Organic Farming Principles and Practices

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Introduction

Farming is both challenging and exciting. We have compiled knowledge about how things grow and why some growing methods might be preferred over other methods. The following information is offered to help expand awareness of methods of organic farming and sustainable agriculture. There are many concerns about how long farming will continue using current conventional methods.

What does organic mean? The philosophical characterization of "organic" agriculture

In the simplest terms, organic growing or farming is based on maintaining a living soil with a diverse population of micro and macro soil organisms. A common phrase used to characterize organic growing that will be explained in detail is "feeding the soil, not the plant". Organic matter is maintained in the soil through the addition of compost, animal manure, and green manures and the avoidance of excess tillage and nitrogen applications. Another common aspect of organic agriculture is growing plants without synthetic fertilizers or pest control chemicals.

On a broader scale, it seems there are some that perceive organic growing as requiring some spiritual or religious commitment. While this is far from the truth, it is true that many people committed to organic agriculture are committed to some important social principles as well. These usually include the desire for organic agriculture to be economically, environmentally and socially *sustainable* and based on integrated production systems. Most people committed to organic production for social and environmental reasons, as opposed to economic opportunists, expect to be operating within and as part of the ecological system or web of life as opposed to dominating and subjugating the system. There often is an emphasis on using locally available and renewable resources, marketing locally, and the quality of food is also seen as a key part of personal health and wholeness.

What does organic mean? The legal definition or organic certification

The Organic Food Production Act of 1990 established a national program and guidelines for the production of certified organic crops or products. Within this program there are national, regional, or state wide independent, privately operated agencies, which define the acceptable practices and the limits and boundaries of acceptable or certifiable practices. The primary emphasis is on careful historical documentation of all farm practices and routine inspection of the farm, farm records, and farming practices by certified organic inspectors. Materials such as nutrient sources are reviewed by the Organic Materials Review Institute (http://www.omri.org/) and if approved placed on a list or acceptable products. In the past, very small farms have not been required to be certified to use the term organic.

For more information about the process of organic certification, the web sites of two agencies certifying organic growers in Michigan can be visited: the Organic Growers of Michigan (OGM) (http://www.michiganorganic.org) and the Organic Crop Improvement Association (OCIA) (http://www.ocia.org). In June 1999, a report issued by the Organic Advisory Committee of the Michigan Department of Agriculture (MDA) recommended development of organic standards (http://www.mda.state.mi.us/prodag/organics/index.html) for Michigan. In November 1999, governor Engler accepted the recommendation and publically called for MDA to begin developing certification standards (http://www.mda.state.mi.us/). In 1998, the federal government (USDA) released a draft document for national standards. Public comment reached record levels due to the proposal to accept genetically modified organisms (GMO's), the use of sewage sludge, and irradiation treatment of fruits and vegetables to reduce post harvest and storage losses. March 2000, the USDA announced the revised federal standards for organic certification which exclude the use of GMO's, sludge and irradiation (http://www.ams.usda.gov/nop/). Michigan and Federal Standards were completed and passed into law in December 2000. The new federal law will not require farms with less than $5000 in gross sales to be certified, but the Michigan law will require all producers using the term organic, to be certified.

The standards provide a framework for the future evolution of commercial organic growing, processing and marketing. Conventional farmers can learn both the letter and the intent of the standards while learning to transition to more sustainable if not certified organic practices. (Also see: Organic Farming Research Foundation http://www.ofrf.org and see http://www.ota.com Organic Trade Association, Facts About Organic, for the National Organic Standards Board (NOSB) 1995 definition of organic) .

What does Organic Mean? The Organic Ethic

While legislation will help standardize practices and expectations, there is grave concern regarding maintenance of the organic ethic and survival of small farms that have depended on the organic label and ethic to mean more than what is included in the current legislation. It is clearly possible to meet organic certification standards as currently written without protecting the soil or farmland for future generations. There is concern that conventional farmers will substitute an organic spray or fertilizer in place of current sprays or fertilizers. The goal is to eliminate sprays and fertilizers. It is also possible for factory farms to obtain organic certification and produce large quantities of certain crops for lower costs and lower prices than is possible for small farms. The success of organic standards cannot only be measured by economic or ecological standards, but must also take into account the long term sustainability of small family farms.
The Michigan Organic Food and Farming Alliance (MOFFA), Michigan Integrated Food and Farming Systems (MIFFS), and the Michigan Association of Sustainable Agriculture (MASA) are examples of organizations that support the organic ethic and or sustainable agriculture. Each of these organizations have a web site with detailed information. (www.moffa.org, http://www.msu.edu/user/miffs/) For more information about sustainable agriculture, just type the term "sustainable agriculture" for a web search. Many sites are available including the The Sustainable Agriculture Network (sare.org), The Leopold Center(www.leopold.iastate.edu), and http://www.msue.msu.edu/misanet/ for examples of sustainable agriculture programs and research at Michigan State University.

