Agriculture Organic Series

Soil Quality

IN ORGANIC AGRICULTURAL SYSTEMS

Building and maintaining soil quality is the basis for successful organic farming.

Organic Farming Requires Quality Soil

Building and maintaining soil quality is the basis for successful organic farming. However, before developing a soil management plan focused on soil quality in organic systems, farmers should become knowledgeable regarding the overall philosophies, legalities, and marketing opportunities in organic agriculture. A brief overview of organic agriculture follows, but for further details, see Iowa State University Extension publication *Organic Agriculture* (PM 1880). (See page 8 for ordering instructions.)

USDA NRCS

Periodic soil testing will help determine soil quality.

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What Is Organic Agriculture?

In order to sell your crop as certified organic, you must follow USDA National Organic Program rules, and be certified by one of the accredited agencies listed in *Organic Agriculture* (PM 1880). State of Iowa organic certification rules will require the following:

- No synthetic fertilizers for 36 months prior to the certified organic crop's harvest.
- No synthetic pesticides (fungicides, insecticides, herbicides) for 36 months prior to the certified organic crop's harvest.
- Crop rotations, including a soil-building legume or small grain/legume mix following row crops, to break weed, insect, and disease cycles and maintain soil fertility.
- No synthetic hormones or antibiotics for livestock may be used, and organic feeds and pastures must be fed.
- Soil fertility in organic systems is maintained primarily through crop rotations (usually corn-soybeans-oat-alfalfa or some variation of this system) and through applications of composted or raw manure. Seaweed, fish emulsion, or plant/animal-based products, such as alfalfa- and feather-meal, can be applied as soil and foliar amendments in organic systems.

Crop Rotations

For an organic crop to be certified, a crop rotation plan must be in place to protect against pest problems and to maintain soil health. A good general rule is that no more than four out of five years should be in row crops, and it is required that the same row crop cannot be grown in consecutive years in the same field. Legumes (e.g., alfalfa, red clover, berseem clover, and hairy vetch) alone, or in combination with small grains (e.g., wheat, oats, and barley), should be rotated with row crops (corn, soybeans, amaranth, and vegetables) to ensure a healthy system. A typical six-year rotation in Iowa is corn (with a cover of winter rye)-soybeans-oat (with an underseeding of alfalfa)-alfalfa-corn-soybeans. Soybeans fix nitrogen and can generally be grown without fertilizer in the first year. Subsequent crops must include rotations of grain crops and nitrogen-adding cover crops to maintain adequate fertility. Horticultural crops should be rotated with a leguminous cover crop at least once every five years.

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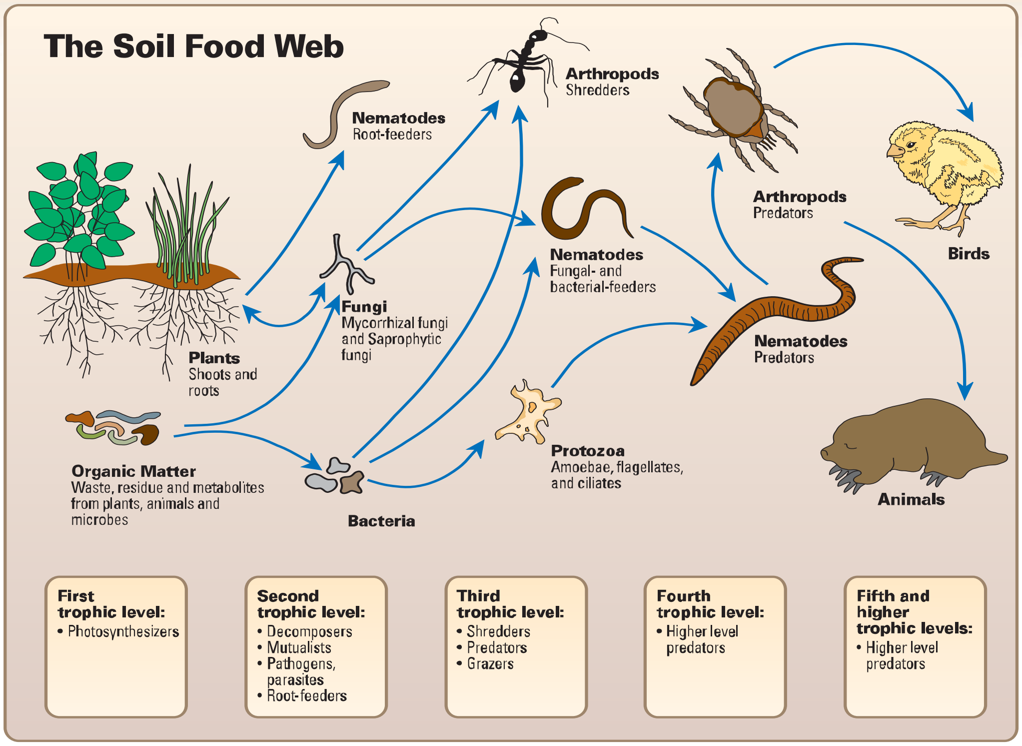
Soil Amendments

