion is untrue, the book clearly played a major role in stimulating industry growth and in altering public perceptions. From the mid-1960s onward, organics was increasingly identified with pesticide issues. It became the idealized alternative for providing clean, healthy food and environmental protection.

Notions of Organic

As organic farming and marketing entered the 1970s, it began to develop as an industry. As a result, a clearer definition was needed to distinguish it and its products from conventional agriculture. This was no straightforward task. Environmental issues and other alternative agriculture philosophies had created diverse notions about what organic agriculture was and what it should be.

A particularly problematic image grew unexpectedly from the anti-pesticide movement of the 1960s. This was the romantic notion that organic simply meant "doing next-to-nothing." In this exploitative approach, not only were pesticides avoided, sound farming practices that built the soil were also largely ignored. The results achieved on such farms were predictable, as yields were low and the quality poor. These approaches became collectively known as *organic by neglect* and are a far cry from the responsible farming models proposed by Albert Howard and J.I. Rodale.

It is unclear how many farmers actually chose to farm "by neglect" *and* advertise themselves as organic over the years. However, this extreme representation of organic agriculture was quickly taken up by critics who tried to characterize all of organic agriculture as soil depleting and unproductive.(10) To counter this, current standards for certified organic production require an "organic plan" outlining the use of soil building activities and natural pest management.

There is a further notion that organic farming also describes farm systems based on soil building, but that continue to use some prohibited fertilizers and pesticides in a limited or selective manner. A USDA study of U.S. organic farms (11) made note of many such individuals who readily and sincerely referred to themselves as organic farmers. While these growers were largely conscientious and would, in most instances, fall under the modern umbrella of "sustainable farmers," industry standards evolved to preclude *all* synthetic pesticides or commercial fertilizers. The approach to farming by this loose-knit group of growers and their supporters has come to be called "eco-farming" or "eco-agriculture" — terms coined by *Acres USA* editor Charles Walters, Jr.(12)

A further notion of organic agriculture that bears addressing is the persistent image of organic farming as being possible only on a very small scale. This impression has been enhanced by the high visibility of organic market gardens. These, of course, are small because market gardening — conventional or organic — is usually done on a smaller scale. Also, some organic market garden systems, such as Biointensive Mini-Farming, use highly labor intensive/low capital investment technologies. These have become popular among U.S. gardeners and, more importantly, with those concerned with Third World development, where such systems are especially relevant. Focus on these systems has, unfortunately, distorted the picture of organics as a whole.

Traditionally, organic farms truly have been smaller than conventional operations. This has been due in part to labor requirements. Organic systems are generally more labor intensive. Studies done in the late 1970s by Washington University, for example, found that about 11% more labor was required per unit of production where agronomic crops were concerned.(13) This difference can be much greater where horticultural crops are involved, and farm size may be limited accordingly. However, technological innovations in organic horticultural production are helping to narrow the gap. Organic systems are also more information intensive, requiring additional management time in planning, pest scouting, and related activities. For this reason, organic management can be better done if a farm is not too large.

Essentially, the notion that organic systems are only possible on very small farms is a false one. Both the Washington University and the USDA studies confirmed this.(3, 11) Given the range of acceptable technologies available, organic agriculture can be sized to fit a wide range of farms and enterprises.

Landmark Research

Throughout its early history, organic agriculture was treated with either hostility or apathy by the USDA, land grant universities, and conventional agriculture in general. Since it was largely promoted as a better alternative to the status quo, this is not surprising. Fortunately, the atmosphere for discussing and investigating organics has improved considerably. While it did not become boldly evident until the 1990s, the tide actually began turning in the late 1970s and early 1980s.

A number of factors precipitated this change, among them the growth in the organic industry. Serious money demands serious attention. Also critical, from the perspective of the research community especially, were some landmark studies that lend credibility to organic farming as a truly viable option for American agriculture.

The first of these "landmarks" was a series of studies done by Washington University. Funded by the National Science Foundation, this research was motivated by the energy crisis of the 1970s and the effect that higher energy prices would have on agriculture in the nation's Cornbelt. When researchers learned that there were commercial farms that were not dependent on the high-energy inputs of conventional farming, the focus quickly shifted to the study of organics.

In addition to the documentation of practices, crop yields, attitudes, and the sustainability indices (cited elsewhere in this publication), the researchers made what was certainly the most astounding discovery of all, that commercial organic farms could be competitive with conventional farms in the conventional marketplace.(3)

Arriving on the heels of the Washington University work was another study of great significance done by the USDA. In contrast to the Washington University effort, these researchers chose to extend their survey of farmers nationally and over a wide range of enterprises. The findings of the USDA study, which were fair, largely positive, and encouraging, kicked open the door for future organic research in ways that a non-land grant/non-USDA entity like Washington University could not. The final report – bound with pastel green cover sheets – was a conspicuous object at alternative agriculture conferences and field days throughout the early 1980s.(11)

Also of particular note was a symposium on organic farming held in Atlanta, Georgia, in late 1981. The meeting was sponsored jointly by the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America — traditionally very conservative entities. It brought together not only representatives of the Washington University and USDA teams, but a surprising number of other researchers clearly interested in the same issues of sustainability and finding a glimmer of hope in organic agriculture.(14)

Organic Certification

In 2002, when the USDA adopted the National Organic Standard that spells out what farmers and food processors must (and must not) do to be certified "organic," the organic industry already had a long history of relying on third-party certifiers to ensure the integrity of their products and practices. Under this system, a state-run or accredited private agency (the third-party) evaluates farmers and processors to see whether they conform to the standards of the National Organic Program (NOP). Those who do can then market their products as "USDA Certified Organic" and display the official USDA organic seal on their packaging.

In essence, certification is largely about integrity — assuring that the buyer is getting what he or she is paying for. Certified organic production, then, means production by approved organic methods, with additional pains taken to eliminate contamination with prohibited materials and commingling with conventional products.

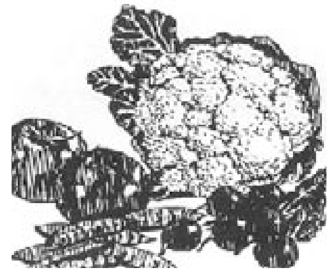
There is a common misconception that certified organic means "pesticide residue-free." Consumers have a right to expect little or no pesticide residue on certified organic crops because none are used in their production. However, ours is a dirty world in which pesticides and their break-down products are ubiquitous. This is only to be expected in a national farm system where more than 99% of all applied farm chemicals miss the target organism. (15)

The principles, practices, and tools discussed in the remainder of this publication reflect the guidelines recognized by the NOP, though minor details may vary among third-party certifiers. It is important, therefore, that producers understand their certifying agency's standards well and keep in close touch with a representative.

Note that these principles and practices also provide a foundation for other sustainable approaches to crop production, perennial or annual.

Organic Principles

There are several compelling principles that characterize certified organic farming. They include *biodiversity*, *integration*, *sustainability*, *natural plant nutrition*, *natural pest management*, and *integrity*. Most organic operations will reflect all of these to a greater or lesser degree. Since each farm is a distinct entity, there is a large degree of variation.



Biodiversity

As a general rule, diverse ecosystems in nature have a higher degree of stability than those with only a few species. The same is essentially true for agroecosystems. Farms with a diverse mix of crops have a better chance of supporting beneficial organisms that assist in pollination and pest management. Diversity above ground also suggests diversity in the soil, providing better nutrient cycling, disease suppression, tilth, and nitrogen fixation.

Good organic farmers mimic the biodiversity of nature through practices like intercropping, companion planting, establishment of beneficial habitats, and crop rotation (sometimes referred to as companion planting across time). The effort to increase biodiversity works hand-in-hand with enterprise diversity, which is often (but not necessarily) an objective on organic farms.

Diversification and Integration of Enterprises

The drive to build biodiversity in organic systems encourages diversity among enterprises, but not as isolated or independent entities. Good organic operations integrate their various enterprises. A good example can be seen among Midwestern organic crop and livestock operations.

The typical Midwestern organic operation ties the needs of crops and livestock together in a practical and elegant way. The forage and grain needs of ruminant livestock make for a diverse mix of crops. Particularly valuable is the inclusion of legume forages for ruminant feed. Forage legumes in rotation fix a sustainable supply of nitrogen in the soil that feeds subsequent non-legume crops in rotation. Manure from the livestock enterprises is conserved as a nutrient resource and recycled back to the crop fields.

Farms such as these have the additional advantage of greater economic sustainability, as their risks are spread over several livestock and crop enterprises.

Sustainability

In addition to the greater economic sustainability afforded by enterprise diversification, organic farmers are often able to reap market premiums for certified production. However, since many organic enterprises realize somewhat lower marketable yields, this has not always translated into higher profits or greater economic sustainability. As more and more organic growers enter the marketplace, it is likely that premiums will stabilize at modest levels and may vanish for some crops. Organic producers need to look well ahead and be aware of shifting trends.

As alluded to earlier, many U.S. organic farms perform well on many of the measurable indicators associated with sustainability, such as energy consumption and environmental protection. However, sustainability is an ideal, and the best that can be said is that current organic farms are closer to the ideal than most alternatives — certainly closer than comparable conventional farming operations.

The extent to which traditional organic agriculture philosophy influences the adoption of sustainable practices has only been touched upon. For example, during the Washington University studies of midwestern farms in the late 1970s, researchers observed that organic farmers had embraced conservation tillage technologies at a much faster rate than their conventional counterparts.(3) Conservation tillage was not and is not considered a traditional practice of organic farming, yet its ready adoption points to the dynamic nature of organic agriculture and offers clear evidence that the underlying philosophy of sustainability — strongly championed by Albert Howard — remains a vital part of organics. Given the option of a sustainable technology that fits the constraints of certified organic agriculture, it is natural for most organic farmers to choose it.

