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

GardenNotes #241

Soil Amendments

Outline:

Terms

The term ***soil amendment*** refers to any material mixed into a soil. ***Mulch*** refers to a material placed on the soil surface. By legal definition, soil amendments make no legal claims about nutrient content or other helpful (or harmful) effects it will have on the soil and plant growth. In Colorado, the term ***compost*** is also unregulated, and could refer to any soil amendment regardless of microorganism activity.

By legal definition, the term ***fertilizer*** refers to a soil amendment that guarantees the minimum percentages of nutrients (at least the minimum percentage of nitrogen, phosphate, and potash).

An ***organic fertilizer*** refers to a soil amendment derived from natural sources that guarantees the minimum percentages of nitrogen, phosphate, and potash. These should not be confused with products approved for use by the ***USDA National Organic Program***. The federal Certified Organic Label, USDA Organic, allows only certain regulated products as listed by the Organic Materials Review Institute (OMRI). For additional information on certified organic soil amendments and fertilizers, refer the web site at www.omri.org.

Many gardeners apply *organic soil amendments*, such as compost or manure, which most often do not meet the legal requirements as a "fertilizer" and generally add small quantities of plant nutrients.

Managing Soil Texture and Structure

Routine applications of organic matter should be considered an essential component of gardening and soil management. Organic matter improves the water and nutrient holding capacity of coarse-textured sandy soil. On a fine-textured clayey soil, the organic matter over time glues the tiny clay particles into larger chunks or *aggregates* creating large pore space. This improves water infiltration and drainage, air infiltration (often the most limiting aspect of plant growth), and allows for deeper rooting depths (allowing the plant to tap a larger supply of water and nutrients). For additional discussion, refer to the CMG GardenNotes #213, *Managing Soil Tilth*.

Using ***organic soil amendments*** is a great way to turn otherwise useless products, like fall leaves and livestock manure, into compost for improving soil tilth.

When using organic soil amendments, it is important to understand that only a portion of the nutrients in the product are available to plants in any one growing season. Soil microorganisms must process the organic compounds into chemical ions (NO_3^-, NH_4^+, HPO_4^{-2}, $H_2PO_4^-$, K^+) before plants can use them.

Cultivate or hand-turn the organic matter thoroughly into the soil. Never leave it in chunks as this will interfere with root growth and water movement.

Selecting a soil amendment

For details on selecting a soil amendment, see the CSU Extension Fact Sheet #7.235, *Choosing a Soil Amendment.*

In selecting soil amendments, first consider the desired results. To improve the water and nutrient holding capacity on sandy, gravelly, and decomposed granite soils, select well decomposed materials like finished compost, aged manure, and peat. To improve aeration and infiltration (improve structure on clayey soils) select fibrous materials like composted wood chips, peat and straw.

Another important consideration is the potential for routine applications to improve the soil over time, as in a vegetable garden or annual flowerbed. In many landscape settings, the amendment is a one-time application added before planting lawns, perennials and woody plants.

Longevity of the product merits consideration. Produces that decompose rapidly (like grass clippings and manure) give quick results, while produced that decompose slowly (like wood chips, bark chips and peat) provide

longer lasting results. For quick improvement that last, use a combination of materials.

Salts are a primary consideration. Products made with manure and/or biosolids are often very high in salts. Salt level may actually increase in the composting process. Water moving through the compost pile leaches out the salts. Use with caution! Plant based products are naturally low in salts.

Routine application rates depend on the salt potential of the material and the depth to which it will be cultivated into the soil. Table 1 gives standard rates.

Table 1. Routine Application Rate for Soil Amendments

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 – **fourth 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 composts 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 are common in many commercially available products sold in Colorado.

In purchasing products, gardeners need to understand that there are no regulations about the quality of the product, salt content or other beneficial or harmful qualities. Voluntary standards for bulk products may help in product evaluation. Use with caution! Many of the soil amendments sold in Colorado are high in salts!

Over amending

Over-amending is a common problem. Some gardeners try to fix their soil limitations by adding large quantities in a single season. This can result in following problems:

- High salts
- High nitrogen
- Low nitrogen (from the tie-up of nitrogen due to a carbon to nitrogen ratio imbalance)
- Holding too much water
- High ammonia (burns roots and leaves)

Problems may also arise, over time, from the continual application of high rates. This can result in the following problems:

- High salts
- Excessive N, P or K
- Ground water contamination
- Micronutrient imbalance

Evaluating the quality of organic amendments

The quality of organic amendments can be determined by both visual evaluation and lab testing.

Visual Evaluation

Color – dark brown to black
Odor – earthy, no ammonia smell
Texture – less than ½ inch particle size; lawn top dressing less than ¼ inch
Foreign materials – less than 1% and smaller than ½ inch size
Uniformity within the batch
Consistency between different batches
Raw materials – concern of heavy metals (biosolids), human pathogens (manure), and salts (manure and biosolids)
Weed seeds – test by germinating some material

Laboratory Testing

C:N ratio – less than 20 to 1 acceptable; 10-12 to 1 is better

Ash content – (This measurement of the mineral portion after the organic matter is burned off will determine if soil was a primary part of the mix.)

- 20-30% common
- Keep below 50%
- If greater than 50-60% it probably contains a lot of soil

Bulk density – less than 1.0 gm/cc

pH – 6.0 to 7.8

- May be higher in manure
- Near neutral (6.8 t0 7.2) is best

Salts – acceptable levels depend on use

- Potting grade: < 2.5 mmhos/cm
- Potting media amendment: < 6 mmhos/cm
- Top dressing: < 5 mmhos/cm
- Soil amendment in a low salt soil: <10 mmhos/cm

Sodium – sodium adsorption ratio less than 13%

Ammonium – less than 1/3 of total nitrogen. If higher, it may not be finished composting.