What does organic mean? Organic Farming is common sense

The organic ethic and survival of small farms is important. Our goal is to keep people and the environment as healthy and happy as possible. Eliminating exposure to poisons intended to kill things is common sense. Recognizing that you can't kill one part of a tightly coupled cycle and interdependent food chain without causing problems somewhere else in the food chain is common sense. Eating the most nutritious and freshest food is common sense.

Some Historical Perspective - The Evolution of Conventional (Chemical) Agriculture

Understanding why a process or practice is done a certain way, or why we think the way we do can often be accomplished by looking at the historical evolution of human learning and perception. The history of agriculture and the human perception of how plants grow are both well documented and can help us be better farmers.

Let’s start with observing the growth of a seed. We plant a little seed and in a short time we have a large plant. The seed weighs a fraction of an ounce and in a short time the plant weights several pounds. What makes up this weight and were did it come from? Based on what we can see with our eyes and
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conclude based on observation, what is necessary for a plant to grow?

Based on observing a seed germinate and grow in a garden, we can say the plant needed soil, water, light, and a reasonable temperature. A seed on poor ground will not grow very well. A seed without water will not grow. A seed without light will only grow a short time. And the seed will not grow for very long if it is too cold or too warm. Where did the mass or weight of the plant come from? We know that some of the plant is made up of water. We know that the plant required light, but we don’t have any evidence just looking with the human eye that light energy was transformed into solid matter. Soil and nutrients were required, but did the weight come from the soil?

We could observe that a seed growing in soil that has decaying plant material or animal manure will usually grow larger and faster than one growing in soil without organic matter added. It is not that long ago, about 150 years, that the main theory of plant growth was the “humus” theory. Those observing plants assumed that the weight of the plant came from the soil. The idea was that the root somehow ingested the soil or something in the soil, perhaps “humus” and the plant was assembled from these building blocks. Plants were thought to be like animals, only eating from the soil.

Ok, lets grow another seed. Only this time, let’s take a container of soil and put the seed in it. We will add water and keep track of how much we add. After the plant grows, we can weigh the plant. If the weight comes from the soil, we will see a decrease in the weight of the soil at the end of the experiment. This has been done before, over 400 years ago for likely the first time that we know about. The answer was that the plant grew but the soil stayed about the same, only a few ounces of soil were lost, and that could have been an error. So where did the plant come from? It must have been the water?

Let’s try growing the seed, or a seedling in just water. A seedling does not grow very well at all in purified water, but if some garden soil is added to the water, the seedling grows. Perhaps there is something from the soil? The thinking continued that the soil was a prime supplier of materials for plant growth (Experiment done about 1700).

What happens if we grow the plant in a giant plastic bag or air tight glass case or greenhouse? After a while the plant doesn’t grow very well if at all. What if we pump some fresh air into the bag or case? Suddenly the plant starts growing better. Is there something in the air that the plant needs? We know the answer is yes, because now we know the air is made up of not one gas but several gasses, including nitrogen (~78%), oxygen (~20%), and carbon dioxide (~0.034%). The identification of oxygen and the purification ability of plants was identified around 1800 (Priestly and others.)

An animal in a closed, airtight container dies and a plant in an airtight container may survive but will not grow. Put them together and they both can thrive. The animal gives off something that would make the plant grow and the plant gives off something the animal needs. Carbon dioxide from the animal to the plant (respiration) and oxygen from the plant to the animal (photosynthesis). Where does the carbon in the food we eat go? Some is incorporated into our body. Some leaves the body in urine or feces. Is there any other way carbon leaves the body? Yes in our breath. Instead of the approximately 350 parts of carbon in fresh air, our breath has approximately 20,000 parts or 80 times more. The exhaling of carbon dioxide is common for animals right down to single cell bacteria.
Ok, let’s try a different approach. Let’s take the plant or plants and dry it and get rid of all the water. Instead

of 100 pounds of fresh plant, we now have 10 pounds dry matter. We evaporated about ninety pounds or 12 gallons of water. There is still 10 pounds of plant. We could take this dry plant and burn it. The plant disappears or goes up in smoke, except for about 1 pound of ashes. Where did the other 9 pounds go? What was in that smoke and gas that formed as the plant burned? What do we get when we burn wood or organic material? Heat, carbon dioxide and water, made up of carbon, hydrogen and oxygen.

What was in the ashes? All the other elements the plant needed to grow and extracted from the soil. That little bit of soil that was missing was not an error in weighing, we have now recovered most of it in the form of ashes. In the ashes would be potassium, phosphorus, calcium, magnesium, sulphur, iron, manganese, zinc, copper, boron, molybdenum, chloride, silicon, nickel and a small amount of other elements. (Ashes once seen as bones of plants.) The nitrogen would be lost to the atmosphere.