Natural Plant Nutrition

Even though we require the same basic "stuff" to live, it is somewhat challenging to draw simple comparisons between the nutritional needs and processes of plants and those of animals. Plants are able to photosynthesize to make sugars, which are ultimately synthesized into proteins and other plant constituents. Humans and other animals, by contrast, can obtain energy foods, proteins, and vitamins only by consuming plants or other animals.

Both plants and animals also require minerals. Humans and other animals extract minerals, along with sugars and proteins, from the food they eat. Plants, too, obtain minerals — and a wide range of vitamins, antibiotics, and other useful compounds — through digestion. However, plant digestive systems are not internalized as they are in animals. Plants must rely on the external digestive processes of the soil system within reach of their roots — a zone called the *rhizosphere*.

The organic philosophy of crop nutrition begins with proper care and nourishment of the organisms responsible for the soil digestive process. Organic farmers believe this is best accomplished by avoiding toxic chemicals and practices — like excessive tillage — that are harmful to soil organisms, as well as by the addition of organic matter and natural rock minerals. Conventional systems, in contrast, try to circumvent the soil's digestive process and provide needed minerals to the plant directly, in a soluble form.

From the organic perspective, the conventional approach has several flaws.

- Applying large quantities of soluble fertilizer to a crop only one, two, or three times per season floods the plant with those nutrients, causing nutritional imbalances that lead to crop diseases, insect infestations, and reduced food quality.
- Failure to support and care for soil biotic life, along with other practices that are downright destructive, ultimately leads to its decline. As a result, plants lose out on the vitamins and other beneficial products these organisms produce, tilth is reduced, and the soil becomes increasingly dependent on synthetic inputs.
- Conventional fertilization tends to concentrate on a limited number of macronutri-

Nutrient Absorption

Critics are often under the illusion that organic farmers believe plants obtain all their nutrients from an organically managed soil in a chemically organic form. While a few organicists may believe that, the majority recognizes that digestion processes in the soil release minerals in forms similar to those applied as commercial fertilizers. Unfortunately, the notion that organic farmers are naïve and ignorant about basic agronomy is a red herring that has often foiled intelligent discussion about the pros and cons of the system.

Among the facts that are often obscured is that plants can and do absorb significant amounts of large organic molecules from the soil; herbicide and systemic insecticides are among these. In healthy soils they also absorb vitamins, chelated minerals, hormones, and other beneficial compounds. (16)

ents, even though the need for at least 13 soil minerals is scientifically recognized. This skewed focus is also responsible for generating imbalances in the plant.

- Application of large amounts of soluble nutrients can stimulate certain problem weed species.
- Soluble nutrients — especially nitrate— are prone to leaching, which can cause a number of environmental and health problems.

It is organic farming's approach to soil building and plant fertilization that is the true basis for the belief that organic food and feed has superior nutritional value, much more so than the absence of pesticide residues, which has drawn the spotlight ever since the 1960s.

Natural Pest Management

Whether conventional or organic, all farmers are concerned with pests. They spend a lot of time and resources controlling them. However, in the organic "world view," pests — whether weeds, insects or diseases — are not simply scourges. They are indicators of how far a production system has strayed from the natural ecosystems it should imitate. Certain weeds, for example, tend to predominate when soils are too acidic or too basic; some become a problem when soil structure is poor and conditions become anaerobic; others may be stimulated by excessive fertilizer or manure salts.

Organic proponents also believe that insect pests are attracted to inferior or weak plants — the result of poor crop nutrition. Their logic continues by asserting that pests are naturally repelled by vigorous, well-nourished plants. This belief is often challenged, and significant research remains to be done.

As scientific understanding has grown, insect pest outbreaks are also being understood as imbalances in the whole agroecosystem and how it is managed. In nature, massive pest outbreaks are relatively rare and short-lived, due to the presence of natural predators, parasites, and disease agents that quickly knock the pest numbers back down to a moderate level. In farming systems that inadvertently destroy or otherwise fail to support the natural control complex, pest problems are routine and, typically, worsen with time. The farmer becomes increasingly addicted to costly and extreme control methods to produce a crop.

Most organic growers consider pesticides to be a cause of agroecosystem imbalances and employ allowed natural pesticides as little as possible.

ORGANIC CROP PRODUCTION
Foundational Principles and Practices

Biodiversity	Diversification & Integration of Enterprises	Sustainability	Natural Plant Nutrition	Natural Pest Management	Integrity
Rotation	Rotation	Rotation	Rotation	Rotation	Buffers
Green Manure	Animal Manure	Green Manure	Green Manure	Green Manure	Records
Cover Crops	Composting	Cover Crops	Animal Manure	Cover Crops	
Animal Manure	Intercropping	Intercropping	Composting	Composting	
Composting	Farmscaping	Biocontrol	Natural Fertilizers	Intercropping	
Intercropping	Mulching	Farmscaping	Foliar Fertilizers	Biocontrol	
Biocontrol		Animal Manure		Farmscaping	
Farmscaping		Composting		Sanitation	
Buffers		Mulching		Tillage	
		Buffers		Fire	
				Natural Pesticides	

Integrity

Integrity refers to the systems in place and actions undertaken to assure that consumers of organic products get what they pay for. Consumers have a right to expect that the organic food they buy not only be raised by organic methods but be protected from contamination and from commingling with non-organic products.

While the responsibility for much of this rests with others in the organic marketing chain, many certified organic growers need to incorporate additional practices that work to assure the integrity of their products. Proper record keeping is very important in this regard, though growers are often reluctant to spend much time on it. Among the more important production practices in the field are buffer strips, which reduce chemical drift from neighboring fields and roadsides, while also serving water and soil conservation objectives.

Tools and Practices

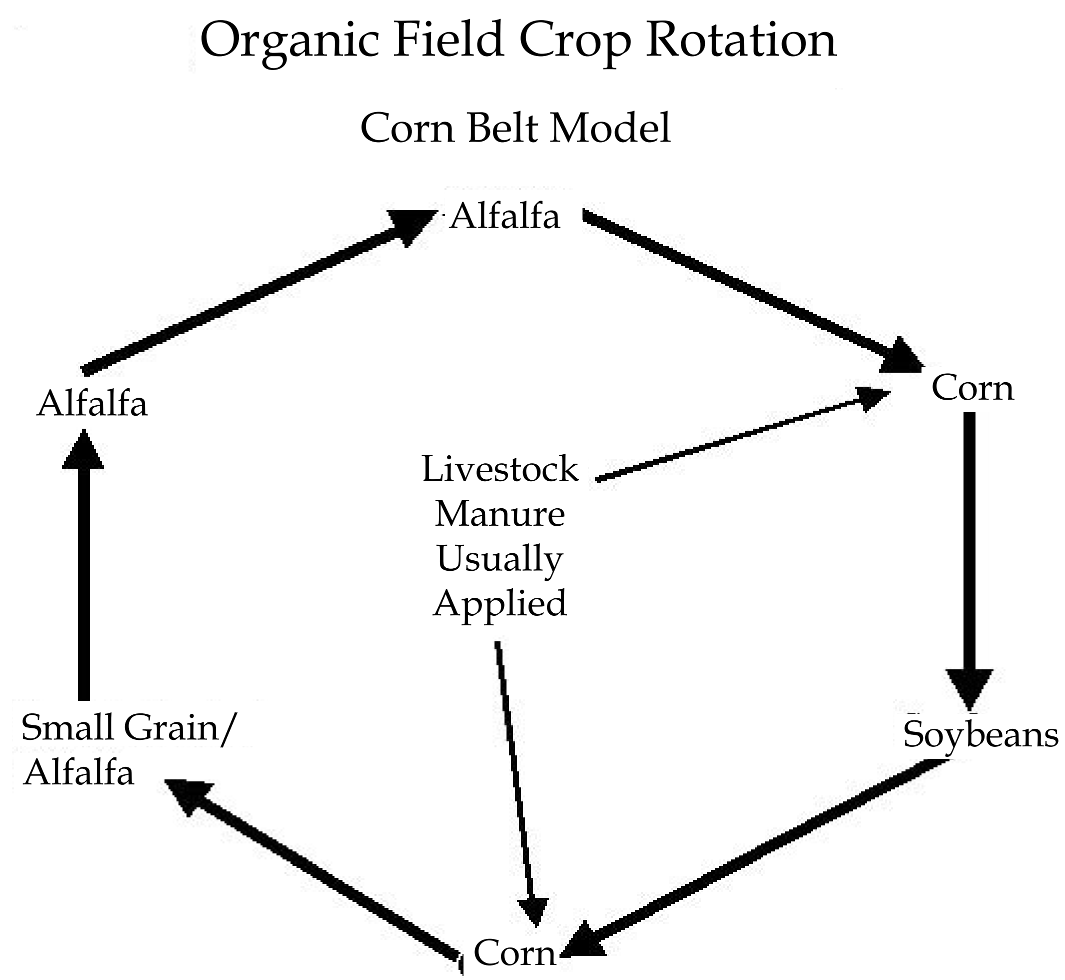
The tools and practices of organic agriculture include traditional alternatives — crop rotation, manuring, liming, etc. — long recognized as important to a sound production system. They also include more contemporary practices and materials that research and keen observation over time have contributed. The following list of tools and practices is not intended to be comprehensive, though the primary options are addressed. Note, too, that each farm operation will employ its own combination of tools and practices to build a working organic system. There is no simple cookbook formula for combining them in ideal proportions.

