

# Maintaining Soil Fertility Under an Organic Management System

Prepared by:

Melissa VanTine, *Graduate Assistant in Horticulture*  
and Sven Verlinden, *Assistant Professor of Horticulture*

Work supported by: WVU Extension Service

Tom McConnell, *Extension Farm Management Specialist and Program Leader*

June 2003

## Feed the Soil to Feed the Plant

Growers who wish to certify their produce as organic under the U.S. Department of Agriculture's Final Rule must comply with certain standards when managing their farm's soil. Under the Final Rule, a farmer cannot apply chemically processed fertilizers or amendments for three years prior to certification. Some examples of materials that are prohibited are urea, sewage sludge, and synthetic fertilizers. Instead, farmers must rely on compost, green manures, and mined mineral products to maintain soil fertility. For a complete list of prohibited and allowed substances, go to the USDA's National Organic Program's Web site (<http://www.ams.usda.gov/nop/NationalList/FinalRule.html> ).

In addition in order to maintain the organic label, a grower is required to document his or her soil fertility plan, which includes a five-year farm history with details about pest management, inputs, tillage, crops, and rotations for farm fields. Below is an overview of the composition of soil and how an organic farmer can keep the soil fertile and less prone to erosion.

### Soil Overview

Soil, one of the most important natural resources, is the medium in which our food, clothing and shelter are produced. Soil is a layer of organic and mineral substances covering most of the Earth's surfaces. It is created by a slow, and constant physical and chemical breakdown of rock and the action and turnover of living organisms. It takes approximately 500 years to replace 1 inch of soil by these processes, making it critical to keep the soil fertile and productive as well as to prevent its erosion (Poincelot 2004).

Soil has four main components: mineral, air, water, and organic matter. Minerals comprise 45% of the soil, water and air 50%, and organic matter 2% to 5%. The organic component consists of dead organisms, plant matter and other organic materials in various stages of decomposition. The organic component is important for nutrition because it serves as a reservoir of nutrients for plants and provides nutrients for soilborne organisms. When the organic matter is stable and no longer undergoing decomposition it is called humus. Microscopic organisms are essential to the stabilization of humus and the release of nutrients from organic matter. The release of nutrients from the soil to the plant is an interdependent process relying on the organisms that reside in the soil. These soil-dwelling organisms include earthworms, arthropods, bacteria, fungi, algae, and nematodes. A soil high in organic matter and humus is characterized as having good tilth or soil structure. This type of soil is easy to work and is in overall good health, which encourages the processes necessary to produce a healthy plant.

### Soil Management

The foundation of organic farming lies in the health of the soil. A fertile soil provides essential nutrients to a growing crop plant and helps support a diverse and active biotic community. Strategies the transitional farmer will employ to build the soil are crop rotations, animal and green manures, and cover cropping.

#### Animal manures

Livestock manure traditionally has been used to fertilize soils of both organic and sustainable farms. Manure can be applied to the field in either raw or composted form. The organic farmer must follow the Final Rule's specific requirements for using raw

or composted manure. Raw manure is useful in supplying nutrients and adding organic matter to the soil, as well as encouraging healthy biological processes in the soil. However, it is important to know what is in the manure because some may contain contaminants, and nutrient content varies with the animal, bedding, and storage. It is a good idea to compost manure, because the heat created during composting may kill weed seeds and break down contaminants such as antibiotics. Fresh manure generally will have higher available nitrogen, but overapplications can lead to salt buildup and leaching. A soil test to monitor soil fertility is highly recommended so the farmer can add the right amount of raw or composted manure to plots and avoid nutrient imbalances.

### Cover cropping

A cover crop can be an annual, biennial, or perennial herbaceous plant grown in a pure or mixed stand for all or part of the year. This crop provides soil cover and can help loosen compacted soil through the growth of roots and improved water filtration. Cover crops can maintain or increase soil organic matter if they are allowed to grow long enough to produce high herbage. Cover crops also help prevent soil erosion caused by both water and wind, suppress weeds by keeping the sun from reaching weed seeds, and reduce insect pests and diseases. In addition, a legume used as a cover crop can provide nitrogen to the soil. Nonlegumes can take up excess nitrogen, phosphorus, and potassium from previous crops and recycle them to the following crop. Common cover crops and green manures include rye, buckwheat, hairy vetch, crimson clover, subterranean clover, red clover, sweet clover, cowpeas, millet, and forage sorghums.

### Green manures

When a cover crop is tilled into the soil while it is still lush and green, it is referred to as a green manure. Green manures are important under an organic farming system because they help to add organic matter and nutrition to the soil. When a green plant is incorporated into the soil, it has high amounts of nitrogen and moisture and becomes a food source for soil microorganisms and earthworms. During the process of decomposition by the organisms in the soil, organic matter and nutrients

become available to the crop plants. An additional benefit from using green manures is the suppression of weeds and soilborne diseases. For more information, read "Overview of cover crops and green manures" at ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

### Crop rotations

Many farmers find that rotating crops improves the tilth or aggregation of the soil. Planning a crop rotation requires a farmer to plant crops at different times and in different locations in the same field. Usually, the succeeding crop will be of a different variety and species than the previous crops. Crop rotations can also be used to promote the soil's fertility, reduce erosion, reduce the buildup of pests, and spread out financial risk in case a crop fails. Farmers who include a legume in the rotation can increase the availability of nitrogen in the soil. The rhizobia that form on the nodules of legume roots convert nitrogen from the atmosphere into organic nitrogen, which then becomes available to plants.