Looking at what elements and minerals were in plants, together with the evolving science of chemistry, led German scientists, particularly one organic chemist by the name of von Leibig, to state that the plant took some things from the soil, but most of the carbon came from the air, not the soil (published around 1840). It was around this time that the assumption developed that only the minerals extracted from the soil had to be replaced in order to maintain yields. Artificial manures made from salts were developed and even patented. Later, around 1860, it was demonstrated that plants could be grown in water if the correct salts were added to the water. This is the process that later became known as hydroponics. *Much of our current approach based on chemical fertilizers used in conventional agriculture is based on these observations and this way of thinking.*

Other than naturally occurring in the soil, fertilizer elements can either be mined from the earth or manufactured. Most of the N used in modern industrial agriculture is taken from the atmosphere. Under high temperatures and pressures, obtained using fossil fuels such as natural gas, the nitrogen molecule (N_2) can be combined with hydrogen (H_2) to form an ammonium molecule NH_4, which is useful to plants. It can also be mixed with oxygen and chemically converted to nitrate (NO_3), which can be used by plants. How did we learn to take nitrogen from the atmosphere? Mostly from research to get nitrogen to make explosives. Large scale nitrogen production traditionally has been looked at as a valuable outcome of World War I. After the war, the munition plants and the people working there needed something to do and someone figured out they could make fertilizers. This lead to the eventual development and application of many chemicals now used in conventional agriculture (1938 USDA yearbook of Agriculture). The rapid growth in agriculture that occurred with the post war (WWII) baby boom is in a large part the result of increased nitrogen fertilizer and how it was used to increase yield and lower food costs.

So, if most of the plant comes from the atmosphere and some salts from the soil, if the plant does not extract organic matter from the soil for growth, what is the importance of having organic matter in the soil? After all, we can grow plants in water and fertilizer solution using hydroponics. Even von Leibig was aware and fascinated by the problems of Virginia tobacco farmers in the new world (approximate 1850). It seems after 100 years of growing wheat and tobacco without any addition of manure, the crops were not growing and the land was being abandoned. It is important to recognize that von Leibig was a chemist, and had little understanding of farming. It has also been reported that late in his career he realized the mistake he had made in making it sound like organic matter was not important, but it was too late to undo the damage.

Some Historical Perspective - The Evolution of Organic Agriculture

The story of organic or sustainable agriculture over the last 100+ years and as we know it today is perhaps more a story of observation of the natural system and taking the time to look back more carefully at the previous several thousand years of agriculture. It is also hard to say if it is a story of the last 100+ years or the last 10,000 years. It is pretty clear that the up until the last 150 years, the only type of agriculture was organic agriculture as it currently is defined. So in some sense, the experiment is conventional agriculture, which has been in practice perhaps 1% of the time people have had some form of cultivating crops.

In 1880, a fellow by the name of Charles Darwin was watching worms and making some observations about how the organic matter ingested was broken down and might provide nutrients to plants. Often noted as a keen observer, it seems reasonable that anyone looking at worms might wonder what else was in the soil. It was about this time that the development of microbiology and knowledge of microscopic organisms like bacteria were being observed by humans for the first time. Could it be that the soil was alive and that there were other factors at play? In the years that followed, others looked at the soil as being alive and asking questions about the importance of organic matter.

In 1911, *Farmers of Forty Centuries*, was published by F.H. King. He told of his observations in Asia where the same land had been farmed for as long as 4000 years. *The Living Soil* was published in 1927 by Lady Eve Balfour and she reported on what else was going on in the soil. In 1940, *An Agricultural Testament* was by Sir Albert Howard. Howard reported on his work in India with composting and the effect of compost on soils and food quality. And in 1945, *Pay Dirt*, by J.I Rodale hit the American scene. These are just some examples of those who saw that the soil is alive.

The early part of the 1900's also saw great strides in the understanding of soil chemistry and processes influencing nutrient availability. There was already evidence of a split in thinking about how to best provide the necessary nutrients. The value of legumes was well recognized and at least one university researcher (Hopkins, 1911) asked the question of why farmers would pay for nitrogen when there was many times more than ample nitrogen sitting in the air above their field that could be fixed with legume crops.

Through the 60's and 70's the alternative view to conventional agriculture evolved into what we have know for over 25 years as *sustainable agriculture*. The concepts of sustainable agriculture are based on developing an agriculture system that will protect soil quality and health for the long term. Many of the basic tenants of sustainable agriculture and organic agriculture are the same and they focus on the question we started with: What does organic matter do besides provide nutrients?
We already established that part of the reason for adding organic matter is to add nutrients. As plant material or manure decays and breaks down, new plants can take up the nutrients. The other key reason for adding organic matter is that soil in its' natural state is full of micro-organisms (bacteria, protozoa, nematodes, fungi, etc) and macro-organisms (bugs, worms, beetles, etc) that serve many roles. The organisms break down organic matter and each other, which makes nutrients available to plants as previously stated. But soil organisms are also essential to the long term physical structure of the soil. Organic matter provides the organic compounds that help provide structure to the soil, which supports water *absorption and retention*. Organic matter feeds organisms, organisms convert organic matter, soil structure is maintained, etc. This interrelated, natural process has recently been referred to as the "soil food web". (http://www.soilfoodweb.com and http://www.statlab.iastate.edu/survey/SQI)