Planned Crop Rotation

Essentially a tool for annual cropping systems, crop rotation refers to the sequence of crops and cover crops grown on a specific field. Particular sequences confer particular benefits to long and short-term soil fertility, and to pest management.

Agronomic operations are especially dependent on crop rotations that include forage legumes. These provide the vast majority of the nitrogen required by subsequent crops like corn, which is a heavy consumer of that nutrient. Even when livestock are present to generate manure, the animals are largely recycling the nitrogen originally fixed by legumes in the system. An example of a basic agronomic rotation, typical of that found on midwestern organic farms, is shown in Figure 2.

Figure 2.



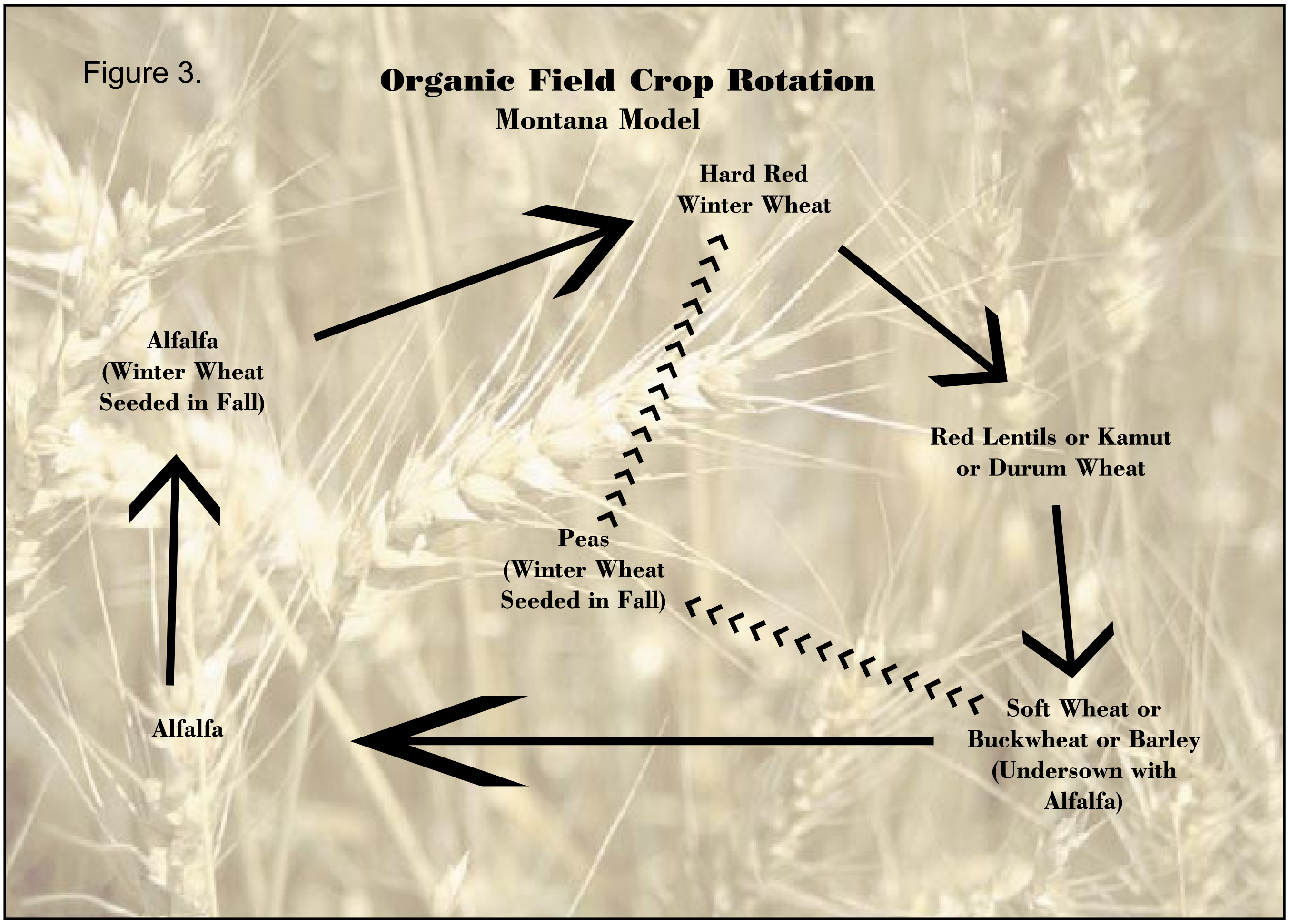
The basic Midwestern rotation demonstrates the elegant way in which a whole farm system can function:

- Legumes fix nitrogen in the soil, providing for subsequent non-legumes in the rotation.
- Several insect pest cycles are interrupted, especially those of the northern and western rootworm species that can be devastating to corn.
- Several plant diseases are suppressed, in cluding soybean cyst nematode.
- Weed control is enhanced as perennial weeds are destroyed through cultivation of annual grains; most annual weeds are smothered or eliminated by mowing when alfalfa is in production.
- Livestock manures (if available) are applied just in advance of corn, a heavy nitrogen consumer.
- All crops can be marketed either as is or fed to livestock to be converted into value-added milk, meat or other livestock products.

Ralph and Rita Engelken, widely respected organic pioneers in the 1970s and 1980s, used a similar rotation that suited their hilly northeast Iowa farm and supported their main livestock enterprise, *backgrounding* beef cattle. (Backgrounding is confined or semi-confined feeding of young range stock to increase their size before final finishing in a feedlot.) The feed ration the Engelkens relied on consisted mostly of haylage, corn silage, and ground ear corn. The 6-year rotation/crop mix that allowed them to produce virtually all their own feed on 410 acres was

oats/hay→hay→hay→hay→
corn→corn→ [cycle repeats]. (17)

Figure 3.



Another example of an agronomic crop rotation — this one suitable to drier, western climates — is typified by the Quinn Farm in North-Central Montana and presented in Figure 3.

Bob and Ann Quinn's rotation begins with the most reliable cash crop, hard red winter wheat, fall-seeded after alfalfa. Weeds are controlled following harvest and the land reseeded to lentils, kamut, or durum wheat the following spring. Switching from a winter grain to a spring grain helps to break weed cycles and optimizes soil moisture. In the next year, another spring grain or buckwheat is planted and undersown with alfalfa.

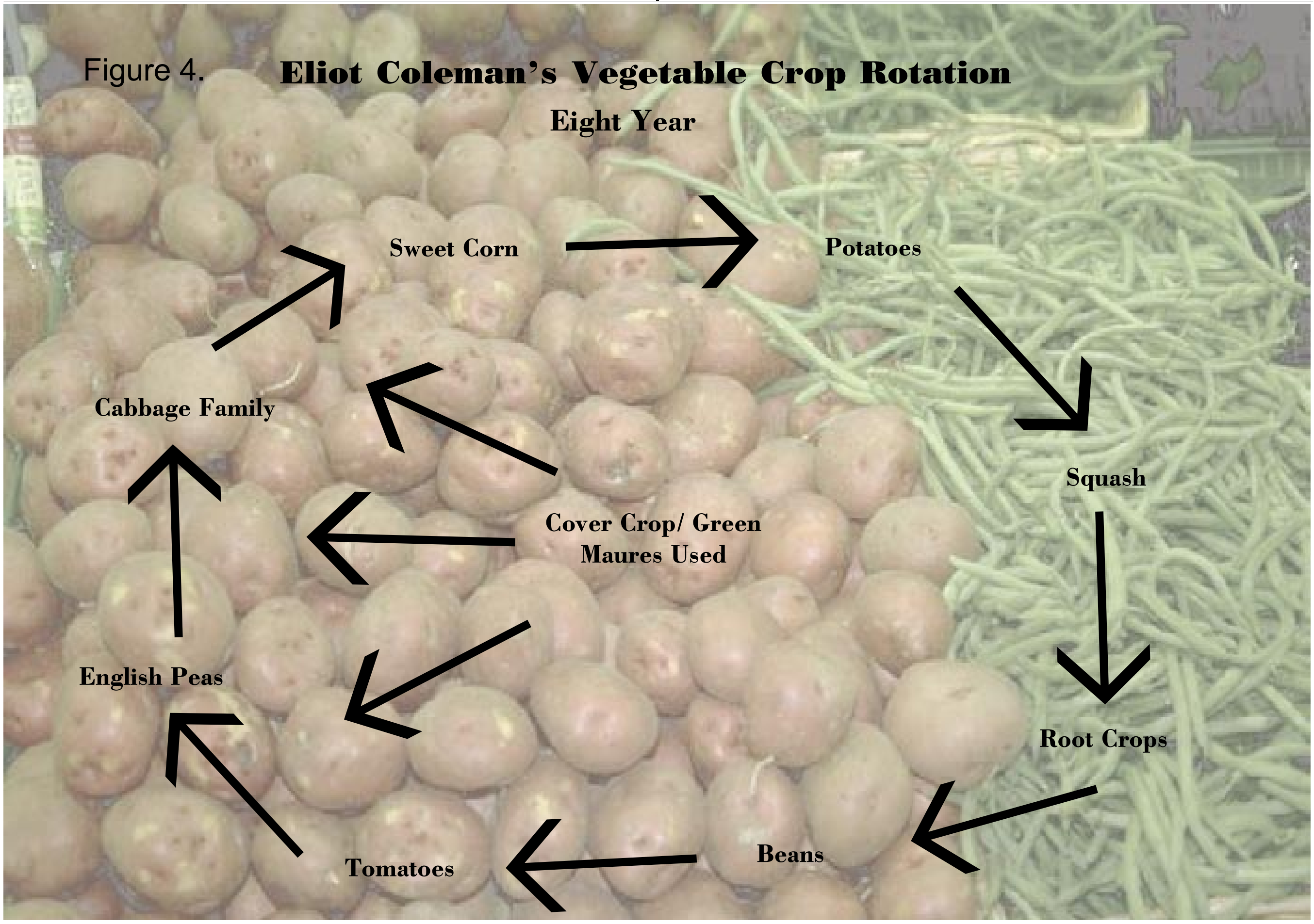
If the alfalfa survives the winter, it is managed as a hay crop for a year and incorporated in April prior to seeding winter wheat. If the alfalfa is winter-killed, peas are planted in spring, followed by winter wheat in the fall — shortening the rotation by one year.(18)

In vegetable crop rotations, nitrogen fixation and carry-over is also important, though it plays second fiddle to pest management. The well-known market gardener Eliot Coleman recommends an eight-year rotation, as shown in Figure 4.

