

THE TENNESSEE VEGETABLE GARDEN

STEWARDSHIP IN SOIL MANAGEMENT

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Vegetable gardening is increasingly popular for Tennessee residents. The value of home gardens includes financial and nutritional benefits from growing fresh vegetables. Gardening activities also enhance personal health and well-being. However, a basic understanding of soils, site selection, and crop maintenance is required before a gardener can take full advantage of the benefits of home vegetable production. To meet these needs, this series of fact sheets has been prepared by UT Extension to inform home gardeners and propel them to success in residential vegetable production.

THE MANY FUNCTIONS OF SOIL

Soil is an amazing combination of minerals, water, air, organic matter and living organisms. It can provide the physical support for plants as well as provide access to water, air and nutrients that are necessary for plant survival, growth and productivity. Much of our success in home vegetable production depends on the proper selection of sites and soil and management of soil nutrients. Those topics are covered in W 346-A “The Tennessee Vegetable Garden: Site Selection and Soil Testing” and W 346-C “The Tennessee Vegetable Garden: Managing Plant Nutrition.” This fact sheet is designed to build upon that information with more in-depth discussions on managing the quality of garden soil.

SOIL STEWARDSHIP FOR QUALITY AND PRODUCTIVITY IN HOME GARDENS

Stewardship is used here to refer to the ability to meet the needs of the present without sacrificing the ability to provide for the needs of the future. In home gardens, appropriate soil management provides important present and future benefits in terms of enhancing soil and water quality.

Soil quality is a description of the ability of soil to fill critical roles in our ecosystem. These include the vital functions of regulating water supplies, providing support and nutrients for plants (and animals), cycling nutrients, and filtering pollutants.



Figure 1. Soil quality and productivity are based on proper physical, chemical and biological functioning of the living, breathing soil illustrated by this image of a high-quality slice of soil. USDA-NRCS image

Soil productivity refers to the capacity of the soil to produce plants. It is important to understand that the productivity of soil is more than the nutrients it contains. Productivity depends on proper physical, chemical and biological functioning. It might be useful to think of soil quality as the cause and soil productivity as the effect. Soil management, whether for one-quarter acre or 1,000 acres, should focus on both soil quality and productivity (Figure 1).

THE CRUCIAL ROLE OF ORGANIC MATTER

One of the most important ways to support soil quality and productivity is to increase organic matter in soil over time. Organic matter is at the heart of stewardship because it impacts many soil properties including:

- Improving water holding capacity.

- Improving nutrient holding capacity.
- Improving soil structure.
- Reducing bulk density and compaction.
- Reducing or preventing soil crusts and increasing water infiltration.
- Increasing soil biological activity and nutrient cycling.

METHODS OF ADDING ORGANIC MATTER TO GARDEN SOIL

CROP RESIDUES

Plant structures remaining after harvest are a significant source of organic material. This residue can be left on the soil surface as a mulch, composted or incorporated into the soil. These options all have positive and negative aspects. Leaving plant residues on the surface protects the soil

from erosion and supports earthworm populations. However, pests and disease can overwinter in the debris, so pest survival often can be reduced by incorporation. Nonetheless, turning crop residues under also causes them to break down faster, which may speed nutrient release. Quicker release of nutrients could mean that they are less available later in the growing season when most needed by plants. Also consider that it may be best to remove crop debris entirely if disease levels were high in the crop during the growing season. When deciding whether to incorporate residues, consider both the need to protect the soil surface (and whether cover crops will be used) and the potential for pest and disease impacts (see UT Extension W 316 “Home Vegetable Garden Disease Control”).

MANURE

Manures have long been used to enhance soil quality and productivity. In addition to providing organic matter, they also supply nutrients. However, there are challenges in directly using manures in vegetable gardens.



Figure 2. Finished compost will smell “earthy”, be cool or only slightly warm, and the original composted materials will not be distinguishable. USDA-NRCS image

One issue is the composition of the manure. Unlike purchased fertilizers, these materials often differ in nutrient content. Also, fresh manure can have such high levels of nutrients that plants can be damaged. High nutrient content also means manures may present risks of rapid nutrient losses due to volatilization (nitrogen loss to the air) or leaching in subsequent rains.

