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

GardenNotes #215

Soil Compaction

Outline:

What is soil compaction?

Soil compaction reduces total pore space of a soil. More importantly it significantly reduces the amount of large pore space, restricting air and water movement into and through the soil. Low soil oxygen levels caused by soil compaction are the primary factor limiting plant growth in landscape soils. Soil conditions, primarily soil compaction, contribute to 80% of the plant disorders in the landscape setting. Figure 1 illustrates comparison in large pore space in a non-compacted and compacted soil. Soil compaction can change a block or aggregate structure (with good infiltration and drainage) into a massive structure (with poor infiltration and drainage). [Figure 2]

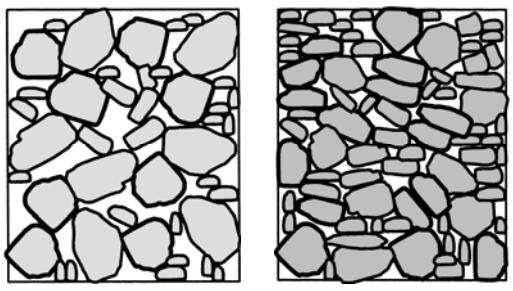
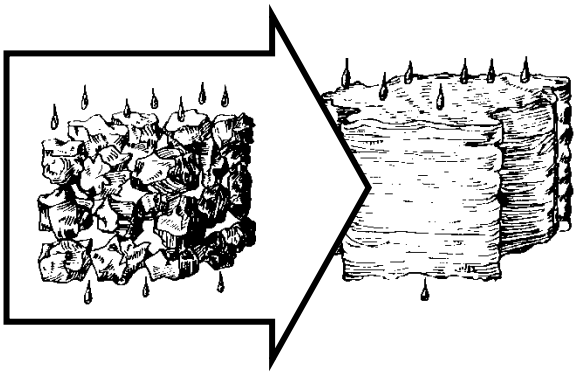


Figure 1. Comparison of large pore space on non-compacted soil (left0 and compacted soil (right).

Figure 2. Soil compaction can change a blocky or granular soil structure (with good air infiltration and drainage) into a massive structure with poor air infiltration and drainage.



Soil compaction is difficult to correct, thus efforts should be directed at preventing compaction. Soils generally become compacted during home construction. Foot traffic on moist soils is another primary compaction force in the home landscape. The impact of falling raindrops and sprinkler irrigation also compacts the surface of fine-textured clayey soils. [Figure 3]

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Figure 3. Foot traffic in the garden bed is a major source of compaction. The impact of raindrops and sprinkler irrigation also compacts fine-textured soils.

Techniques to minimize soil compaction

Adding organic matter

Ideally, cultivate organic soil amendments 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.

General application rate for organic soil amendments is based on the type of product and the salt content. Table 1 gives standard application rates for compost products. Compost made solely from plant residues (leaves and other yard wastes) is basically free of salt problems, so higher application rates are safe.

Compost that 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. For 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.

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.

For additional information on soil amendments refer to the following CMG GardenNotes: Earthworm, #218; Soil Amendments; #241, Using Manure; #242; Using Compost, #243; and Cover Crops and Green Manure Crops, #244.

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 cultivation 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.

Manage traffic flow

Traffic over the soil is the major contributor to soil compaction. For example a moist soil could reach 75% maximum compaction the first time it is stepped on, and 90% by the forth time it is stepped on.

Raised bed gardening techniques, with established walkways, eliminate compaction in the growing bed. On fine-textured clayey soils, limit routine traffic flow to selected paths.

Soils are more prone to compaction when wet. Soil water acts as a lubricant allowing the soil particles to readily slide together reducing large pore space.

Use mulches

Some types of mulch effectively reduce the compaction forces of traffic. For example, three to four inches of wood or bark chip will minimize the effect of foot traffic. For additional details on mulching, refer to the CMG GardenNotes #245, *Mulching with Wood/Bark Chips, Grass Clippings and Rock*.

Mulch minimizes the compaction forces of rainfall and sprinkler irrigation. On fine-textured clayey soil, keep garden beds mulched year round to minimize the compaction forces of summer and winter storms. Organic mulches create an ideal home for beneficial earthworms and soil microorganisms, which play a key role in improving soil tilth.

Aerate lawns and around trees

In a lawn or tree's rooting area, where organic matter cannot be cultivated into the soil, reduce compaction with soil aeration. Make enough passes with the aerator to have plugs at two-inch intervals. [Figure 4]

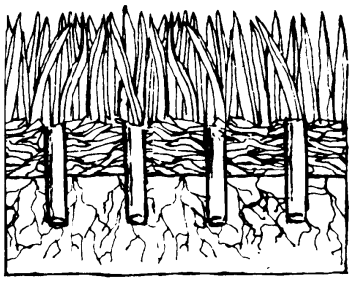

Figure 4. Lawn aeration helps manage the impact of soil compaction if enough passes are made with the aerator to have plugs at two-inch intervals.