Heavy metals – A concern with biosolids but regulated by application permits.

Pesticide residues – Rarely a problem since they breakdown in composting. Long-term residues of chlordane have shown up in some samples.

Pathogens – *E-coli* and other human pathogens are a potential in manure

Nutrient content – varies greatly from product to product

Germination test – Seeds are started to check potential of toxic chemicals.

Stability (respiration rate) vs. maturity – relative measurement of the completeness of microbial activity. If microorganisms are active, it will consume oxygen in the root zone causing root problems.

Bacterial and fungal diversity – Some compost has been found to suppress plant diseases. This is a high tech field with commercial applications.

Examples of soil amendments

There are two broad categories of soil amendments: organic and inorganic. Organic amendments come from something that is or was alive. Inorganic amendments, on the other hand, are either mined or man-made. Organic amendments include sphagnum peat, wood chips, grass clippings, straw, compost, manure, biosolids, sawdust, and wood ash. Inorganic amendments include vermiculite, perlite, tire chunks, pea gravel, and sand.

Peat

Sphagnum peat is a good soil amendment, especially for sandy soils, which will retain more water after sphagnum peat application. Sphagnum peat is generally acid (i.e., low pH) and can help gardeners grow plants that require a more acidic soil. Sphagnum peat is harvested from bogs in Canada and the northern United States. The bogs can be revegetated after harvest and grow back relatively quickly in this moist environment. In recent years however, harvest rates have become so high that it is raising questions on renewability.

Colorado mountain peat is not an acceptable soil amendment. It often is too fine in texture and generally has a higher pH. Mountain peat is mined from high-altitude wetlands that will take hundreds of years to rejuvenate, if ever. This mining is extremely disruptive to hydrologic cycles and mountain ecosystems.

Biosolids

Biosolids are a way to add slow release nutrients and organic matter to soil. They are available from some communities or sewer treatment districts in bulk and from garden stores in bags.

Some biosolids are extremely high in salts. For example, tests on MetroGro report a salt content of 38.3 dS/m (38.3 mmhos/cm), which is considerably above acceptable tolerances for soil amendments. (A soil amendment above 10 dS/m is considered questionable.) For details on salty soil amendments, refer to CMG GardenNotes #224, *Saline Soils.*

Biosolids typically have 5-6% nitrogen content. Annual applications should be made only when the biosolids and garden soil are routinely tested for salt content.

Compost, cover crops, green manure crops, manure, and organic fertilizers

For details on these soil amendments, refer to the following CMG GardenNotes:

#234, Organic Fertilizers
#242, Using Manure
#243, Using Compost
#244, Cover Crops and Green Manure Crops

Worm castings

Versatile worm castings can be used in potted plants, soil mixes, and in garden beds. Worm castings pose no threat of burning potted plants. Worms should have digested the batch of vermicompost for 4 months to ensure that microbial oxygen consumption has diminished sufficiently.

Red worm castings are the feces from compost worms. It has a slow release performance due to a mucus covering which is slowly degraded with microorganism activity. It contains highly available forms of plant nutrients that are water-soluble, has a neutral pH, and contains trace elements, enzymes, and beneficial microorganisms. The release time for nutrients is around 4 months. For continual release of nutrients, repeat application at 4-month intervals.
Some batches made from livestock manure may have high salts depending if the animals producing the manure had access to a salt lick, and if the vermicompost maker leached them or not.

Castings can be applied as a top dressing, 1/4 inch deep, on potted plants, as 25% of a soil mix (1 to 4 mix) or tilled into a garden at 1 gallon per 13 square feet or 7.5 gallons (1 cubic foot) per 100 square feet. Due to the high cost in Colorado, they are generally used in small gardens or potting mixes.

Perlite and Vermiculite

Perlite and vermiculite are common inorganic amendments used in potting soils and planter mixes.

Vermiculite is made from heat expanded silica (mica). It is used to increase pore space and has a high water holding capacity. Perlite is made from heat expanded volcanic rock. It is used to increase pore space and has a low water holding capacity.

Soil practices to avoid

The following is a summary of common practices that should be avoided to maximize soil tilth and plant growth potential.

- **Avoid working the soil when wet –** Water lubricates soil particles, making the soil easier to compact.

- **Avoid excessive fertilization –** This has the potential for surface and ground water pollution, adds salts to the soil and can become toxic to plants. Heavy fertilization will not compensate for poor soil preparation.

- **Avoid adding too much organic matter** – This leads to salt build-up, large release of nitrogen, the build-up of excessive phosphorus and an imbalance in K, Ca, Mg and Fe.

- **Avoid adding lime or wood** ashes – Being calcium sources, they are used to raise the soil pH. Most Colorado soils have a neutral to high pH. Lime or wood ashes would only be used on soils with a soil pH below 5.5.

- **Avoid adding gypsum (a calcium source)** – Gypsum is used to reclaim sodic soils by displacing the sodium with calcium.

- **Avoid creating texture interfaces** – For example, when making a raised bed, adding a different soil in the box creates an interface at the change line. Use similar soils and mix the soils.

- **Avoid trying to make dramatic changes in soil pH** – If the soil is high in *free lime* (calcium), lowering the pH is not effective.

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

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

Authors: David Whiting, Adrian Card, Catherine Moravec, and Carl Wilson: Colorado State University Extension

Revised September 2008