When manures with large amounts of hay or straw bedding are added directly to soil, the breakdown of organic matter can pull nutrients from soils and slow crop growth if not properly managed (see below). They can also contain weed seeds or herbicide residues if animals were fed pasture that had been treated with certain herbicides (see additional resources for specific products). Additionally, pathogens can be present in manures that can pose a food safety risk when used for fresh vegetables. To address these concerns, it is best to confirm sources and feed material of animals producing the manure and properly and completely compost before use in gardens.

COMPOST

Compost can be purchased or produced at home. If purchased, care should be taken to use a source that has consistent quality and is free from weed seeds, pathogens or herbicide residues that could impact soils and crops.

Residential composting can combine a sustainable cycling of plant residues and food waste with the need for nutrients and organic materials to enhance soil quality and plant nutrition in the home garden. Composting is essentially the management of biological breakdown processes to ensure a stable and safe product. Please reference UT Extension PB 1479 “Composting Yard, Garden and Food Wastes at Home” for more complete instructions on home composting.

Only stable (or finished) compost that is cool or only slightly warm, smells earthy, and does not contain identifiable original material should be added to the garden (see Figure 2). A critical aspect of the composting process is the carbon (C) to nitrogen (N) ratio of the initial material. Woody

materials (paper, bark, wood chips, straw, sawdust—sometimes called “browns”) have mostly C with little N, resulting in a high C to N ratio. Green materials and manures have more N and thus a lower C to N ratio. The balance between C and N controls the speed of breakdown. If too much C is present, there will not be enough N in the soil to support microbes. This is an important concept for gardeners to understand because adding too much “browns” with high C organic matter directly to your garden will create demand for N as microorganisms rapidly reproduce and break down those materials. This can pull nutrients away from crops and damage productivity in addition to slowing down decomposition. Conversely, adding materials that are too high in N content can increase the likelihood of nutrient losses and runoff as N is released faster than plants can take it up. As with composting, it is important to balance browns and greens to target the optimal C to N ratio.

Keep in mind that not all composts are equal. If not produced at home, inquire about the materials used to

produce the compost. If composted animal wastes were used, be aware of the soluble salts content, which can be higher than in compost from plant waste. Frequent applications of compost over many years will impact the pH and nutrient availability in your garden soil. Use consistent soil testing to ensure that an oversupply of specific nutrients is not occurring. Compost is an excellent tool to address organic matter needs in the home garden, but additional tools may be needed to ensure soil quality and productivity.

COVER CROPS

Cover crops (i.e., those planted when the soil would otherwise be bare between crops or growing seasons) are plants grown for their contribution to soil, water and plant relationships as well as pest, pathogen and weed management. These crops can provide a range of benefits:

- Enhance soil structure through organic matter additions and actions of cover crop roots.
- Reduce compaction through organic matter addition and cover crop rooting.
- Increase water infiltration through organic matter addition and surface cover (prevention of crusting).

- Reduce soil erosion (especially in the winter when soil would be bare).
- Enhance nitrogen cycling by reducing leaching (holding N in plants instead of allowing it to move with water through the soil).
- Potential reduction in weed growth.
- Potential suppression of insects and diseases.
- Production of nitrogen (legumes).

Both legumes and non-legumes are used as cover crops. Legumes (peas, beans, clover, vetch, alfalfa) have root nodules that contain N-fixing bacteria. Nitrogen fixed by these plants is assimilated into their tissues and will be available for later crops after the legume is killed and incorporated into the soil. Legumes may also have deep roots, which improve soil drainage and bring up nutrients from the subsoil to enable access by shallow-rooted plants. Non-legumes used as cover crops are mostly grasses that are often grain crops if grown to maturity. They are grown because they are economical, easily established, and can produce large amounts of plant material in a relatively short period of time. These crops stabilize the soil, prevent erosion, and help break some plant disease or pest cycles in addition to increasing

organic matter. Examples include rye, oats and wheat. Buckwheat, rape and radishes are examples of cover crops that are neither a grass nor a legume. These crops can increase organic matter and improve soil structure. They also assist with disease management because some have biofumigation (potential for decomposing tissue to suppress pests or disease in the soil) when incorporated into garden soil.