Naturally mined lime products are used to adjust the soil pH to within a range of 6.0 to 7.0 (depending on crop requirements). In addition to lime, manure and composted manure are the most common forms of soil amendments in organic operations. Raw manure may be obtained from organic or conventional farms, provided the manure is applied at least 3 months prior to the harvest of an agronomic crop, or at least 4 months prior to the harvest of a horticultural crop. These rules were developed in order to provide adequate time for decomposition of manure and avoid bacterial contamination of produce. To prevent contamination of waterways, raw manure cannot be applied to frozen or snow-covered ground. Organic certification agencies recommend manure should be composted prior to land application (see photo on next page).

Composting is the preferred method of stabilizing manure. Composting is a controlled process in



The basis for all organic farming systems is the health of the soil.

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which nitrogen-containing materials (e.g., manure, yard waste, or kitchen waste) are mixed with a carbon-containing source (e.g., corn stalks or cobs, straw, and wood chips) to produce a mixture preferably with a carbon-to-nitrogen ratio (C:N) of 30 to 1. The compost mixture must reach and maintain a temperature of ≥ 140° F for at least three days during the composting process in order to limit bacterial contamination. Adequate moisture and temperature are required for proper composting. Most organic farmers utilize front-end loaders or windrow turners to construct outdoor composting systems. Other composting systems include vermi-composting

Compost can be made in a 50-gallon barrel, with a front-end loader or with a commercial windrow turner.

(utilization of earthworms in "beds" to decompose manure and other wastes), in-vessel digesters, and anaerobic systems. Additional information on composting practices is listed in the references.

Many soil amendments are available for organic farming. The key, however, is that the material is

naturally based, and that no prohibited substances, such as hexane, are used in the processing or collection of the materials. In addition to manure-based fertilizers, many organic farmers rely on fish emulsion and seaweed preparations to supply nitrogen and other elements. When phosphorus and potassium limit crop production, rock phosphate and naturally mined potassium chloride are allowed. It is imperative that farmers check with their certification agencies before applying any materials. A farmer's certification may be revoked for three years if it is discovered that he or she has applied a material found to be contaminated with prohibited materials.


K. DELATE

Hairy vetch *(Vicia villosa)* and rye can supply up to 120 lb. of nitrogen per acre to crop fields.

Soil Health in Organic Systems

Soil organic matter, created through decomposition and recycling of plant and animal residues, has many important roles in organic systems, including supplying the necessary elements for plant growth. The first step in formation of soil organic matter is fixation of carbon dioxide (CO_2) by plants. Capturing the energy of sunlight and efficiently recycling it through various forms of different soil organic matter is, therefore, a basic goal associated with organic production systems. The soil organic matter or carbon (C) inputs improve soil physical properties, such as aggregate stability, and provide food, habitat, and shelter for billions of soil organisms. Increased aggregate stability, improved soil structure, and surface protection provided by crop residues, manure or compost, and cover crops reduce soil erosion losses and increase water-holding capacity and aeration. Maintaining soil organic matter content at levels that are consistent with the natural characteristics of the soil (i.e., loamy soils will generally have higher organic matter than sandy soils) helps soil biological activity and the healthy microbial and macrofaunal populations that are required for efficient nutrient cycling. These populations include bacteria, fungi, actinomycetes, nematodes, and earthworms. Crop rotations (required for all organic operations) are crucial for organic systems because the legume crops (e.g., alfalfa and red clover) provide nitrogen (N) and also help recycle nutrients, such as phosphorus (P) and potassium (K). Including crops with deep root systems in the rotation helps extract nutrients from lower soil depths and return them to the surface when the vegetation dies. Crop residues also provide the carbonaceous biomass upon which soil microfauna (e.g., earthworms and beetles) and microorganisms depend on for survival.