Avoid excessive cultivation

Avoid cultivating fine-textured clayey soils except to incorporate organic matter and fertilizer, and to prepare a seedbed. Use mulches to help manage weeds.

Avoid cultivating overly wet or dry soils

Never cultivate a clayey soil when wet since this will destroy soil structure; the dirt clods created by tilling wet clay may last for years. To check dryness, take a handful of soil and gently squeeze it into a ball. If the soil is dry enough to crumble, it may be cultivated. If the ball only reshapes with pressure, it is too wet for cultivation. On some clayey soils, there may be only a few days (or even hours) between the time when the soil is too wet and too dry (too hard) to cultivate. In years when frequent spring rains prevent the soil from drying, planting will be significantly delayed.

Avoid fill over compacted soil

Adding a thin layer of topsoil over compacted soil is a common practice that leads to future landscape management problems. It is often justified as "a way to get plants established." However, root growth into the compacted layer will be restricted or even minimal.

Do not create a layer with added topsoil that is of a different texture than the soil below. This change in texture (actually pore space) interferes with water movement and root spread. Where additional fill is desirable, lightly mix the fill with the soil beneath.

Long-term landscape management will be much easier by breaking up surface compaction with tilling and organic matter amendments. Before planting a yard, enhance soil organic content to the extent feasible. A minimum of 3 to 4 cubic yards of organic matter per 1,000 square feet is recommended.

What about adding sand?

Some gardeners try to improve fine-textured soils by adding sand. The practice may help the gardeners feel that they have done something, but it will have a limited or even negative impact on the soil. Adding sand to a clayey soil may actually reduce large pore space until enough medium-to–coarse-size sand is added to reduce the clay content well below 20%. On clayey soils, this actually become a process of soil replacement rather than soil amendment. In some situations, adding sand to clayey soil can create concrete-like soil properties. To improve the soil, put efforts into adding organic matter, not sand.

What about adding gypsum?

Gypsum is a salt also known as calcium sulfate. When added to calcareous clayey soils (typical of Colorado), it simply increases the already high calcium content. Gypsum will not break up a compacted soil, but can increase the soil's salt levels.

Gypsum is useful when a soil has a high sodium problem. Sodium has a unique physical characteristic that brings soil particles closer together, reducing large pore space and "sealing" soils to water penetration. The calcium in gypsum replaces the sodium on the soil cation exchange site and then the freed sodium is leached out by heavy irrigation. Good quality (low salt) irrigation water must be available to successfully reclaim a high sodium soil.

The use of sulfur has also been incorrectly acclaimed to break up compacted soils. Over a period of time, sulfur may have an acidifying effect on a soil (if the soil is not high in lime). Adding sulfur to a calcareous soil only creates gypsum (calcium sulfate).

Compaction issues around trees

The area where trees are especially intolerant of soil compaction is called the ***Tree Protection Zone*** (***TPZ***) or ***Protected Root Zone***. This is typically about 40% larger than then dripline (reach of outer branches) area. [Figure 3]

To approximate a tree's *Tree Protection Zone*:

1. Measure the tree's circumference (distance around the tree) in inches at 4.5 feet high.
2. Divide the number by 2
3. This is the radius (distance out from the tree), in feet, of the *Tree Protection Zone.*

Example:

1. Circumference = 30 inches
2. 30 / 2 = 15
3. PRZ = 15 feet out from the tr

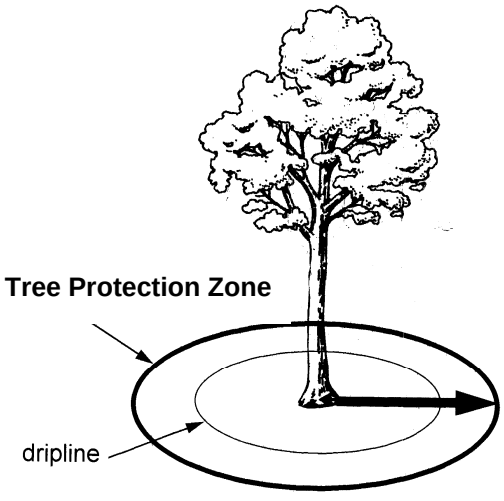

Figure 3. The ***Tree Protection zone, TPZ,*** is a tree's rooting area particularly intolerant of any rooting issues, including soil compaction, adding soil, removal of soil, trenching, stock-piling of materials, and chemical spills.

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Revised November 2008