The rationale for Coleman's eight-year rotation follows. Since he gardens in the Northeast, some of the details reflect those constraints.

> ***Potatoes*** *follow sweet corn…because research has shown corn to be one of the preceding crops that most benefit the yield of potatoes.*
>
> ***Sweet Corn*** *follows the cabbage family because, in contrast to many other crops, corn shows no yield decline when following a crop of brassicas. Secondly, the cabbage family can be undersown to a leguminous green manure which, when turned under the following spring, provides the most ideal growing conditions for sweet corn.*

Figure 4. Eliot Coleman's Vegetable Crop Rotation



***The Cabbage Family** follows peas because the pea crop is finished and the ground is cleared [early] allowing a vigorous green manure crop to be established.*

***Peas** follow tomatoes because they need an early seed bed, and tomatoes can be undersown to a non-winter-hardy green manure crop that provides soil protection over winter with no decomposition and regrowth problems in the spring.*

***Tomatoes** follow beans in the rotation because this places them 4 years away from their close cousin, the potato.*

***Beans** follow root crops because they are not known to be subject to the detrimental effect that certain root crops such as carrots and beets may exert in the following year.*

***Root Crops** follow squash (and potatoes) because those two are good "cleaning" crops (they can be kept weed-free relatively easily), thus there are fewer weeds to contend with in the root crops, which are among the most difficult to keep cleanly cultivated. Second, squash has been shown to be a beneficial preceding crop for roots.*

***Squash** is grown after potatoes in order to have the two "cleaning" crops back to back prior to the root crops, thus reducing weed problems in the root crops (19).*

Georgia growers Ed and Ginger Kogelschatz use a somewhat simpler rotation scheme that divides most garden crops into four basic classes that are then sequenced for a 4-year cycle.(20) They have adapted this concept from Shepherd Ogden, the author of *Step By Step Organic Vegetable Gardening.* (21) Ogden's basic rotation scheme is

leaf crops→fruit crops→root crops→ legumes→[cycle repeats].

Green Manures and Cover Crops

Green manuring consists of incorporating into the soil a crop grown for the purposes of soil improvement. It is a practice with a long history. Green manuring has been ignored in recent years as a serious option for soil improvement because the traditional practice entailed planting a full-season cover crop. This removed the field from commercial production for a whole season. Interest has returned, however, since green manuring strategies have been combined with cover cropping schemes.

Cover cropping is growing a crop for the purpose of soil and nutrient conservation. It is a more contemporary concept than green manuring, in crop agriculture. The two concepts — cover cropping and green manuring — go well together, as most cover crops are easily used as green manures prior to the planting of a commercial crop. The combined benefits become economically feasible when the cover is grown during the off-season or interseeded with the main crop. It is made even more desirable when the cover crop includes nitrogen-fixing legumes.

Manuring and Composting

Livestock manures are the most traditional and widely recognized organic fertilizers. Under ideal circumstances, livestock enterprises are integrated into the whole farm operation, and manuring becomes part of a closed system of nutrient recycling. This is still strongly encouraged in organic operations. In reality, however, crops and livestock production are often divorced from each other, and manures must be imported.

This has created some concerns in the organic community, since much manure is now generated by large, industrial agriculture feeding operations called CAFOs (Confined Animal Feeding Operations). Not only are there concerns about contaminants (heavy metals, antibiotics, pesticides, hormones) but many in the organic community also object to any "partnering" with this segment of conventional agriculture, which is considered at odds with the environmental and social values represented by organic farming.

Nonetheless, the National Organic Program does not differentiate between CAFO and other livestock manure sources. However, the NOP regulations do require that livestock manure not contain any synthetic substances not included on the National List of synthetic substances allowed for use in organic crop production.

Another issue that has grown up around manure use in organic farming relates to food safety. At a time when concerns about microbial contamination are high, there are questions about the risks associated with manure use on food crops. A focus piece on the February 2000 television news program *20/20* was especially controversial. The segment suggested that organic foods were more dangerous than other food products in the marketplace due to manure fertilization.(22) The reporter ignored the fact that conventional farms also use manures. Were all the manure generated annually in the U.S. (about 1.4 billion tons) applied only to organic farm acreage (estimated at roughly 1.5 million acres in 1997), each acre would receive about 933 tons.(23) Furthermore, certified organic producers have strict guidelines to follow in handling and applying manures. The National Organic Program regulations require raw animal manure be incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles, and be incorporated into the soil not less than 90 days prior to harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles.

One of the best means of handling manures is composting. Composting stabilizes the nutrients in manure, builds populations of beneficial organisms, and has a highly beneficial effect on soils and crops. Compost can be produced on-farm by a number of means. Additional products from composts, such as compost teas, have special applications in organic agriculture.

Human manures are expressly forbidden in certified organic production. This includes composted sewage sludge (also called "biosolids"). The organic community made its opinion on this quite clear when the USDA's first draft of the national rule (December 1997) proposed allowing the use of sludge in certified production. It was counted as one of the "big three" targets of protest, along with food irradiation and genetic engineering. The prohibition of biosolids would have been disconcerting to Albert Howard, who decried the failure of cities to return their organic wastes to the countryside. Such recycling was, in his mind, a key aspect of sustainability.(7)

What Howard had not taken into account is the almost universal contamination of urban wastes

Livestock on Organic Farms

Among the thorniest of issues swirling around the edges of organic agriculture is the role of livestock. The disagreements arise because of the diversity of people and philosophies in the organic community. Organic agriculture can usually count vegetarians and animal welfare proponents among its more vocal supporters. Many of these people feel strongly that animals should not be exploited. Their rationale often goes beyond emotional and religious beliefs; convincing human health concerns, social issues, and environmental reasons are commonly cited. On the other side of this argument are those who feel that an organic farm cannot achieve its full potential or ecological balance without livestock manure; that it is essential to nutrient cycling and to the finer aspects of soil building.

Excellent soil fertility can be built in the absence of farm livestock and livestock manures by using vegetation-based composts (25) and by harnessing the livestock in the soil — earthworms and other soil organisms. However, it is clearly easier to design a contemporary, low-input organic farm when traditional livestock are integrated. The biological and enterprise diversity that livestock can bring contributes enormously to stability and sustainability. A good example is provided by Rivendell Gardens in Arkansas, which began integrating livestock enterprises after several years as a solely horticultural operation.

The owners of Rivendell, Gordon and Susan Watkins, now rotate their strawberry and vegetable crops with grass-fed, direct-marketed beef and pastured poultry. Ideally, poultry follows beef on pasture to reduce cattle parasites. The seasons in mixed legume/grass pasture leave the soil quite mellow and well-manured for subsequent high-dollar horticultural crops. (26)

The Rivendell operation demonstrates the sort of organic management where a large number of organic farmers and many animal welfare proponents find common ground. The Watkins' animals are all raised with minimal confinement and generous access to sunshine, fresh air, and free-choice foodstuffs. While domesticated and destined for slaughter, they lead low-stress lives in conditions much closer to natural than the conventional alternatives. This is the antithesis of industrialized factory farming systems, which are increasingly becoming the norm in livestock production.

Many in both the organic and animal welfare communities are working to prohibit factory farming of livestock in organic systems. Many of the difficulties revolve around the fine interpretations of language in various organic standards. Wording such as "access to fresh air and sunlight," for example, can be construed to mean nothing more than opening the door on one end of a large confinement poultry house for a couple hours a day.

with heavy metals and chemicals that are not eliminated by composting and may even be concentrated. Perhaps this was not yet a serious problem in his time; it is, however, in ours. Organic farmers and consumers concerned about contamination of soil and crops with agricultural pesticides and synthetic fertilizers would be remiss to ignore the contamination hazards of even well-composted sewage.

Fred Kirschenmann, a farmer and former NOSB member, has written eloquently about the progress of the National Organic Program. In a critique of the March 2000 draft of the proposed rule (24), he pointed to another reason why the use of biosolids ought to be prohibited in organic production. Because of the manner in which biosolids are generated, they are easily hauled and land-applied on an industrial-scale to industrial scale organic farms. Furthermore, since biosolids can essentially supplant animal manures as a source of organic matter and nutrients, their use would allow some very large farms to circumvent the traditional practices that promote biodiversity and enterprise diversity and integration. What Kirschenmann fears from biosolid use is technology that would nudge organic agriculture down the same road of industrialization taken by conventional ag.