If soil is only provided nutrients in the form of fertilizer, and the crops are harvested from the land each year, eventually there is no organic matter and the "soil food web" starts to fall apart. This is a slow process which can occur in as little as 5 to 10 years or as long as 50 to 100 years. Organisms are lost, soil structure is lost, soil can wash or blow away, and eventually some micro-nutrients even become present at lower concentrations and the nutrient value of the food crop is reduced.

In summary, we can grow plants with no soil at all, this is called *hydroponics* or feeding the plant. *What we can't do over the long term is treat field soil like hydroponics and just keep adding synthetic fertilizer without* *organic matter. The soil will eventually die, compact, and or blow away. This is a main point of organic and sustainable agriculture*. Organic and sustainable agriculture are about feeding the soil for the very long term health and quality of the soil as opposed to feeding the plant. There is a wide range of farming methods from using little or no organic matter to making heavy organic matter additions, with farmers at various levels in between. Our goal is to improve and assure maintenance of as much farm land as possible.

Methods or Schools of Organic Farming

As you read and learn more about organic farming, you may encounter some differences in approach, style or what might be called philosophy. While there have likely always been some farmers who have grown crops without fertilizers or pesticides, these are several examples of people who proposed or popularized a particular method. Please do not let this presentation format of separating them out give the impression that one or the other method must be selected. The goal is just to help give some history, background, and names to help you learn more.

Biodynamic Perhaps the oldest (this century) recognized method of organic gardening or farming is referred to as the Biodynamic Method. Rudolph Steiner developed the method in Germany during the 1920's and "his basic theory was that nature is a mystical, spiritual thing, and to garden it well, one must treat it as a whole entity and system, both physical and spiritual". Farming practices are related to lunar and planetary phases. Plant and mineral based preparations are often sprayed on crop plants to provide necessary nutrients. For more see the Biodynamic Farming and Gardening Association at www.biodynamics.com. Addtional information is available from the biodynamic certifying agency, Demeter (www.demeter.net) .

The Rodales J.I. Rodale searched for alternative agriculture methods in the early 1940's. He was not from a farming background but wanted to grow more of his own food. The recommendations of the day to treat with chemicals that he saw as potential poisons did not make sense to him. He learned about the composting methods of Sir Albert Howard in India (*An Agricultural Testament)*, the work of Lady Eve Balfour (*The Living Soil)*, and F. King (*Farmers of Forty Centuries)* who studied growing systems in Asia. Rodale developed an emphasis on human health and how organic gardening through reduced exposure to pesticides and production of nutrient rich vegetables was related to human health. A major emphasis was placed on the production and use of compost to enrich the soil. The work was continued by his son, Robert Rodale. The family developed the Rodale Institute, Organic Farming and Gardening Magazine, and Rodale Press. A third generation now carries on the tradition. (www.rodaleinstitute.org)

Biointensive The Biointensive Method is mostly outlined in the book *How to Grow More Vegetables Than You Ever Thought Possible on Less Land Than You Can Imagine* (1974, 5th edition in 1995) by John Jeavons. High organic matter, growing organic matter specifically for soil building, deep cultivation or double digging, and extremely high yields per unit area of production are some key principles. As reported in the book mentioned above, the techniques were originally outlined by Alan Chadwick, an English horticulturist who combined French Intensive gardening methods such as double digging with Biodynamic methods. Extremely high yields have been achieved on small plots of land around the world. For more information (http://www.growbiointensive.org). The organization "Ecology Action" works to promote biointensive methods and how they can be used to develop food supply for local communities.

Natural Farming The Natural Farming method of gardening or farming is based on building soil with regular surface applications of organic matter and little or no cultivation. Organic matter is allowed to slowly decompose on the surface as opposed to composting in piles. Weeds are controlled by applications of more mulch or organic matter. This method was popularized by Masanobu Fukuoka in Japan (*One Straw Revolution* 1978). See http://www.seedballs.com/2seedpa.html for more information on Fukouka. He has worked extensively to establish plants in dry or desert regions around the world using clay seedballs. He is a proponent of observing what works in nature and keeping gardening simple.

No Work Method This method is very similar to the Natural Farming method. Ruth Stout published a book in 1971 called The Ruth Stout No-Work Garden Book" (Rodale Press, Emmaus, Penna, 1971). A recent book titled Gardening Without Work : For the Aging, the Busy and the Indolent, 1998 is likely a reprinting of the information. The emphasis in on lots of organic matter for mulch to control weeds and provide nutrients. Worms and other organisms are allowed to do the work of getting nutrients to the roots.

