Colorado Master Gardener[sm] Program
Colorado Gardener Certificate Training
Colorado State University Extension

GardenNotes #711

Vegetable Garden:
Soil Management and Fertilization

In the garden, managing soils to improve ***tilth*** and garden ***fertilization*** are related but not necessarily the same process. For example, compost or manure may be added as a soil amendment to improve tilth; however, they will add nominal amount of plant nutrients. A manufactured fertilizer may be added to supplement soil fertility levels, but it will not improve a soil's tilth. For optimum yields and quality, gardeners need to pay attention to both soil management for improving tilth and soil fertilization.

> ***Tilth*** is a term related to the suitability of a soil to support plant growth. Technically speaking, tilth is "the physical condition of soil as related to its ease of tillage, fitness of seedbed, and impedance to seeding emergence and root penetration".

Soil Amendment or Fertilizer

The term ***soil amendment*** refers to any material mixed into a soil. By law, soil amendments make no legal claims about nutrient content or other helpful (or harmful) properties. Compost and manure are common soil amendments used to improve soil tilth. They may also supply nominal amounts of plant nutrients. Some of the nutrient effect seen from adding soil amendments is likely due to their effect on soil microorganisms. The

organic material in soil amendments is a food source that allows microorganisms to multiply. The larger numbers increase the conversion of nutrients already in the soil to plant usable forms.

Mulch refers to a material placed on the soil surface.

By law, the term ***fertilizer*** refers to a material that guarantees a minimum percentage of nutrients (at least the minimum percentage of nitrogen, phosphate, and potash). An ***organic fertilizer*** is derived from natural sources and guarantees the minimum percentages of nitrogen, phosphate, and potash.

Soil Amendments

In the vegetable garden, the routine addition of organic soil amendments such as compost will optimize potential yields and quality. The goal in soil management is to increase the organic content to 4-5%, over a period of years.

Common amendments include compost, manure, compost made with manure, fall leaves, straw, and peat moss. Home compost has the advantage that the gardener controls what goes into the compost, reducing problems with salts, weed seeds, and plant diseases.

Another method to add organic matter is to replant the fall garden with a green manure crop such as winter rye or Austrian peas. Some of these cover crops fix small amounts of nitrogen in their roots that is tilled into the soil for plant use.

How Organic Amendments Improve the Soil

On clayey soil, organic matter (over a period of years) glues the tiny soil particles together into larger aggregates, increasing pore space. This increases soil oxygen levels and improves soil drainage, which in-turn increases the rooting depth allowing roots to readily reach a larger supply of water and nutrients.

On sandy soils, organic matter holds over ten times more water and nutrients than the sand.
Organic matter also encourages the beneficial activity of soil organisms and helps remediate soil compaction.

Application

General application rates for compost or other organic soil amendments are based on the salt content of the materials and soil and on the depth to which it is cultivated into the soil. Ideally, cultivate the soil amendment into the

top six to eight inches of the soil. On compacted/clayey soils, anything less can lead to a shallow rooting system with reduced plant growth, lower vigor, and lower stress tolerance.

Table 1 gives standard application rate for compost. Compost made solely from plant residues (leaves and other yard wastes) is basically free of salt problems, and higher application rates are safe.

Table 1. Routine Application Rate for Compost

Site	Incorporation Depth[2]	Depth of compost before incorporation[1]	
		Plant Base Compost and other compost known to be low in salts[3]	**Compost made with manure or biosolids** for which the salt content is unknown[4]
One-time application—such as lawn area	6-8”	2-3”	1”
	3-4”	1-1½”	½”
Annual application to vegetable and flower gardens – **first three years**	6-8”	2-3”	1”
	3-4”	1-1½”	½”
Annual application to vegetable and flower gardens – **forth year and beyond**	6-8”	1-2”	1”
	3-4”	1”	½”

1 3 cubic yards (67 bushels) covers 1,000 square feet approximately 1 inch deep.