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Cooperative research by scientists at Iowa State University and USDA-Agricultural Research Service (ARS) is being conducted to evaluate soil quality within organic and conventional crop production systems. After one growing season, several soil quality indicators showed a positive response to organic management (Table 1).

Table 1

First-Year Effect of Organic and Conventional Management Practices on Selected Soil Quality Indicators at the Neely-Kinyon Farm, Greenfield, Iowa

	Carbon Pools[1]			Nitrogen Pools[2]		Other Indicators[3]		
Farming System	**Total**	**POM**	**Biomass**	**PMN**	**NO_3-N**	**WSA**	**EC**	**PH**
	Mg ha^{-1} to 30 cm		kg ha^{-1} to 7.5 cm	kg ha^{-1} to 30 cm		%		dS cm^{-1}
Conventional (n=8)	82.1 a[4]	10.7 a	36.6 b	136 a	29.6 a	20.6 a	240 a	6.4 a
Organic (n=28)	85.0 a	12.1 a	83.2 a	144 a	14.8 b	22.6 a	223 a	6.4 a

[1] POM—particulate organic matter; Biomass—microbial biomass

[2] PMN—potentially mineralizable nitrogen; NO_3-N—nitrate nitrogen

[3] WSA—water stable aggregation; EC—electrical conductivity

[4] Means followed by the same letter are not significantly different at p=0.10.

Soil microbial biomass carbon was 228 percent higher in plots fertilized with compost than in those receiving inorganic N fertilizer. The conventional treatment also had 50 percent higher residual nitrate nitrogen (NO_3-N) and excessive levels of NO_3-N in basal corn stalk samples collected at physiologic maturity. (For more information on corn stalk sampling, see Iowa State University Extension publication PM 1584, *Corn Stalk Testing to Evaluate Nitrogen Management.)*

Soil quality evaluations generally include indicators such as microbial biomass carbon (MBC) and particulate organic matter carbon (POM-C) because these carbon pools are more responsive to changes in soil and crop management practices than total organic carbon. Changes in these indicators occur more quickly because MBC and POM-C are associated with nutrient cycling and turnover throughout the year. Potential nitrogen mineralization (PMN) also showed a slight response (+8 percent) to organic management, which coupled with the lower NO_3-N concentration in the soil, suggests the N applied through compost was being incorporated into biologically active soil organic matter. The 15 percent increase in water stable aggregation (Table 1) also suggests the slight increase in soil organic matter was beginning to have positive effects on soil physical properties.

Relevant Field Research

Organic Soybeans and Cover Crops for Organic Vegetable Production

Building improved soil quality is laudable, but a moot point, if organic production systems are not profitable. Organic soybean production is one of the most lucrative crops for organic farmers in Iowa today. A typical crop rotation that includes organic soybeans is corn followed by a winter cover of rye, soybeans, and oat with an underseeding of alfalfa or red clover in the third year. In the spring, rye that is less than 8" in height can be killed with a field cultivator. If plants are taller, rye should be mowed or cut with a stalk chopper before cultivating. A second cultivation may be necessary if there are remaining rye plants. Sample soil in the fall to determine if soil conditions are adequate for soybean production. Adjustments to a proper soil

Organic soybean production is one of the most lucrative crops for organic farmers in Iowa today.

pH of 6.5 to 7.0 can be made through applications of lime in the fall or spring. Iowa soils usually do not require dolomitic lime. For additional details on organic soybean production, see the Iowa State University Extension publication *Growing Organic Soybeans on CRP Land* (PM 1881).