Permaculture A broader, more holistic method know as Permaculture has been popularized by Bill Mollison and others. It appears to have originated in Australia or New Zealand. Permaculture goes even farther to evaluate and take into account the entire landscape and physical features of a growing area. Plant and animal raising are considered together to make the best use of the land. Sustainability of practices and design and care for the earth are key components of Permaculture. In some ways it appears to be a process of observing nature and methods of indigenous people and perhaps making them formal or complicated or academic. (http://www.permaculture.org.uk/ , http://csf.colorado.edu/perma/)

Veganics Some people have chosen to use the term *veganics* as opposed to *organics*. The main difference is basing nutrient management on only plant derived nutrients and organic matter as opposed to making use of manures and other animal products. This is not a widely used term but is does point out that there are different degrees of organic farming/gardening and what people consider important.

Summary Regardless of what you call it, the ideas have common threads. Organic gardening is gardening in a way that considers the whole picture of the environment and how we fit into the existing cycles. Gardening with nature is a common sense way of putting it. There are many other methods that could be considered, including the French Intensive gardening methods and the old and widely used method of China and Southeast Asia based on intensive cultivation of diversified plots. We could also consider the work of Wes Jackson and other at The Land Institute in Kansas that are working on methods to use more perennial plants for staples such as wheat, rice and corn. Hopefully there are enough choices and ideas here that you won't get the impression that there is only one way or one recipe to follow. Just farm with nature.

Ecological Soil Nutrient Management and The Nitrogen Cycle

A key part to farming with nature is understanding how nutrients become available for plants. Perhaps the most important of the nutrients is nitrogen, so the focus of this discussion is placed on nitrogen. For many years we have understood the nitrogen cycle which can be simplified like this:

Organic matter --> Mineralization --> Ammonium --> Nitrification --> Nitrate –> Plant Uptake

We can add in fertilization, nitrogen fixation, immobilization, volitization, denitrification, leaching, runoff, and in the case of perennial crops, mobilization from the roots and woody tissue. There are a number of inputs, conversions, and outflows of nitrogen in the complete nitrogen cycle. (See Field Crop Ecology by Cavigelli et al for detailed diagram on pg 31.)

What really happens in *mineralization* or the breakdown of organic matter and organic nitrogen to the ammonium and nitrate forms absorbed by plant roots? I learned it mostly as a black box on a diagram. Something happened there, but it was not clear what. As I currently understand it, the process is not much different than when a cow eats hay. In the soil there are millions and billions of living organisms that are feeding on the carbon based organic matter and releasing nutrients. The carbon is either incorporated into the living organisms as they grow, or is exhaled as carbon dioxide, or is excreted in the form of manure. In the manure is an increased level of soluble nutrients and nitrogen, just like in the manure of a cow or any other animal. In natural systems, the waste of one organism is often the nutrient source of another. One dead organism becomes the food source of the next organism in the chain. With each level of digestion, there is continued breakdown and availability of nutrients. Based on our current understanding and analytical methods, the final nutrients that the plant takes up from organic matter are no different than the nutrients that would be provided by synthetic fertilizer.

Soil with 2% organic matter contains 40,000 lbs organic matter per acre in the top 7 inches. Organic matter often contains 6 to 8% N, or 2,400 - 3,200 lb N per acre. Up to 1% organic N may be released annually via mineralization. For this example, the N per acre would be 24 to 32 lbs.

Sources of Organic Matter and Nutrients

Animal Manure. A traditional source of soil organic matter has been animal manures. Dairy and beef cow, horse, sheep, swine, and poultry manure can be spread directly on land and incorporated. The amount of nitrogen in manure sources from different animals can vary by a factor of 3 or 4. The amount of nitrogen in the fresh manure (feces and urine) that ends up available to the plant is also very dependent on handling methods. Nitrogen in the form of ammonia or ammonium can be quickly lost (volitazation) to the atmosphere if the manure is not incorporated into the soil.

Animal manure has been a primary source of nutrients for hundreds if not thousands of years, up until the last century. There are recent concerns about the presence of certain bacteria in the manure that if allowed to contaminate crops may effect the food safety of fresh fruits and vegetables. Part of the more recent concern has to do with how animals are fed, housed and treated with antibiotics. Manure from factory animal production units will not be acceptable for organic certification. The USDA standards will also require certain lengths of time (90 to 120 days) from the time of application to the time of any crop harvest from the same land. Composting manure will tend to stabilize the nitrogen and nutrient content, reduce the volume and make it easier to transport, and reduce if not eliminate the risk pathogens related to food safety. Manure used in composting must also be handled according to the final rule composting procedures which requires a certain number of turns of the pile and the maintenance of certain temperatures.