Intercropping and Companion Planting

Interplanting two or more mutually beneficial crops in close proximity is one strategy for increasing biodiversity. In large-scale mechanized crop culture, this is called *intercropping*. It typically involves alternating rows or a number of rows of compatible field crops, like soybeans and corn. It also applies to sowing multiple forage crops, like alfalfa, bromegrass, and timothy, when these are grown together.

When interplanting is done on a smaller scale, it is often called *companion planting*. A classic example of companion planting is the interplanting of corn with pole beans and vining squash or pumpkins. In this system, the beans provide nitrogen; the corn provides support for the beans and a "screen" against squash vine borer; the vining squash provides a weed suppressive canopy and discourages corn-hungry raccoons.

Biological Pest Control

Organic farming relies heavily on populations of beneficial insect predators and parasites, pest disease agents, insect-eating birds and bats, and other creatures, to help manage pest problems. These biological controls help keep pest numbers at levels where further cultural activities or relatively mild pesticides are (usually) adequate to assure a crop. In some instances, biological control can be so effective that no additional action is even needed by the farmer.

Some see biological control as a default benefit of the soil fertility practices of organic farming. The diversity of crops in a soil-building rotation, the use of cover crops, and other practices build a diverse soil biology that works to keep soil pests in check. They also provide substantial aboveground habitat for beneficials. The absence of pesticides also favors biocontrol.

In many organic systems, farmers sometimes purchase and release control agents like ladybird beetles, lacewings, trichogramma wasps, etc., or use weeder geese — a quaint but effective biological weed control.

Increasingly, growers are designing and maintaining both permanent and temporary habitats specifically for beneficial insects, spiders, and other helpful species. This is known as *farmscaping*.

Sanitation

Sanitation can take on many forms:

- removal, burning, or deep plowing of crop residues that could carry plant disease or insect pest agents
- destruction of nearby weedy habitats that shelter pests
- cleaning accumulated weed seeds from farm equipment before entering a new, "clean" field
- sterilizing pruning tools

As in human and animal health, sanitation practices can go a long way in preventing crop pest problems. However, many practices— such as clean cultivation, deep plowing, and burning crop residues — can increase erosion and reduce biodiversity. Thus, they may conflict with sustainability. Good organic growers recognize this and treat those practices as transitional or rescue options, rather than relying on them on an annual basis.

Tillage and Cultivation

Tillage and cultivation are tools that can accomplish a variety of objectives in farming systems: weed control, crop residue management, soil aeration, conservation of manures and other fertilizers, hardpan reduction, sanitation to destroy pest and disease habitat, etc.

While conventional farmers rely on chemicals to accomplish many of these objectives, organic growers focus more on improving tillage and maximizing its benefits. Guidelines for primary tillage, for example, are intent on conserving crop residues and added manures in the upper, biologically active zones of the soil, rather than burying them deeply where decomposition is anaerobic (oxygen-starved). Leaving soils completely bare and vulnerable to erosion is discouraged; fall moldboard plowing is certainly frowned upon.

Cultivation in organic systems often rises to the level of art. Row-crop farmers frequently use *blind cultivation* —shallow tillage, which largely ignores the crop rows—beginning shortly after seeding until the plants are but a few inches high. Rotary hoes, wire-tooth harrows, and similar equipment can be used for blind cultivation, delaying the first flush of weeds and giving the crop a head start.

Conservation Tillage and Organic Farming

Organic agriculture is often characterized as addicted to *maximum tillage* — with growers using every opportunity to lay the land bare with shovel, plow, or rototiller. This image has been magnified through the popularity of small-scale organic systems like the French Intensive and Biointensive Mini Farming models that espouse double- and triple-digging to create deep rooting beds. While appropriate to such intensive systems, this degree of cultivation is not characteristic of organic agriculture in general. It may surprise some to learn that a large number of organic producers are not only interested in conservation tillage, they have adopted it. This will be a surprise because many believe that conservation tillage always requires herbicides.

The interest in conservation tillage among organic producers in the Cornbelt was well documented in the mid-1970s by Washington University researchers. They noted that the vast majority of organic farmers participating in their studies had abandoned the moldboard plow for chisel plows. Plowing with a chisel implement is a form of *mulch tillage*, in which residues are mixed in the upper layers of the soil, and a significant percentage remains on the soil surface to reduce erosion. Furthermore, a notable number of organic farmers had gone further to adopt ridge-tillage, a system with even greater potential to reduce erosion.(3) It was especially interesting to note that the use of these conservation technologies was almost nil among neighboring conventional farms at the time. Organic growers were actually pioneers of conservation tillage in their communities.

Among the more well-known of these pioneers were Dick and Sharon Thompson of Boone, Iowa. Their experiences with ridge-tillage and sustainable agriculture became the focus of a series of publications titled *Nature's Ag School*. These were published by the Regenerative Agriculture Association — the forerunner to the Rodale Institute. They are now, unfortunately, out of print.

Research continues to open up new possibilities in conservation tillage for organic farms. New strategies for mechanically killing winter cover crops and planting or transplanting into the residue without tillage are being explored by a number of USDA, land-grant, and farmer researchers. Notable among these is the work being done by Abdul-Baki and Teasdale at the USDA in Beltsville, Maryland — transplanting tomato and broccoli crops into mechanically killed hairy vetch and forage soybeans.(27, 28) There are also the well-publicized efforts of Pennsylvania farmer Steve Groff, whose no-till system centers on the use of a rolling stalk chopper to kill cover crops prior to planting.(29) Systems like Groff's and Abdul-Baki's are of particular interest because close to 100% of crop residue remains on the soil surface – providing all the soil conservation and cultural benefits of a thick organic mulch.

After blind cultivation, subsequent weed control operations in larger-scale systems can make use of advances in tillage equipment such as rolling cultivators, finger weeders, and torsion weeders that allow tilling close to the plant row. Smaller-scale operations often use wheel hoes, stirrup hoes, and other less capital-intensive hardware.

Determining the amount, the timing, and the kind of tillage to be done can be a balancing act for the organic grower, but experience and observation over time lead to proficiency.

There are downsides to tillage, however, and most organic growers are well aware of them. The most obvious of these is the dollar cost; organic farmers are as concerned as their conventional counterparts about costs of production and strive to minimize expensive field operations. There is also a cost to the soil and environment. Every tillage operation aerates the soil and speeds the decomposition of the organic fraction. While this may provide a boost to the current crop, it can be overdone and "burn up" the humus reserves in the soil. Excessive tillage can also be directly destructive to earthworms and their tunneling, reducing their benefits to the land. There is also the danger of compaction, even when field operations are well timed.

Mulching

Mulching is a practice often used by organic growers. Traditionally, it entails the spreading of large amounts of organic materials — straw, old hay, wood chips, etc. — over otherwise bare soil between and among crop plants. Organic mulches regulate soil moisture and temperature, suppress weeds, and provide organic matter to the soil. Mulching is most appropriate to small, intensive operations with high-value annual or fruit crops.

A few systems of no-till organic gardening have evolved from the concept of deep, *permanent* mulching. Among these are the well-known Ruth Stout method and *Synergistic Agriculture* — a raised bed system developed by Emilia Hazelip, who adapted concepts from *Permaculture* and the ideas of Masanobu Fukuoka.(30, 31, 32) Mark Cain and Michael Crane, co-owners of Dripping Springs Gardens — an intensive market gardening operation in Arkansas — have adapted Emilia's system to their farm with considerable success.(33)

Plastic mulch, as long as it is removed at end of growing or harvest season, is also permitted in certified organic production. Its use allows larger acreage to be brought more easily under herbicide-free management, though there are serious issues to be addressed (see discussion on *High-Input Organic Agriculture*).

High-Input Organic Agriculture

At the beginning of this publication, organic farming was described as a system that uses a minimum of off-farm inputs. While that describes most of organic agriculture as it is currently practiced in the U.S., certified organic farming can also entail much greater reliance on off-farm inputs.

Intensive annual strawberry and vegetable systems under plasticulture are good examples. In these systems, traditional rotations and soil building practices are usually employed, followed by clean cultivation and the laying of plastic mulch and drip irrigation tape on shaped beds. During the season, large amounts of soluble organic fertilizers — typically fish-based — are fed to the crop through the drip system (i.e., organic fertigation). At the end of the season, all plastics must be removed from the field, and it is returned to more standard organic management. Ideally, an off-season cover crop will be planted. Such systems are often exceptionally productive and economically attractive, when organic premiums are good. The high cost of soluble organic fertilizer (typically hundreds of dollars/acre), however, plus the marginally higher cost of pest controls, make such systems largely non-competitive in the conventional marketplace.

The labeling of such high-input systems as organic presents a paradox for many proponents of organic agriculture. It is unclear whether these technological advancements reflect the kind of farming most practitioners and supporters of organics think of as truly "organic." To begin with, the research citing environmental and economic benefits has largely been done on low-input organic systems; it is questionable whether similar findings would be made about high-input systems, especially regarding environmental matters. Of particular note, while low-input organic systems are documented as being more resistant to erosion, fields under plastic mulch are reported to be fifteen times more erodible.(34) Traditional organic farms leach minimal amounts of nitrogen into tile or groundwater; the losses from fields loaded with high levels of soluble organic fertilizers is certain to be greater, but how much greater is unknown. The fossil fuel energy involved in plastic manufacture, transportation, and application may or may not be compensated by reductions in tractor fuel use.