There are three common methods of using cover crops in the vegetable garden. The most common practice is using cover crops as green manures. This means that the cover crop is sown, allowed to grow, and then killed and tilled into the soil. This practice adds both nutrients and organic matter to the soil. Often mixtures of cover crops are planted that provide benefits of both legumes and non-legumes. For instance, a rye/vetch mixture could provide quick cover and high levels of plant material to incorporate while also providing nitrogen and deep rooting from the legume. Green manures can be used as an overwintering cover crop (see Figure 3) or a summer cover planted during the main growing season (see Figure 4).

The second, killed mulch, means that a cover crop is sown and grown much in the same way as a green manure.



Figure 3. A cover crop in spring that was seeded in a garden raised bed the previous fall. Cereal crops (rye) and legumes (vetch, peas), were seeded together in this bed.



Figure 4. A summer cover crop of buckwheat that was seeded between spring and fall cool-season vegetable crops.

However, instead of tilling into the soil, the plant is killed and left on the soil surface as a mulch. In this manner, organic matter can be slowly added to the soil while reducing weed growth and protecting the soil surface from erosion. See additional resources at the end of this publication for additional information on management of cover crops.

The third way to use a cover crop is as a living mulch grown with the main crop. These living mulches, such as white clover, can block weed growth, reduce erosion, and add organic matter to the soil. Living mulch crop species

must be carefully selected so that they will not detrimentally compete with the main crop for water and nutrients.

CAN THERE BE TOO MUCH OF A GOOD THING?

This discussion has focused on the many beneficial roles of organic matter in soil and the importance of maintaining and increasing it. However, it is important to understand that for most of our soils in Tennessee, the percentage of organic matter in a high-quality garden soil will generally be less than 5 percent. Our intent in adding

organic matter is to enhance the quality and productivity of native soil.

Keep in mind that organic matter is optimally enhanced over time. When gardeners rapidly add large amounts of organic matter, often through compost, the balance of nutrients may be disrupted. Excessive phosphorus is one possible result. In addition to increasing the possibility of loss to the environment, excessive levels of some nutrients can create issues in uptake of other nutrients. So, practice patience and moderation in building the soil quality in your garden.

Crop	Type	Common sowing time	Incorporation time
<i>Crimson clover (Trifolium incarnatum)</i>	Legume	Fall or spring	Fall or spring
<i>White clover (Trifolium repens)</i>	Legume	Year-round	Varies, often used as a perennial living mulch
<i>Hairy vetch (Vicia villosa)</i>	Legume	Fall or spring	Fall or spring
<i>Wheat (Triticum aestivum)</i>	Non-legume grain	Fall	Spring
<i>Oats (Avena sativa)</i>	Non-legume grain	Fall or spring	Spring, fall, or summer
<i>Winter rye (Secale cereale)</i>	Non-legume grain	Fall	Spring
<i>Buckwheat (Fagopyrum esculentum)</i>	Non-legume	Late spring or summer	Summer or fall
<i>Annual ryegrass (Lolium multiflorum)</i>	Non-legume grass	Fall	Spring
<i>Rape (Brassica napus)</i>	Non-legume	Fall or spring	Summer or fall
<i>Forage radish (Raphanus sativus)</i>	Non-legume	Fall	Spring

Table 1. Vegetable crops categorized by their need for vertical support in raised beds.

CROPPING AND TILLAGE PRACTICES

CROPPING AND NUTRIENT MANAGEMENT

Managing garden soil requires consideration of current soil conditions, crops and production seasons. One of the most basic cropping decisions is how to schedule plantings in space and time. Crop rotations can reduce disease risks (see W 316) in many crops and help in more effectively utilizing soil nutrients.

Regardless of cropping sequences, vegetable production is an intensive management system. Furthermore, when season extension is practiced (see W 346-F “The Tennessee Vegetable Garden: Season Extension Methods”), gardeners may be growing and/or harvesting crops year-round. Good management of soil nutrients is essential to maintain productivity for crops over many years in a home garden.