2 Cultivate compost into the top 6-8 inches of the soil. On compacted/clayey soils, anything less may result in a shallow rooting depth predisposing plants to reduced growth, low vigor and low stress tolerance. The 3-4” inch depth is shown as an illustration of how application rates need to adjust when the deep cultivate is not practiced.

3 Plant based composted are derived solely from plant materials (leaves, grass clippings, wood chips and other wards wastes). Use this application rate also for other compost known, by soil test, to be low in salts.

4 Use this application rate for any compost made with manure or biosolids unless the salt content is known, by soil test, to be low. Excessive salts

Compost, which includes manure or biosolids as a component, has a potential for high salts. Excessive salt levels are common in many commercially available products sold in Colorado. On compost made with manure or biosolids, application rate is limited unless a soil test on that batch of product shows a low salt level. An amendment with up to 10 dS/m (10 mmhos/cm) total salt is acceptable if incorporated six to eight inches

deep in a low-salt garden soil (less than 1 dS/m or 1 mmhos/cm). Any amendment with a salt level above 10 dS/m (10 mmhos/cm) is questionable.

> Note: dS/m or mmhos/cm is the unit used to measure salt content. It measures the electrical conductivity of the soil.

Compost need to be thoroughly mixed into the upper six to eight inches of the soil profile. Do not leave compost in chunks, as this will interfere with root growth and soil water movement.

As the soil organic content builds in a garden soil, the application rate should be reduced to prevent ground water contamination issues. A soil test is suggested every four to six years to establish a base line on soil organic matter content.

If using a green manure cover crop, till the cover crop in before it reaches four inches in height.

In the vegetable garden do not plow in woody materials such as bark or wood chips. They may interfere with seedbed preparation and may result in soil nitrogen depletion.

Precautions When Using Compost and Manure

Manure, compost made from manure, and bio-solids may be high in salts that will interfere with crop growth. Do not add more than one inch per season without conducting a soil test to evaluate potential salt build-up.

Due to a health issue (*E coli* contamination), fresh manure additions should be made at least four months prior to the harvest of any edible crops. In other words, apply fresh manure only in the fall after crops are harvested.

Fresh manure or unfinished compost products may be high in ammonia. Avoid application of products with an ammonia smell; they could burn roots and leaves. Manure and compost may be source of weed seeds.

Nutrient Release Rates from Compost and Manure

Gardeners need to understand that the nutrient release from compost and manure is slow, taking years. Adding compost or manure to improve soil tilth is not the same as fertilizing.

The typical nitrogen release rates from manure is only 30% to 50% the first year (fresh manure), 15% to 25% the second year, 7% to 12% the third year, 3% to 6% the fourth year, and so on. With compost and composted manure, the release rate is even slower, 5% to 25% the first year, 3% to 12% the second year and 1% to 6% the third year.

Since the nitrogen percentage of compost and manure products is typically only 2% to 4%, the amount of actual nitrogen release to support crop growth is very small.

For soil with 4% to 5% organic matter, the mineralization (release) of nitrogen from soil organic matter will likely be sufficient for crop growth.

For soils with 2% to 3% organic matter, the mineralization of nitrogen from soil organic matter will not likely be sufficient for heavy feeding vegetable crops. Supplement with 0.1 pound nitrogen fertilizer per 100 square feet.

For the typical garden soil with 1% organic matter or less, the mineralization of nitrogen for soil organic matter will be minimal. Add 0.2 pounds of nitrogen fertilizer per 100 square feet.

Fertilization

Soil fertilization is the addition of soil nutrients to support crop growth. While some soil amendments add small amounts of nutrients, amending the soil to improve soil tilth is not the same as amending the soil to provide nutrients.

Manufactured fertilizers are popular with gardeners because they are readily available, inexpensive, easy to apply, and generally provide a quick release of nutrients for plant growth. Application rates for any fertilizer depend on the content and the amount of nutrient to be applied. **In products containing multiple nutrients, the application rate is always based on the nitrogen content.**

Nitrogen Applications

Nitrogen is the nutrient needed in largest quantities by plants and the one most frequently applied as fertilizer. It is annually applied in the form of manufactured fertilizer, organic fertilizers, and/or organic soil amendments. **Application rates are critical, because too much or too little directly impacts crop growth**.