Green Manures. Another very old, traditional source of organic matter and nutrients is growing plants on the land and then plowing them into the soil to decay and release nutrients for the next crop. Crops grown to add nutrients to the soil are called green manures. Some plant species are selected as *green manures or cover crops*, because of efficient, deep root systems that bring nutrients up to the soil surface, others because they are hardy or more tolerant of nutrient, moisture or environmental stresses. The most important green manures are plants that together with bacteria are able to capture nitrogen from the atmosphere and make it available to plants. The plants provide soil bacteria around the plant roots carbon in the form of sugars from photosynthesis. In "exchange" the bacteria provide nitrogen in a form the plants can use. The plants can grow larger with the nitrogen and provide more carbon. This nitrogen can be used by other plants as the original nitrogen fixing plant decays. We can grow nitrogen fertilizer using crops like alfalfa , clover and soybeans and other legumes. We can then use the fresh, dried, or decomposed plant as a fertilizer. Estimates of N fixation from clovers, vetches and lupines are in the range of 50 to 100 lbs per acre. Grass and clover swards may fix as much as 200-400 lbs/acre N. The green manures can either be tilled under, mowed or grazed. The effect of green manures or cover crops on rodent populations or rodent damage to trees must be taken into consideration.

Compost. A third primary source of organic matter and nutrients, particularly for smaller plots of land or gardens is compost. Compost is the end product of biological breakdown of organic matter. Composting or breakdown can result from fungal activity at lower temperatures (<90 F) and bacterial activity at higher temperatures (from 120 to 160F). During composting, carbon from the organic matter is lost as carbon dioxide and heat and water are generated. The resulting material has more concentrated nutrients and can be used as a fertilizer as well as a source of organic matter for soil microorganisms. The product is more stable, decreases the solubility of nutrients, and avoids the immobilization of N that can occur with straw or saw dust bedding. The amount of weed seed is also decreased compared to manure and there may be beneficial effects on reducing plant soil born pathogens. The process of composting is also like a cow eating hay. Bacteria are feeding on the carbon, releasing carbon to the atmosphere, but at the same time making nutrients more soluble and more concentrated in the material left behind.

Organic fertilizers and amendments. There are naturally occurring fertilizers or amendments that are acceptable for certified organic production. They can be categorized as either mineral derived, animal derived, or plant derived. Following is a table of several organic fertilizers and a range of rates they can be applied to the garden (in pounds (lbs) per 100 square feet of garden area). Examples of *mineral derived organic fertilizers* are mined phosphates either in the form of raw rock phosphate, colloidal rock phosphate, or black rock phosphate; a mined potassium silicate based mineral from New Jersey called greensand; lime, which is mined calcium and magnesium carbonate; gypsum, which is calcium sulfate; either potassium sulfate or potassium magnesium sulfate (sol-po-mag) that are also mined, and elemental sulfur. There is a large, naturally occurring deposit of nitrate of soda, or sodium nitrate in Chile, South America. Sodium nitrate is a very water soluble salt that is usually not considered acceptable. Examples of *animal derived organic fertilizers* are blood meal (dried blood), bone meal, feather meal, fish meal or fish emulsion, and oyster shell lime. There are some concerns about the safety of these fertilizers when they are derived from poorly managed animals or animals that were not produced organically. Examples of *plant derived fertilizers* include alfalfa meal, soybean meal, cotton seed meal, sea weed or kelp based materials, and wood ash. As with some animal derived nutrient sources, there is reservation about using cotton seed meal derived from cotton that is often heavily sprayed with insecticides. Since genetic modified organisms are not allowed, and more than half of the soybeans in the United States were GMO's, soybean meal may also become unacceptable. Alfalfa is an excellent source of nitrogen and nutrients, but the price is not supportive of large scale use as a fertilizer.

One of the best presentations of the organic fertilizer options listed above is in the book Fertile Soil, A growers guide to Organic and Inorganic Fertilizers, by Robert Parnes (1990). Other useful books include "Solar Gardening" by Leandre and Gretchen Poisson (1994, Chelsea Green Publishing Company, White River Junction, Vermont) and "The New Organic Grower" by Elliot Coleman (1995, also by Chelsea Green Publishing).

Managing Nutrients and Organic Matter

Our goal is similar to conventional agriculture in regards to identifying the nutrient or nitrogen requirements of the crop and supplying some amount each year to meet those needs. From the table below one can start to get a feel for some of the differences between organic and synthetic fertilizers. What do you get for all the extra effort and probably cost? The carbon being applied to the soil is keeping the soil alive and healthy. The organic matter is helping provide water penetration, moisture retention, and soil stability. The improvements in soil physical properties and likely improved plant vigor that may reduce pest problems.