Nutrients can be applied through organic matter additions, such as compost, or organic and chemical fertilizers. Each gardener should decide the fertilizer materials they are comfortable with in their own gardening system. Regardless of the specific fertilizer selected, it is best to consider garden management methods that address both organic matter and soil nutrients. Many gardeners find that managing organic matter over time can reduce the need for fertilizer additions in their gardens because organic matter both supplies plant nutrients and helps keep them around longer to be used by the vegetable crops.

TILLAGE PRACTICES

Vegetable gardeners commonly use tillage to maintain air circulation, reduce weed pressure, and incorporate composts and plant residues in the soil. Tilling certainly can incorporate organic matter, but it also exposes organic matter to loss by rapidly increasing

microbial activity. Frequent tillage can lead to a reduction in organic matter percentage over time without the addition of composts and/or cover crops. A low percentage of organic matter can reduce the amount of nutrients and water available for the vegetable crops to take up.

Tillage also impacts soil structure, or how the components of soil are grouped together. While tillage can be used to circulate air in the soil, it does break the soil down into smaller pieces and reduces the larger pores and water channels in soil created by earthworms and plant roots. Organic matter reductions can also contribute to reduced structure in soil. Gardeners can reduce tillage in traditional gardens through use of mulches and cover crops to reduce weed issues and add organic matter. However, soils will warm up slower in the spring in no-till gardens. A lack of tillage can also mean some soils may not have good air circulation if poorly drained or compacted. No-till management is quite common in raised beds. Because of faster drainage and soil warming in spring, raised beds can reduce some of the drawbacks of no-till methods.

These facts illustrate the complexities of soil management. Many lawns, landscape beds or fruit production areas are rarely tilled. In these areas, tillage may be justified when used prior to planting to incorporate organic matter, lime and other materials. In vegetable gardens, tilling will have more impact because it often occurs multiple times each year. The need for weed control and organic matter

incorporation should be balanced with the drawbacks of frequent tillage in building soil organic matter and structure. Different soils will require a different balance of techniques.

USE OF ORGANIC FERTILIZERS

Vegetable gardeners can use chemical or inorganic fertilizers or organic fertilizers to supply plant nutrients. Chemical fertilizers are formed using industrial processes or are mined from deposits in the earth and then purified, mixed, and blended for ease of handling and application. See W 346-C “The Tennessee Vegetable Garden: Managing Plant Nutrition” for information on the use of inorganic fertilizers.

Organic fertilizers described in Table 2 include materials that fit the scientific definition of organic (containing biological carbon), such as fertilizer materials that are from previously living things (composts; manures; and bone, feather or blood meal). Table 2 also includes some mined natural materials that are commonly used in certified organic production. Organic fertilizers provide the same nutrients to plants as chemical fertilizers, but may be available more slowly because microbes are needed for conversion to forms that can be readily taken up by plants. The slower release of nutrients from organic fertilizers can be a drawback, but it also can reduce

Material	Nutrient applied
<i>Blood meal, feather meal</i>	<i>Nitrogen</i>
<i>Fish meal</i>	<i>Nitrogen (some phosphate)</i>
<i>Cottonseed or soybean meal</i>	<i>Nitrogen (some phosphate)</i>
<i>Bone meal</i>	<i>Phosphate (some nitrogen)</i>
<i>Rock phosphate</i>	<i>Phosphate</i>
<i>Greensand</i>	<i>Potassium</i>
<i>Kelp products</i>	<i>Potassium (some nitrogen), trace minerals</i>

Table 2. Common organic fertilizer materials and main nutrients provided

nutrient leaching (when water moves through the soil and takes nutrients along with it). Organic fertilizers often contain lower nutrient percentages by weight, so more may be needed to supply the same amount of nutrients compared to chemical fertilizers. However, the addition of organic matter to the soil is an added benefit not provided by chemical fertilizers.

Soil tests provide recommendations for nutrient additions needed for home gardens (see W 346-A and W 346-C for additional information on taking and interpreting home garden soil tests). The soil test report will list recommended amounts of N, P and K, and this information can be useful for both inorganic and organic fertilizers. A couple of simple calculations will be needed to determine the correct amount of fertilizer.