The standard annual application rate for home vegetable gardens is 2 pounds actual nitrogen per 1,000 square feet (0.2 pound actual nitrogen per 100 square feet). When organic matter is supplied, adjust the rate accordingly to account for nitrogen released by the organic matter. [Table 2]

Manufactured nitrogen fertilizer can be broadcast and watered in, or broadcast and tilled into the top few inches of soil. It can be banded 3-4" to

the side of the seed or plant row. Do not place the fertilizer in the seed row or root injury will occur. Some fully soluble types are applied in the irrigation water. "Organic" nitrogen fertilizers are typically tilled in or some can be applied in irrigation water.

Table 2. Standard Nitrogen Fertilizer Application Rates for Gardens

	Soil Organic Content		
	Typical garden soil low in organic matter (1% organic matter)	Moderate level of organic matter (3% organic matter)	High level of organic matter (5% organic matter)
Nitrogen needed	**0.2 lb. actual N per 100 sq. ft.**	**0.1 lb actual N per 100 sq. ft**	**0**
Fertilizer examples			
Ammonium sulfate 21-0-0	1 lb. fertilizer per 100 sq. ft (approx. 2 cups)	0.5 lb. fertilizer per 100 sq. ft (approx. 1 cup)	0
OR			
Ammonium nitrate 34-0-0	0.6 lb. fertilizer per 100 sq. ft. (approx. 1 1/3 cups)	0.3 lb. fertilizer per 100 sq. ft (approx. 2/3 cup)	0
OR			
Urea, 45-0-0	0.4 lb. fertilizer per 100 sq. ft. (approx. 1 cup)	0.2 lb. fertilizer per 100 sq. ft (approx. ½ cup)	0

Starters Fertilizers

In setting out transplants, starter solutions often promote early growth. Because transplants have been hardened-off (growth slowed to prepare the plant for movement to the exposed, windy, outdoor environment), the nitrogen in the starter solution gives the signal to resume active growth. Since phosphorus is less available in cold soils, phosphate may also be helpful in spring and before soils have thoroughly warmed.

A starter fertilizer is any water-soluble fertilizer added to the irrigation water. Common examples include MiracleGro, Peters, Schultz Plant Food, Fertilome Root Simulator and Plant Starter Solution, etc. They generally contain ammonium nitrate since it is readily usable by the plant. Some products claim that vitamins or hormones promote plant growth. These claims are not supported by research findings.

Nitrogen "Side Dressing"

Plant need for nitrogen varies. Beans, peas, tomatoes, and vine crops (cucumbers, squash, pumpkins, and melons) are examples of vegetables with a lower need for nitrogen. High nitrogen promotes excessive growth of the plant at the expense of fruiting.

Crops such as potatoes, corn, and cole crops (broccoli, cauliflower, cabbage, and kale) use large amounts of nitrogen and need supplemental applications during the growing season (referred to as ***side dressing***). For example, home garden potatoes often show nitrogen deficiency from August into fall. Symptoms start as a yellowing of lower leaves and progress into a general browning and dieback of the vine. When nitrogen stress hits, potatoes become more susceptible to diseases, including early blight and verticillium wilt. [Table 3]

Fertilizers commonly used in the home garden for side dressing include ammonium sulfate, ammonium nitrate, and water-soluble fertilizers such as MiracleGro, Peters, etc. Phosphate and potash fertilizers are best added in the spring or fall, when they can be cultivated into the soil.