### **Required elements for plant nutrition**

Sixteen elements are considered necessary for plant growth. Carbon, hydrogen, and oxygen make up most of the elements in plants and are used in the formation of organic compounds. The other 13 elements are classified as macro- or micronutrients based on the amount found in plants. Macronutrients of greatest concern are nitrogen, phosphorus, and potassium. Other macronutrients include sulfur, calcium, and magnesium. Micronutrients include iron, zinc, manganese, copper, boron, chlorine, and molybdenum.

In general, fertilizers or amendments for organic production must come from natural carbon containing nonsynthetic materials or nonsynthetic inorganic materials. Organic fertilizers usually are needed in larger quantities than conventional fertilizers since they are lower in nutrients. It is good to know the nutrient analysis of the organic fertilizer before its application so that the right amount is applied.

## Nitrogen

The most common sources of nitrogen are from animal manure, either composted or raw, and green manures in the form of legumes that fix nitrogen from the atmosphere. Additional sources of nitrogen include blood meal, fish emulsion, fish protein, kelp and seaweed, and various vegetable meals.

## Phosphorus

Sources include manure, bone meal, fish and poultry meal, and rock phosphate.

## Potassium

Sources include manure, alfalfa meal, kelp meal, greensand, wood ash, potassium sulfate, and granite dust.

## Sulfur

This element is found in rainwater, especially in acid rain. When a farmer uses organic sources of nitrogen, the sulfur requirements are usually met.

## Calcium

Generally supplied through lime applications used to adjust acidic soils. Sources include calcitic lime, and dolomitic lime that also contains magnesium. Other sources include colloidal phosphate, bone meal, gypsum, and wood ashes.

## Magnesium

Sources: Dolomitic lime and langeinitite.

Micronutrients are mostly satisfied through manure, compost, and liming amendments.

## Soil pH

It is important to manage the pH of the soil since it can affect the plant's ability to take up nutrients and the microbial activity in the soil that affects the processes needed for plant nutrition. To correct acidic soil, farmers apply lime based on a soil test. An alkaline soil can be more difficult to correct since adding sulfur to make the soil more acidic is only a temporary remedy and

can be more expensive than liming. When adjusting the pH, it is important to know the crop's pH requirement since different crops grow best at different pH levels. For most crops, optimum pH levels are between 6.0 and 7.0.

## Soil test

Using soil tests and monitoring crop growth will indicate to the farmer what nutrients need to be added to the soil. The soil test is often required for certification. Tissue analysis can complement the soil analysis and offer more clues about the fertilizers that need to be added. There are three sources available to a farmer or grower to get a soil and tissue analysis: a home testing kit, a government or university lab, and a private laboratory.

## Soil Erosion

To keep soil from eroding, farmers employ contour plowing and planting around hillsides instead of planting up and down hills. Strip cropping, in which a row of clover or a row of grasses is planted in strips between crops, can be used to hold water and keep the soil from eroding. Farmers in hilly or mountainous terrain concerned with erosion can terrace their land. Terracing involves building small level patches into the slope and building a wall to keep the soil from being washed away. On treeless plains, farmers plant shelterbelts or wind belts to break the wind speed and decrease wind erosion.

Managing crop residues and preparing seedbeds for planting through tillage can damage the soil structure and lead to an increase in erosion and the loss of organic matter. Tillage smooths the soil surface while incorporating plant residue. In the process, it destroys the soil structure as well as earthworm channels. When the soil structure is damaged, there is a decrease in pore space, which means a decrease in air and water infiltration. Many farmers are switching to conservation tillage methods to manage crop residue and prepare seedbeds by preserving the residue from the previous crop and reducing the number of times equipment passes over a field. For more information about conservation tillage, refer to the Appropriate Technology Transfer for Rural Areas (ATTRA) publication "Pursuing con-

servation tillage systems for organic crop production" ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

#### References and additional information:

Al-Kaisi, Mahdi. 2001. Impact of tillage and crop rotation systems on soil carbon sequestration. Iowa State University Extension.

Gaskell, Mark. 2000. Soil fertility management for organic crops. University of California Division of Agriculture and Natural Resources, publication 7249.

Gershuny, Grace and Smillie, Joseph. 1986. The soul of soil: A guide to ecological soil management, 2<sup>nd</sup> ed. GAIA Services. St. Johnsbury, Vermont.

Kuepper, George. 2001. Pursuing conservation tillage systems for organic crop production. ATTRA. ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

Poincelot, Raymond P. 2004. Sustainable horti-

culture: Today and tomorrow. Prentice Hall, Upper Saddle River, N.J.

Rosen, Carl. 2003. Practical organic soil fertility management. Department of Soil Science. University of Minnesota.

Sandretto, Carmen. 2001. Conservation tillage firmly planted in U.S. agriculture. Agricultural Outlook. Economic Research Service, USDA.

Sullivan, Preston. 2003. Applying the principles of sustainable farming. ATTRA ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

Sullivan, Preston and Diver, Steve. 2001. Overview of cover crops and green manures. ATTRA ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

Sullivan, Preston. 2001. Sustainable soil management. ATTRA ([www.attra.ncat.org/attra-pub/](http://www.attra.ncat.org/attra-pub/)).

Programs and activities offered by the West Virginia University Extension Service are available to all persons without regard to race, color, sex, disability, religion, age, veteran status, political beliefs, sexual orientation, national origin, and marital or family status. Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Director, Cooperative Extension Service, West Virginia University. West Virginia University is governed by the Board of Trustees of the University System of West Virginia.