However, the nutrients also have to be available at the proper time of the crop cycle relative to growth, bloom, fruit set, fruit maturation, harvest, and preparation for dormancy. For tree fruits, N availability early in the season is reportedly important while reduced N availability late in the season is also considered important. It is also important to recognize that tilling the soil adds oxygen and speeds up the breakdown of organic matter. Over application of nitrogen also results in a faster breakdown of organic matter and decreases in the soluble forms of carbon. Reduced N availability may increase the size of root systems relative to top growth, which can increase mining of the soil and also storage of N in the roots.

Some examples of nutrient sources acceptable for organic certification. Values in lbs/100 square feet can be converted to pounds per acre by multiplying by 436.

Mined or Mineral Sources		**Animal Derived Sources**		**Plant Derived Sources**	
Material	lbs/100 ft^2	Material	lbs/100 ft^2	Material	lbs/100 ft^2
lime - carbonate, not hydrated or	2-10	bone meal (6-12-0)	1-3	alfalfa meal (3-0.5-3)	5-10
burnt	1-4	blood meal (12-0-0)	1-3	soybean meal (6-1.4-2)	1-5
gypsum - calcium sulfate	1-10	fish emulsion (5-1-1)	1-4fl oz	cotton seed meal (6-2-2)	1-5
rock phosphate - calcium phosphate	3-10	fish meal (7-7-0)	1-3	kelp and seaweed (1-0.2-2)	1-2
greensand - potassium (0-0-7)	0.5-1	feather meal		wood ash (liming action)	1-2
potassium sulfate (0-0-50)	1-2	manure - many types		compost (may include	5-20
potassium magnesium sulfate (0-0-	3-10	3 to 5 ft^3 per year		manure)	5-10
21)	3-10	worm castings	5-25	dry greens - herbs	
basalt rock powder				(nettle, comfrey, yarrow, etc)	
granite rock powder (5-10% K_2O)					

Comparison of Nitrogen Sources and Application Rates. These are estimates provided primarily for comparison purposes. Many values are average or mid range figures that can vary over a wide range. An acre is equal to 43,560 square feet.

Example Material	**%N**	**C:N**	**N lbs/ton**	**50-100 lb N/acre (dry)**	**Cost**	**Rate/acre and $**
Compost or Manure	1	20:1	20	5000 -10,000 lbs	Compost $20/$yd^3$	10 ton moist, 25 yd^3 - $500
Alfalfa hay or pellets	3	15:1	60	1667 - 3333 lbs	$4/bale or $6/bag (50lbs)	67 x 50 lbs $268
soybean meal	6	7:1	120	833 - 1666 lbs	$10/50 lbs	33 x 50 lbs $330
blood meal	12	3:1	240	416 - 832 lbs	$25/25lbs	34 x 25 lbs $850
16-16-16	16	-	320	313 - 626 lbs	$10/50 lbs	12.5 x 50 lbs $125
ammonium nitrate	33	-	660	152 - 304 lbs	$8/50 lbs	6 x 50 lbs $48
Urea (46-0-0)	46	-	920	109 - 218 lbs	$7/50 lbs	4.4 x 50 lb $31

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Competitor (Weed) Management

As you get into the philosophy of organic agriculture, you become less likely to look at plants as weeds. However, uninvited volunteers will compete for nutrients, water and light so maybe we could call them competitors. Chemical agriculture makes use of herbicides (chemicals that kill plants) to prevent the growth of broad leaf weeds and grasses. Chemical herbicides are not allowed with organic certification. There currently is research into using naturally occurring compounds for weed management

Weed management is based on routine physical cultivation, crop rotations, mulches, and planting cover crops in combination with cultivation. Non chemical weed control is more than hand hoeing. Soil preparation, developing balanced nutrient levels, and incorporating green manures can help reduce seed populations. Increased populations of soil macroorganisms that eat seeds can also reduce the number of weed seeds. One organic farm consultant reported that the presence of certain weeds could indicate a certain type of nutrient deficiency, pH problem or a nutrient imbalance. It is also important to try to exclude weed seeds by mowing or removing overgrown areas.

The most practical recommendation for the large scale agriculture is the use of properly timed cover crops, green manures and shallow cultivation. This is an area where more research and information is needed. There is research work in progress.

A non chemical form of weeding that is acceptable for organic certification is called flaming. The seedlings are torched with a flame thrower type propane fired burner. Some crops can recover from heat damage once they get to a certain size. In other cases, such as onions, the field is flamed just before the onion seedlings emerge.

For certain perennial crops, covering the soil surface to prevent seed germination or *mulching* is a very effective means of weed control. There are many different types of mulches. Plastic or fabric matting are available in a variety of sizes and shapes. Some high carbon low nitrogen materials like bark, wood chips, or sawdust that would not be acceptable for soil incorporation can be used on the soil surface as long as they are not deeply incorporated into the soil. Straw and hay can be used as mulch and will break down and increase organic matter, but may also bring more weed seeds.