Table 3. Nitrogen Side Dressing of Vegetable Crops

Vegetable	**Timing**	**Application Rate** (Based on rate of 0.1 lbs. actual N per 100 square feet)		
		Ammonium sulfate 21-0-0	Ammonium nitrate 34-0-0	Water soluble fertilizers
Asparagus	1) early spring 2) at end of harvest season	0.5 lbs. fertilizer per 100 sq. ft. (approximately 1 cup) Sprinkle over soil and water in, OR place in furrow to side of plant. CAUTION: an over application will burn roots, stunting or killing plants.	0.3 lbs. fertilizer per 100 sq. ft. (approximately 2/3 cup) Sprinkle over soil and water in, OR place in furrow to side of plant. CAUTION: an over application will burn roots, stunting or killing plants.	See label of specific product. Water soil with fertilizer added to water. Low burn potential, but significantly more expensive.
Sweet Corn	1) 12" tall 2) one month later			
Leafy green vegetables	3-4 weeks after emergence			
Onions	3-4 weeks after emergence			
Potatoes	Late-July to early-August			
Tomatoes, peppers, and eggplants	First fruits 1" diameter			
Cole crops (broccoli, cabbage, cauliflower)	1) 2-3 weeks after transplanting 2) 4-5 weeks after transplanting			See label for specific product.

Phosphorus and Potassium Applications

A soil test is the best method to determine the need for phosphate and potash. With a fertilizer containing nitrogen and phosphate and/or potash, the application rate is always based on the nitrogen percentage because nitrogen is most critical to plant growth.

Phosphate and potash fertilizers are best applied in the spring or fall, when they can be tilled into the soil

Phosphorus

Phosphate levels are adequate in the majority of established Colorado gardens. Deficiencies are most likely to occur in new gardens where the organic matter content is low and in soils with a high pH (7.8 to 8.3). Excessive phosphorus fertilizer can aggravate iron and zinc deficiencies and increase soil salt content.

Routine application of compost or manure will supply the phosphorus needs in most garden soils in Colorado.

Where phosphorus levels are believed to be low, the standard application rate without a soil test is ¼ to 1-pound triple super phosphate (0-46-0) or ammonium phosphate (18-46-0) per 100 square feet.

Potassium

Potassium levels are naturally adequate to high in most Colorado soils. Deficiencies occasionally occur in new gardens low in organic matter and in sandy soils low in organic matter. Excessive potash fertilizer can increase soil salt content.

Routine applications of compost or manure will supply the potassium needs for most garden soils in Colorado.

Where potash levels are believed to be low, the standard application rate without a soil test is ¼ to ½ pound potassium chloride (0-0-60) or potassium sulfate (0-0-50) per 100 square feet.

Managing Soil Compaction

On clayey soils, soil compaction is a common problem limiting crop growth potential. Soils are typically compacted in the construction process. Walking on wet soils, cultivating wet soils, and the impact of rain are other common forces compacting soils.

The following are suggested to help minimize soil compaction in the garden:

- Add organic matter to clayey soils.
- Avoid cultivating or working a clayey soil when wet. To evaluate, squeeze a handful of soil. Then try to crumble it. If it will crumble, it can be worked. If it will not crumble but stays in mud balls, it is too wet to be worked.
- Avoid cultivating other than to prepare a seed bed or till in organic matter and fertilizers. For weed control, use a mulch, hand removal, or shallow cultivation only.
- Use a raised bed with established walkways, and avoid walking on the growing bed.
- Mulch the soil, year round, to minimize the compaction forces of rain and sprinkler irrigation. This also helps manage weeds and reduces irrigation need.

Additional Information – *CMG GardenNotes* on Soils, Fertilizers, and Soil Amendments:

#211	The Living Soil	#223	Iron Chlorosis
#212	Earthworms	#224	Saline Soils
#213	Managing Soil Tilth	#231	Plant Nutrition
#214	Estimating Soil Texture	#232	Understanding Fertilizers
#215	Soil Compaction	#233	Calculating Fertilizer Rates
#216	Mulching with Wood/Bark Chips, Grass Clippings and Rock	#234	Organic Fertilizers
		#241	Soil Amendments
#217	Soil Drainage	#242	Using Manure
#221	Soil Tests	#243	Using Compost
#222	Soil pH	#244	Cover Crops and Green Manure Crops

Authors: David Whiting, Carol O'Meara and Carl Wilson; Colorado State University Cooperative Extension

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