Finally, the lowered capital investment required to produce a crop by traditional organic methods makes this form of farming more accessible to resource-poor farmers and entails less risk in years of crop failure or lack of premiums. These factors are less certain in a high-input system. A further consideration is the issue of plastic disposal following removal. At this time, there are few to no options for recycling, and landfills are the fate of plastic mulches at the end of each season.

While it is unwise to rush to judgement regarding high-input organic farming, it is clear that some adaptations will need to be made, if the traditional character and sustainability benefits of organic farming are to be preserved.

Fire

While fire can be used in a number of ways in organic agriculture, the area of greatest interest is *flame* or *thermal weeding*. In its most common application, torches mounted on a tractor toolbar throw a hot flame at the base of mature (i.e., heat-resistant) plants, over the inter-row area, or both. Tractor speed is adjusted so that weeds are not *burned* so much as *seared*. Searing is sufficient to kill most seedling weeds and uses less fuel. Liquid propane (LP) gas is the fuel most commonly used, though alternatives such as alcohol and methane offer the possibility of on-farm sources.

Supplemental Fertilization

In many organic systems, crop rotation, manuring, green manuring, along with enhanced biological activity in the soil, provide an abundant supply of plant-essential minerals annually. This is especially true on naturally deep and rich prairie soils. It is less true on poorer soils and on those that have been heavily exploited through non-sustainable farming practices. To correct mineral deficiencies in organically managed soils, organic growers often apply ground or powdered rock minerals.

The most commonly used rock mineral is high-calcium aglime. Dolomitic limestone, various rock phosphates, gypsum, sulfate of potash-magnesia, and mined potassium sulfate are also common. These are all significant sources of primary (P, K) and/or secondary (Ca, Mg, S) plant nutrients. The savvy organic grower applies significant amounts of these materials only with the guidance of regular soil testing.

Less common are other rock powders and fines that are limited sources for the major nutrients but are rich in micronutrients or have some other soil-improving characteristic. Among these are glauconite (greensand), glacial gravel dust, lava sand, Azomite®, granite meal, and others.

Supplementary nutrients that include nitrogen are often provided in the form of animal or plant products and by-products such as fish emulsion, blood meal, feather meal, bone meal, alfalfa meal, and soybean meal. Most of these products also supply some organic matter, though that is not the primary reason they are used.

Evaluating Tools and Practices

One basis on which to evaluate the tools or practices one chooses for an organic operation is whether or not they contribute to biodiversity — biodiversity being one of the principal characteristics of a sustainable organic agriculture.

Crop rotation, cover cropping, farmscaping, companion planting, and intercropping are outstanding examples of practices that contribute to biodiversity. They therefore contribute to the long-term stability and sustainability of the farm agroecosystem. Composting and manuring likewise contribute to biodiversity, but since the diversity they promote is mostly in soil biota, it is rather less obvious to the casual observer.

On the other end of the spectrum are practices such as tillage, cultivation, thermal weeding, solarization, and plastic mulching. Such tools significantly reduce diversity in the field and tend to move the system in a less sustainable direction. This, however, does not necessarily make these practices bad choices.

Organic farming has often been called *natural* farming, as it tries to mimic the processes of nature in producing crops and livestock. However, the analogy goes only so far, since most agricultural systems are characterized by a struggle between human and nature, each with a clear notion of what plants and animals the land *ought* to support and in what proportions. The farmer is typically in the position of "holding back" the natural succession of plant and animal species through the use of diversity-reducing tools and practices. The ideal is to bring about an agricultural system in which the long-term direction emphasizes diversity and sustainability. Among the best visualizations of this ideal are those emerging from the Permaculture movement.

Balanced Nutrition

Whether or not it has been customary in the past, organic growers are encouraged to have periodic soil testing done on their fields. How the results of a soil test are used, however, can vary considerably among farmers, depending on their personal philosophy and management skill.

While there is certainly a segment of the organic farming community that has no faith in soil audits, most growers use them as a means to monitor progress in building their soils, to identify nutrient deficits, and to guide supplementary fertilization. While there are many ideas about fertilization guidelines, there are two schools of thought that dominate.

The first is commonly known as the *sufficiency* approach or model. Though somewhat oversimplified, the following are among its significant characteristics:

- annual fertilizer additions of P and K are based in good part on how much the crop is expected to remove from the soil at harvest
- additional amounts of P and K are recommended based on keeping the soil nutrient reserves at a particular level
- lime is added to the soil based on pH
- little to no attention is paid to nutrient balance or to the levels of secondary nutrients Ca and Mg

The second approach is referred to variously as *cation nutrient balancing*, the *Albrecht system*, the *CEC*, or the *base saturation* approach. It differs from the sufficiency approach in that fertilizer and lime recommendations are made based on an idealized ratio of nutrients in the soil and its capacity to hold those nutrients against leaching.

Cation nutrient balancing is more popular among practitioners of organic farming and sustainable agriculture in general than it is among conventional growers. However, there is no universal agreement on which approach is most appropriate for organic management.

A wide range of other products —humates, humic acids, enzymes, catalyst waters, bioactivators, surfactants, to name a few — are also acceptable in organic crop production. However, the tradeoff between out-of-pocket cost and efficacy of such materials is often challenged by conventional and organic growers alike. Organic growers are encouraged to experiment, but to do so in a manner that allows the actual results to be measured.

Biorational Pesticides

While, in principle, any pesticide use is discouraged in organic systems, a rather wide range of *biorational* pesticides is permitted. The frequency of pesticide use varies considerably with crop and location. For example, there is virtually no use of pesticides on organic row crops in the Cornbelt. By contrast, organic tree fruits in the Midsouth routinely receive heavy applications of several fungicides and insecticides allowable in organic production.

The pesticides permitted in organic farming fall predominantly into several classes.

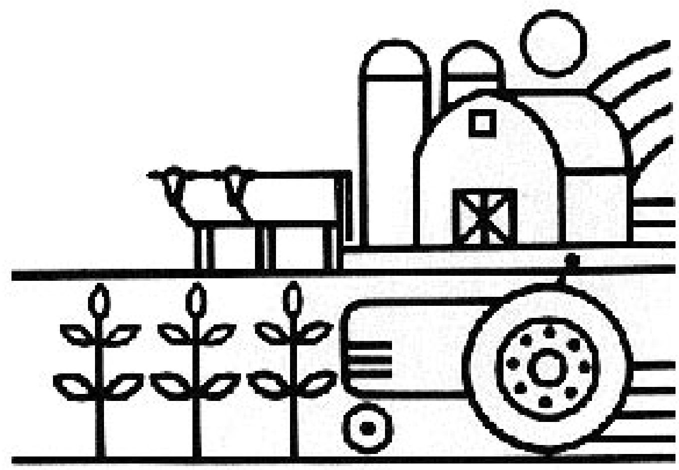
<u>Minerals</u>: These include sulfur, copper, diatomaceous earth, and clay-based materials like Surround®.

<u>Botanicals</u>: Botanicals include common commercial materials such as rotenone, neem, and pyrethrum. Less common botanicals include quassia, equisetum, and ryania. Tobacco products like Black-Leaf 40® and strichnine are also botanicals but are prohibited in organic production due to their high toxicity.

<u>Soaps:</u> A number of commercial soap-based products are effective as insecticides, herbicides, fungicides, and algicides. *Detergent*-based products are *not* allowed for crop use in organic production.

Pheromones: Pheromones can be used as a means to confuse and disrupt pests during their mating cycles, or to draw them into traps.

Biologicals: One of the fastest-growing areas in pesticide development, biopesticides present some of the greatest hope for organic control of highly destructive pests. Among the most well-known biopesticides are the *Bacillus thuringiensis* (Bt) formulations for control of lepidopterous pests and Colorado potato beetle.



What Can I Use in Organic Crop Production?

One of the greater difficulties that organic producers face on a regular basis is determining whether or not a particular product or material can be used in organic production. Sad to say, the problems are real, but some basic clarifications will help. First of all, all natural or nonsynthetic materials can be assumed to be acceprable in organic production. There are a few exceptions, however, which will be explained shortly.

Most organic producers and prospective producers have heard about the National List. §§205.600–205.619 of the National Organic Program Regulations comprise the National List; §205.601 and §205.602 are those directly pertinent to crop production. §205.601 includes synthetic materials that are allowed in organic crop production — for example, sulfur, insecticidal soap, etc.; §205.602 contains natural, or nonsynthetic, materials that are prohibited — for example, ash from manure burning, nicotine sulfate, etc. When considering commercial products, the grower must be aware of all ingredients to determine that none are prohibited. If a full disclosure of ingredients is not found on the label, details should be obtained from the distributor or manufacturer and kept in the grower's files. Note that such details must extend to inert ingredients. When in doubt about the acceptability of any material or product for certified organic production, contact your certifier.The NOP National List of Allowed and Prohibited Substances is available at <www.ams.usda.gov/nop/NOP/standards/ListReg.html>.

An important organization to know about is the Organic Materials Review Institute (OMRI). OMRI is a non-profit organization that evaluates products for suitability in organic production and processing. OMRI does not have status as a regulatory body. However, its decisions with regard to the acceptability of commercial products are highly respected and accepted by most certifiers. OMRI Listed products can be purchased and used with a high degree of confidence. Producers should be aware, however, that there are many acceptable products in the marketplace that have not been evaluated by OMRI and do not carry the OMRI Listed seal. Again, it is important to contact your certifier to verify whether a particular product or material can be used.