Cover crops should be grown at least once every five years in certified organic horticultural operations in Iowa. Therefore, to help sustain or improve soil quality and to remain in compliance with the organic standards, many organic farmers rotate to a soil-building legume cover crop after every vegetable crop. Successful cover crops in Iowa include hairy vetch, alfalfa, clover, and medics. The annual legumes typically have 3.5 to 4 percent nitrogen in leaves before flowering and 3 to 3.5 percent at flowering. After flowering, much of the nitrogen is directed to seed production. Therefore, it is recommended that legumes be incorporated at the start of flowering. To estimate nitrogen additions from a cover crop, take cuttings from several areas in the field and dry and weigh them. Use a yardstick or metal frame of set dimensions (e.g., 1 square foot) and clip the plants at ground level. After drying for several days, use the following estimate to determine the per acre yield of dry matter:

$$\text{Yield (lb./acre)} = \frac{\text{Total weight of dried sample (lb.)}}{\text{3 sq. ft. you sampled}} \times \frac{\text{43,560 sq. ft.}}{\text{1 acre}}$$

Divide this quantity from the above equation by 2 if the cover crop will be conventionally tilled or divide by 4 if it is to be left on the surface in a no-till system. To estimate the total N in green manure:

$$\text{Total N (lb./acre)} = \frac{\text{Biomass yield from above calculation}}{\text{(lb./acre)}} \times \frac{\text{\% N (in leaves)}}{100}$$

K. DELATE

Red or crimson clover, in addition to alfalfa, is used as a legume plowdown on many organic farms. To estimate nitrogen additions from a cover crop, follow the instructions on this page.

If sufficient biomass is produced by cover crops, there may be adequate nitrogen for the subsequent crop. If the cover crop growth is limited by poor weather, however, additional nitrogen, from compost or manure, may be needed. Details on cover crop additions can be found in *Managing Cover Crops Profitably* (EDC 201), which is available through Iowa State University Extension.)

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Philosophies in Organic Agriculture

Inputs

Environmental, economic, and food safety concerns are among the many reasons why some farmers choose organic production. Likewise, organic producers differ in the methods they use to achieve the ideal system. Some organic farmers completely shun external inputs, and these farmers enhance the native biological insect control on their farms by conserving beneficial insects' food and nesting sites instead of importing natural pesticides. Compost is created on the farm for their fertilization needs. Other organic farmers do not make a distinction in inputs, and they rely on imported inputs for soil fertility and pest management. This philosophy of "input substitution" is discredited by many long-time advocates of organic agriculture who believe that a truly sustainable method of organic farming would seek to eliminate, as much as possible, reliance on external inputs. Organic certification, however, is based on the use of allowable substances, regardless of their origin.

USDA NRCS

Leaving plant residue from the previous year's crop can increase the level of soil carbon sequestration in organic fields.

Organic Agriculture and Carbon Sequestration

Recently, some world governments have promoted soil carbon sequestration (storage) as a way to help mitigate elevated levels of atmospheric CO_2 caused by burning fossil fuels and other sources of industrial pollution. The use of crop rotations, effective manure management, and green manure crops as required for effective and efficient organic farming are all management practices that can enhance carbon storage in soils. However, tillage practices, which can increase CO_2 emissions, must be considered when evaluating the tradeoffs associated with organic systems and carbon sequestration. Additional information on carbon sequestration can be obtained in the Iowa State University Extension publication *Impact of Tillage and Crop Rotation Systems on Soil Carbon Sequestration* (PM 1871).

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Prepared by Kathleen Delate, Iowa State University;
Cynthia Cambardella and Douglas Karlen, USDA National Soil Tilth Laboratory.

Edited by Jean McGuire, ISU Extension
Continuing Education & Communication Services.

Illustrated by Jane Lenahan.

Designed by Mary Sailer, Spring Valley Studio.

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For the latest on organic agriculture from Iowa State University go to **http://extension.agron.iastate.edu/organicag/.**

Publications mentioned in this booklet can be ordered by contacting any ISU Extension county office or the ISU Extension Distribution Center at (515) 294-5247. There is a charge, plus shipping and handling, for some publications.

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