MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG 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 that 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 soil amendments that guarantee 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, at least, the minimum percentages of nitrogen, phosphate, and potash. Examples include plant and animal by-products, rock powders, seaweed, inoculants, and conditioners. These are often available at garden centers and through horticultural supply companies.

These should not be confused with substances approved for use with the ***USDA National Organic Program (NOP)***. The USDA NOP, with its "USDA Organic" label, allows for the use of only certain substances. The Organic Materials Review Institute (www.omri.org) and the Washington Department of Agriculture (WSDA) (http://agr.wa.gov/) review and approve brand name products made with ingredients from the "national list" for use in certified organic production. If a fertilizer is not OMRI or WSDA approved, it may still be allowed for organic production but has not been reviewed and deemed suitable for use in certified production. To learn more about which inputs are allowed and which are

prohibited refer to http://www.ams.usda.gov/about-ams/programs-offices/national-organic-program Many of the organic fertilizers listed here will meet NOP standards (based on the National List). Growers participating in the NOP should consult with their certifier to ensure compliance for organic certification.

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 only 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. In a fine-textured clayey soil, the organic matter 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 Soil Amendments

Desired results – 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.

Potential for routine applications – 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, trees and shrubs.

Longevity of the product merits consideration. Produces that decompose rapidly (like grass clippings and manure) give quick results, while products 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 levels may actually increase in the composting process, although 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-Based 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 inches	2-3 inches	1 inch
Annual application to vegetable and flower gardens – **first three years**	6-8 inches	2-3 inches	1 inch
Annual application to vegetable and flower gardens – **fourth year and beyond**	6-8 inches	1-2 inches	1 inch

1 Three 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. If the actual incorporation depth is different, adjust the rate accordingly.

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. For a few products in the market with extremely high salt levels, even this low rate may be too high.

When 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 of bagged products. 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!

Need for nitrogen fertilizer – Soil microorganisms release nitrogen tied-up in organic matter over a period of time. Release rates from compost are very slow,

over a period of years. The need for nitrogen fertilizer is based on the soil organic content. As the soil organic content increases, the need for fertilizer decreases. [Table 2]

Table 2.
Need for Nitrogen Fertilizer Based on Soil Organic Content

Soil Organic Content	Routine Application Rate For Gardens
1%	2 pounds actual N / 1,000 square feet
2-3%	1 pound actual N / 1,000 square feet
4-5%	0

Over Amending

Over-amending is a common problem. Some gardeners try to fix their soil limitations by adding large quantities of amendment 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 nitrogen, phosphorus, and potassium
- Ground water contamination
- Micronutrient imbalance

Evaluating the Quality of Organic Amendments

The quality of organic amendments can be determined by both visual evaluation and laboratory 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 to 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 – Generally not a problem as they breakdown in composting.

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 highly active, they may 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 acidic (i.e., low pH) and may 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 (sewage sludge) 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.

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 applications at 4-month intervals.

Some batches made from livestock manure may have high salts depending on whether the animals producing the manure had access to a salt lick and if the vermicompost maker leached them out or not.

Castings can be applied as a top dressing, 1/4 inch deep, to 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. It helps 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.

Summary: Considerations in Selecting Soil Amendments

There is really not a best amendment to use in each situation. What is practical and available varies from place to place. The important points are that 1) soils are routinely amended to improve soil tilth and 2) the gardener follows the limitations for the specific product used. The following summarizes selection considerations:

- Cost
  - Local availability
  - Cost of product
  - Size of area to be treated (quantity needed)
  - Depth of incorporation (application rate / quantity needed)
  - Transportation costs
- Need for fertilizer after amending
  - Soil organic content
- Precautions with specific products
  - Salts (manure and biosolids)
  - Weed seeds (manure and compost)
  - Plant pathogens (compost)
  - Human pathogens (manure)
- Alternatives to amending
  - Potential to incorporate amendments
  - Accepting a reduction in plant growth and vigor
  - Accepting increased maintenance requirements
  - Selecting plants more tolerant of poor soils
  - Avoid crowding plants competing for limited soil resources
  - Mulching with organic mulch to slowly improve soil over time
  - Container and raised-bed gardening
  - Preventing compaction forces

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