Of Seeds, Seedlings, and GMOs

One of the challenges faced by organic growers is getting suitable planting stock. Certified production requires that seed not be treated with pesticides and be organically grown.

Transplants must be purchased from a certified organic source or otherwise be grown using organic methods. This presents some difficulty, as most commercial potting mixes contain prohibited fertilizers and wetting agents, requiring special ordering or the added effort of making a homemade mix.

Generally, planting stock for perennial crops like tree fruits and berries is available from conventional sources, even if treated with pesticides. However, no production can be sold as organic for a minimum of 12 months following transplanting to an organic field.

In all instances, organic growers are not permitted to use varieties of crops that have been developed through genetic engineering (GE). At first glance, this might seem perplexing. GE crops promise further means of non-chemical pest control and the possibility of nutritionally enhanced foods. However, the organic community is concerned about environmental, economic, and social impacts from this new technology which, they feel, have not been adequately studied. This same concern applies to GE foods. Natural foods consumers — a large segment of the organic market — do not want them. This was made abundantly clear to the USDA when its first draft of the proposed rule, which suggested permitting genetically modified organisms (GMOs), was released in 1997. The backlash was so strong that not only GE crop varieties, but all inputs, such as GMO-derived biopesticides, are prohibited from organic production.

Unfortunately the GE issue does not resolve itself so simply for organic farmers. The proliferation of GMOs in the marketplace and across the landscape has created a host of new challenges that have particular implications for organic agriculture:

- Genetic drift onto crops. Pollen drifting from adjacent fields can contaminate organic crops. Some clients in the lucrative European Union market accept 0% GMO contamination; others accept only very low levels. Pollen from cross-pollinating crops like corn easily travels hundreds of yards and may be carried for miles under the right conditions. No reasonable amount of non-crop buffer can prevent contamination except in highly isolated locations.
- Genetic drift onto soils. Concerns have been expressed over the persistence of GE pollen in soils. Should contaminated soils be decertified?
- Non-labeled products. Should soybean, cottonseed, and corn gluten meals be prohibited as fertilizers, since these may come from GE varieties? Should pesticidal use of vegetable oils be prohibited?
- Pest control problems. The rapid proliferation of corn, cotton, and other crops featuring the Bt gene from *Bacillus thuringiensis* is likely to accelerate the development of resistance to this natural pesticide. Organic growers may lose one of their most useful pest management tools.
- Domination of the food system. In the late 1990s, the public was made aware of two specific developments of agricultural biotechnology dubbed the *terminator* and *traitor* technologies. Terminator technology is the genetic altering of seed so that the subsequent generation will not germinate. This prevents farmers from saving a portion of the harvested crop to replant the next year — a traditional practice among farmers worldwide. Traitor or *suicide* technology is the genetic altering of seed so that it will fail to germinate or mature unless a proprietary chemical is applied.(36) Such technologies are authoritarian and advance the centralization and industrialization of the food system. Organic farmers perceive additional challenges from genetic drift impacts and difficulty in finding non-GE seed in the marketplace.(37)

Foliar Fertilization

Foliar fertilization or feeding entails the application — via spraying — of nutrients to plant leaves and stems and their absorption at those sites. It is not specifically an organic practice, though it is commonly used by many organic growers. The fertilizer materials used are typically soluble fish- and seaweed-based products, naturally chelated nutrients, humic acid extracts, and teas made from plants, dried blood, manure, guano, or compost.

At first glance, the use of foliar feeding appears contradictory to the organic notion that one feeds the soil to feed the plant. Organic growers rationalize the use of this approach on two points.

1. Foliar feeding is strictly supplemental fertilization; it is not used as a substitute for traditional soil building practices.
2. Foliar fertilization is understood to increase the production of root exudates, which stimulates biological activity in the rhizosphere (soil area adjacent to plant roots). The soil bio-life gets considerable benefit in this indirect way from foliar feeding.

Esoteric Practices

There are a number of farming and gardening practices based on belief in a non-physical world closely aligned with our physical reality. Those who use these practices believe that conditions in this unseen realm influence, or even dictate, what happens on a material level. They take pains to understand these influences and adjust their farm activities. In some instances, they act to influence events. Obviously, these practices are rooted more deeply in metaphysics than in the conventional sciences.

The most well-known of these esoteric practices is the scheduling of planting or other field operations according to lunar or other astrological signs. Dowsing and other forms of *divining* may also be used to guide scheduling, fertilizer selection, and other facets of farming. The use of potentized *preparations*, as done in Biodynamic™ farming, is also a metaphysical practice.(35) Radionics, energy balancing towers, "medicine" wheels, prayer — these are further examples of practices used by some farmers to bring a tangible spiritual element into their farm operation.

Esoteric practices like these (there are many others) are not inherently part of organic agriculture. In all likelihood, only a small-to-modest minority practice them or believe in their efficacy. Still, esoteric practices are sometimes associated with organic agriculture, and it is almost a given that practitioners of "energetic agriculture" are either certified organic or actively pursue a sustainable form of agriculture.

The rationale for this association of organic with the esoteric is not difficult to understand. Most metaphysical practices are founded on a worldview similar to that of ecology, in which everything is related to everything else. The difference is that ecology considers this interrelationship only on a hard physical level; metaphysics perceives it also on a non-physical level. This belief tends to cast humankind as part of nature, not merely as an inhabitant. This perspective would tend to make one more concerned about the environment and, therefore, more readily drawn to organics as a philosophy and pragmatic farming approach. To put it in a nutshell, it is natural for the metaphysically-inclined to choose organics; it is far less likely, however, that the average organic farmer is drawn to metaphysical practices.

A further factor plays into the association between esoteric farming practices and organics. It relates to the fact that organic agriculture has, for many years, been marginalized and treated as pseudoscience by the mainstream — an experience shared by practitioners of metaphysical arts. It is not surprising for underdogs to seek common ground.

Buffers and Barriers

Field buffers are strips of sod or other permanent vegetation at the edge of or surrounding crop fields. There is considerable interest in both conventional and alternative agriculture in these buffers, since they assist in reducing soil erosion and improving water quality. If managed properly, some buffers also serve as beneficial insect habitat.

Organic Farming: Niche Market or Viable Alternative?

The pioneers of organic farming considered organics the preferred direction for the whole of agriculture to take. It is likely that most contemporary proponents still hold that view. While recent growth in the organic industry is definitely encouraging, much of the impetus is tied to its growth as a niche market, not as a serious shift in the direction of mainstream agriculture. Unfortunately, a likely reason for the newfound "tolerance" of organic agriculture in many land grant universities and other formerly hostile environs is its perception as a niche market opportunity only. As such, it is not a serious threat to the status quo.

Is it practical and responsible to promote organic agriculture as the dominant approach to farming in the future? While some are quick to answer, "Yes!", most are buffaloed by the nagging question, "Can organic agriculture feed the world?" Questions about the productivity and the prospects of widespread starvation have long been an effective tactic for stonewalling serious discussion of organics. While it is not the purpose of this publication to settle such a compelling issue, there are a few points that can and should be made regarding the "starving billions" scenario.

- Critics warn that, were organic farming to be adopted on a wider scale, per-acre agricultural productivity would decline sharply; that meeting food needs would necessitate the plowing of even more erodible hillsides and the draining of more wetlands. Such scenarios are often based on pre-chemical era yield data that ignore the advancements of modern organic farming. Contemporary research on organic systems — as limited as it is — indicates that the per-acre productivity of organic and conventional systems is not vastly different.(39) Other scenarios are sometimes based on the perceived need for vast quantities of grain — particularly corn.(40) Since overproduction of grain has led to prices below costs of production for several years, this is a questionable basis for argument. It also ignores the fact that most of the grain produced is fed to livestock and that many livestock species can eat forage instead. Ruminant livestock — cattle and sheep especially — are designed by nature to thrive on forage and can even be finished for market on pasture.
- The paucity of good research on the productivity of organic systems also spotlights the lack of practical research for organic producers. That organic farms are as productive as they appear to be is remarkable in light of minimal research and extension support for many decades. It has often been argued that, had comparable resources been put into organic research, its widespread feasibility would be unquestionable. This assertion is well-supported by the development, in recent years, of a number of alternative, organically acceptable pesticides, that are certain to expand organic production of many crops in regions where it had previously been near impossible on a commercial basis.
- Increasing agricultural production alone does not alleviate hunger. The amount of grain produced in the world in 1999 could, by itself, sustain 8 billion people – 2 billion more than our current population.(39) Total food production is estimated to provide each human being with at least 3500 calories per day.(41) The issue of hunger, it appears, is not so much a lack of food, but lack of *entitlement* to food. People are shocked to learn that while many Bangladeshees starved during the 1974 floods, roughly 4 million tons of rice produced in that country were stacked in warehouses for want of buyers. The people were simply too poor to buy it.(42) They are surprised to learn that Ireland exported grain during the Irish potato famine while 1 million of its citizens died and even more emigrated; that India regularly exports food and animal feed despite an estimated 200 million in starvation.(39) Those lacking the ready cash to buy food or the resources to produce it themselves seem destined for hunger no matter what miracles agricultural technology provides. The world's nations will need to deal with issues of equity and democracy first, if hunger is ever to be effectively addressed.
- No agriculture can continue to feed a growing population if it depletes or fouls its resource base. The path undertaken by conventional agriculture is ultimately a dead end in this regard, though there is an almost mystical faith that genetic engineering and other complex technologies will always triumph. Agriculture needs to be sustainable. Therefore, those who promote organic agriculture as a true alternative are well advised to do their part in ensuring that certification and regulation does not create a "compliance agriculture" in which sustainability becomes little more than an afterthought.