1. (Area of the garden/area used in the recommendation) x recommended amount of nutrient from the soil report = amount of nutrient needed for garden area

2. Amount of nutrient needed for garden area/percentage of nutrient in fertilizer = fertilizer needed for the garden

An example is provided below:

The soil test report recommends applying 2 pounds of N per 1,000 sq. ft., and the garden is 500 sq. ft. (20 x 25 ft).

First, divide the planting area size by 1,000 sq. ft. (as used in the recommendation) and then multiply by 2 (the recommended lb N from the soil test) to determine the pounds of N needed in the entire area.

Equation 1:
(500 sq. ft./1000 sq. ft.) x 2 lb N = 1 lb N for the 500 sq. ft. garden

Second, divide the amount of N needed for the area by the amount of N in the fertilizer.

These calculations can be used for any fertilizer material (bone meal, blood meal, fish meal, cottonseed meal,

compost, etc.) for which nutrient values are known. For instance, an example is provided here of using an organic blood meal fertilizer with a guaranteed analysis of 12 percent N. Equation 2 will calculate the weight needed in the garden area.

Equation 2:
1 lb N/ 0.12 (12% N in fertilizer) = 8.33 pounds of 12% N blood meal is needed in a 500 sq. ft. garden to provide the recommended N*

*Keep in mind that organic fertilizers must be broken down by soil microorganisms to enable nutrients to become available to plants. These biological processes are slower and less predictable than nutrients from a chemical fertilizer. However, this slower release does NOT mean that more fertilizer should be added than is needed to supply the nutrients. Overuse of organic nutrient sources can be cost ineffective as well as leading to leaching and runoff to our surface waters.

TESTING FOR SOIL ORGANIC MATTER

The term organic matter has been used here to broadly describe formerly living materials added to soil. In reality, there are different classifications of soil organic matter (SOM). Green manures and raw materials in compost are fresh sources of organic matter that microorganisms break down rapidly (decompose). In fact, a large percentage of the volume of this material will be lost during the process of decomposition or composting. The process of decomposition converts this green fraction into carbon dioxide or more stable decomposition products. A second fraction of SOM is the microbes themselves. Even though these organisms are mostly single-celled, billions of them can be found in every teaspoon of soil, so they represent a significant amount organic matter in soil. The third fraction is the most stable and difficult to break down, and will exist for years or decades without little change. This SOM is called humus,

and is made up of materials that are resistant to microbial degradation. Stable SOM is extremely valuable in enhancing soil properties. Many of the water and nutrient holding impacts of organic matter are provided by SOM. However, even though this fraction is considered stable, it, too, will be decomposed slowly over time by soil microorganisms.

The next important question is whether SOM can be assessed and changes recommended as is done for soil nutrients. SOM can be described by laboratory tests, and this technique is used by the UT Soil, Plant and Pest Center. However, there are valid reasons that no recommendations are currently provided with SOM tests. Soil texture, vegetation, climate and many other factors, including human management, impact the level of organic matter in soil. Additionally, there are currently no well-described minimum levels of SOM below which crops and plants suffer. So, organic matter testing can be used as an indicator that management is supporting SOM increases in soil over the long term, but recommendations for improving organic matter or target levels are not currently provided.

ADDITIONAL RESOURCES

UT Extension publication W 235-G “Cover Crops and Green Manures.”
extension.tennessee.edu/publications/Documents/W235-G.pdf

UT Extension publication W 235-I “Fall Cover Crop Selection and Planting Dates in Tennessee.”
extension.tennessee.edu/publications/Documents/W235-I.pdf

UT Extension publication W 316 “Home Vegetable Garden Disease Control.”
extension.tennessee.edu/publications/Documents/W316.pdf

North Carolina State Cooperative Extension publication Herbicide carryover in hay, manure, compost, and grass clippings.
content.ces.ncsu.edu/herbicide-carryover

Cornell blog with information on using cover crops in the home garden.
blogs.cornell.edu/gep/blog/



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W 346-G 10/16 17-0033