Herbivore (insects and four legged) and Decomposer (disease) Management

The widespread use of chemical herbivore and decomposer controls allows large mono-culture plots of varieties that are susceptible to herbivores and decomposers. (The idea here is to look at the natural role of insects and fungi and to get away from the “pest” mentality. They do serve a natural function.) It also makes non chemical herbivore and decomposer control more difficult since many naturally occurring controls have been eliminated due to the use of chemicals. Many of the more pest and disease resistant cultivars are also no longer available. Commercial agriculture is move towards reduced chemical use and systems based on *integrated crop management* (web site).

There are many non chemical options that can be used to prevent serious crop damage from herbivores and decomposers. If you are already used to a silver bullet, use a chemical to kill anything that looks suspicions approach, one of the first steps is to get used to paying more attention and depending on many different strategies as opposed to just one. It takes time to unlearn some methods.

One of the first steps is to develop a farm plan that uses crop rotations. Plants like tomatoes or potatoes and many others should not be planted in the same location each year. Part of the organic certification process is showing records and plans to routinely change the production location of crops. Part of the planning process can also include grouping certain plants that do well together, *companion planting*, and not grouping plants that have similar insect or disease problems. *Mixed plantings*, perhaps even several *small plantings of a crop rather than one large mass planting* can help reduce both insects and diseases. Also plan to *give plants* *adequate space* so there will be enough light and no excessive crowding which can weaken plants resulting in a greater susceptibility to herbivores and decomposers. If you expect herbivore damage, increase the amount planted to allow for adequate harvests.

Another part of the planning process is selecting *varieties resistant* to insects and diseases. You can also buy or grow transplants carefully so they are *insect and disease free at planting*. Once crops are planted, *inspect crops frequently* so pest populations can be identified early. Provide adequate water and fertilizer to provide healthy growth, but don't over fertilize which may lead to soft, succulent growth possibly more susceptible to insect infestation or disease infection.

Cultural techniques will also help. *Clean up waist* when fruiting or harvest is complete. This may remove breeding or overwintering places. In some cases *mulches* may help (they will definitely help keep moisture and nutrients in and weeds out). Eliminate or exclude volunteers (weeds). *Mechanical control* such as pruning out infested plant parts.

Biological pest control involves systems that favor or invite predatory or parasitic beneficial insects. In some cases predators or parasites are bought and released, for example ladybugs or lacewings and certain parasitic wasps. Biological control may include trap or sacrifice crops that will attract pests away from more desired plants.

There are some sprays that are considered acceptable for organic certification. Some examples are Bt formulations for worm control, insecticidal soap, and a living fungus that attacks insects (Botanigard). Some sprays may be allowed on an emergency basis when severe crop failure is imminent. Compost teas, or water extracts of compost have also been used to help prevent insect attack and disease infection. Other preventative sprays used on a small scale but not likely practical on a large scale include garlic barrier and hot pepper wax.

Some Closing Thoughts

Take the time to truly understand the history of agriculture production and organic agriculture in particular and how it has possibly influenced your approach to farming. Many of the farming with nature concepts are not new, but are tried and true methods that have worked for many, many years. There are many good reasons for organic and sustainable agriculture.

It may take time to build the soil and learn the techniques. It may take some additional physical labor and intellectual exercise compared to other gardening methods. Conversion does not have to be total, complete and immediate. Learning the concepts and methods takes time.

Does or will organic farming take twice as much space to get the same yields? No. In a recently published report, "For a total of 154 growing seasons for different crops, grown in different parts of this country on both rain-fed and irrigated land, organic production yielded 95% of crops grown under conventional high-input conditions". But land does need to be rested and restored with cover crops and green manures to provide organic matter. This is not necessarily true for small plots were organic matter can be brought from off site in the form of manure, straw, hay or compost. Although using cover crops over the winter can really help in many ways.

The first steps in organic competitor (weed), herbivore (pest) and decomposer (disease) control are rooted in building a healthy soil and a healthy plant. Managing the soil has direct effects on weed and pest populations that must be considered. A basic premise of organic growing is learning to trust that investment of time and effort in the soil will pay rewards by reducing monetary investments in chemicals commonly made in other forms of farming.

Above all, remember the human health benefits and the benefits for the natural world around you. These are long term effects that require long-term commitment, dedication and passion. Remember that another way of describing sustainability is the concept of taking responsibility for seven generations that will come after you. Will they thank you for what you have done?

Additional References: (Many references are also included in the text.)

Appropriate Technology Transfer for Rural America (www.attra.org.),
Many, Many articles that can be downloaded.

See also Do not panic, eat organic (many, many links): http://www.rain.org/~sals/my.html .

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USDA NRCS Soil Quality Institute Web Site http://www.statlab.iastate.edu/survey/SQI/ For information on SoilQuality and the Soil Biology Primer.

For a challenging 60 page report on the sustainability of agriculture systems see the following web site:
http://css.snre.umich.edu/css_doc/CSS_2000_4.pdf