In certified organic production, however, field buffers have an added purpose in reducing crop contamination from chemicals used on adjacent land. Most agencies require a minimum 25-foot buffer along "uncontrolled" borders where there is a hazard of chemical use. Wider borders may be required where hazards are great — for instance, where adjacent farms have synthetic pesticides applied by aircraft.

Record Keeping

Few would consider record keeping as a tool for organic crop production. However, the documentation of how and where a crop was raised, what products were applied and when, which bin or cooler it was stored in, is of critical importance to establishing the integrity of the product. If the farmer cannot provide reasonable documentation that his or her crop was organically grown, that it has not been contaminated with chemicals, and that it has not commingled with a similar conventional product, then certification may well be denied.

Other Tools and Practices

As stated at the outset, the tools and practices described in detail here are by no means an exhaustive listing of organic options. Among those not discussed but requiring mention are timing of planting and field operations to avoid pests or disrupt their life cycles, various forms of pest traps, physical barriers to pests, and increasing plant populations to enhance crop-weed competition.

Summing Up

While there have been varying notions of organic farming over the years, the growth of the industry and the introduction of standards and certification have led to a clearer definition in recent years. That definition describes organics as a viable agriculture, based on sound farming practices, that does not include synthetic chemicals.

Certified organic agriculture can be further characterized by a set of principles that include biodiversity, integration, sustainability, natural plant nutrition, natural pest management, and integrity. These principles are expressed through the implementation of both traditional and cutting-edge farm practices.

As the organic industry continues to grow and evolve, it faces many challenges, including the consequences of its own success. Economic opportunities invite new players into the marketplace who may have little interest in sustainability or the positive social benefits many have come to associate with organics. This matter was touched on by rural socialogist Dr. William Heffernan. Dr. Heffernan has gained considerable attention in recent years for his insightful analyses of the causes and social consequences of the increased concentration and corporate control of the U.S. food system. In an interview published in Acres USA (38), he expressed the following regarding organic farming.

> We are beginning to realize that up to this point we believed that organic was synonymous with family farms and we are finding out that is changing. In fact, the organic is going to continue to grow. That doesn't mean that it is going to support family farms the way it has in the past. With the whole organic movement, we assumed that the social would go along with the environmental movement, and what we are finding out is no, that is not necessarily true, and even what they do environmentally is questionable.

Whether certified organic farming will survive its own success and continue as a socially and environmentally responsible alternative, or merely become a parallel production system based on minimal compliance to standards, remains to be seen.

AN ATTRA GUIDE TO SELECTED RESOURCES

A Supplement to *An Overview of Organic Crop Production*

History and Philosophy of Organic Agriculture

Many of the foundational books on organic farming are out of print, but they should not be too difficult to locate through interlibrary loan or a good used bookstore. A few resources currently available are:

- The *Soil and Health Library* at <http://soilandhealth.org/index.html> features many old titles on-line. Among them are Albert Howard's *An Agricultural Testament* and *Soil and Health*, Eve Balfour's *Toward a Sustainable Agriculture – The Living Soil*, and Newman Turner's *Fertility Farming*.
- Copies of Rachel Carson's *Silent Spring*, Louis Bromfield's *Pleasant Valley*, and William Albrecht's bound papers are available from the Acres USA Bookshelf, P.O. Box 91299, Austin, TX 78709. 800-355-5315 (toll free), 512-892–4400, FAX: 512-892–4448, <http://www.acresusa.com.>

Several contemporary books on organic agriculture and organic soil management that deserve mention include the following:

- *Organic Farming,* by Nicholas Lampkin. 701 p. A highly comprehensive book on organics published in England.
- *Successful Small-Scale Farming,* by Karl Schwenke. 134 p. A low-capital approach to organic farming.
- *The New Organic Grower,* by Eliot Coleman. One of the best books available on intensive organic market gardening.
- *How To Grow More Vegetables,* by John Jeavons. 201 p. The classic book on biointensive mini-farming.
- *Edaphos,* by Paul Sachs. 197 p. Does an excellent job of creating a unified whole out of the various theories and methods of ecological growing.

> *The above books are all available from Acres USA Bookshelf, P.O. Box 91299, Austin, TX 78709. 800-355-5315 (toll free), 512-892–4400, FAX: 512-892–4448,* <http://www.acresusa.com>. *Catalog available.*

- *The Soul of Soil,* by Grace Gershuny & Joseph Smillie. 174 p. A very good basic book on understanding soils and fertility from an organic perspective. Available for $16.95 plus $6.00 s&h from : Chelsea Green publishing, c/o Resolution, Inc., P.O. Box 2284, South Burlington, VT 05407. 800-639–4099 (toll-free), <http://www.chelseagreen.com>.

- *Building Soils for Better Crops,* by Fred Magdof and Harold van Es. 240 p. Practical information on soil management to boost fertility and yields while reducing environmental impacts and pest pressures. Available for $19.95 plus $3.95 s&h from: Sustainable Agriculture Publications, 210 Hills Bldg., U. of Vermont, Burlington, VT 05405-0082. 802-656–0484, <http://www.sare.org/publications/>.

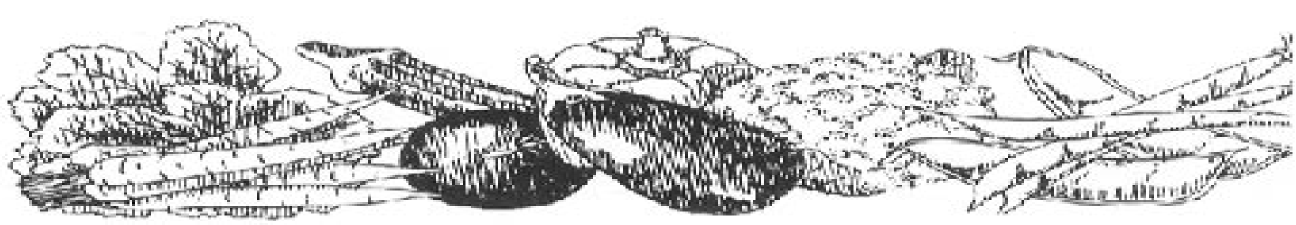
National Organic Program

The National Organic Program (NOP) was created to implement the Organic Foods Production Act of 1990, which is the over-arching legislation behind the federal standards. The NOP Web site is the place to view the Regulations, to view all Accredited Certifying Agents, and to monitor the progress and recommendations of the National Organic Standards Board. The NOP Web site is <http://www.ams.usda.gov/nop/indexNet.htm>.

ATTRA Publications and Materials of Particular Value to Organic Producers

• *Organic Farm Certification & the National Organic Program*. Our basic guide to the organic certification process. Provides a brief history of organic certification, steps in the certification process, how to evaluate a certifier, and examples of how feeds are assessed.
• *Documentation Forms*. These forms are tools for documenting practices, inputs, and activities that demonstrate compliance with the National Organic Standard. They are intended to make recording easy and should be shown to the inspector during annual inspections. There are three separate packages: "Field Crops," "Livestock," and "Orchard, Vineyard, & Berry Crops."
• *National Organic Program Compliance Checklist for Producers*. A tool to assist farmers, ranchers, inspectors, and certifiers in assessing compliance with the National Organic Standard. The document is reformulations of the Regulations into "yes" and "no" questions and is organized to reflect the content requirements of the Organic System Plan.
• *Opportunities in Agriculture—Transitioning to Organic Production*. ATTRA has a special relationship with the Sustainable Agriculture Network (SAN) and distributes many of their publications. We are especially pleased to provide this publication on transitioning to organic production.
• *Organic Crops and Livestock Workbooks*. NCAT's "Organic Crops Workbook" and "Organic Livestock Workbook" are the products of two years of collaborative effort with many leaders from the organic community. Both publications are written from the perspective of organic inspectors and give the user a clear picture of all the details that must be considered in developing a system that is compliant with the National Organic Standard. The reader will get an excellent picture of the range of practices and inputs allowed and prohibited. Guidelines for selecting the most sustainable options are provided. Unresolved issues are highlighted and discussed. The Workbooks are excellent tools for anyone making the transition from a convention operation.
• *Creating an Organic Production and Handling System Plan*. Contains template forms that are in common use by U.S. certifiers. Provides prospective organic producers with an insight into the kinds of information they will need to provide when making application for certification.
• *Biodynamic Farming & Compost Preparation*. Provides details on a unique approach to organic production.
• *Manures for Organic Crop Production*. Addresses the problems and challenges of raw and composted manure. Also deals with guano.
• *Holistic Management*. Outlines a decision making framework that creates a link between sound economics and the environment. Such a framework is invaluable to farmers evaluating organic agriculture as an option, and to organic farmers trying to select the best tools, practices, and marketing strategies for their operation.
• *Overview of Cover Crops & Green Manures*. A guide to selecting and using cover crops and green manures, which are among the most useful tools for bringing an operation into organic production.
• *Suppliers of Seed for Certified Organic Production*. Organic growers must use organic seed if commercially available.

ATTRA has more than 240 publications on organic and sustainable agriculture topics, including rotational grazing, multispecies grazing, intercropping, composting, sustainable soil management, weed control, and agroforestry—topics that typically interest organic producers and which they find very useful. Descriptions of these materials can be found in the *ATTRA Publications Catalogue*, which is available free of charge by calling toll-free 1-800-346-9140, or on our Web site at <http://attra.ncat.org/>.



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By George Kuepper and Lance Gegner
NCAT Agriculture Specialists
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