Achieving Solid Soil Structure Is Keystone to Healthy Soils

Jul 1, 2009
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TurfGrass Trends

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Walking around on a perfectly manicured golf course, it's easy to forget most of the plant is below ground. It almost goes without saying that proper soil management is vital in turf management.

The best kind of soil structure for plant growth is granular structure, which resembles cookie crumbs and is usually less than 0.5 centimeter in diameter.

One important soil property that can be easily overlooked is soil structure or tilth. Soil structure refers to the spatial arrangement of soil particles. These aggregates form through physical, chemical and biological processes, which will greatly influence soil quality (Brady and Weil, 2008). Good soil structure is a hallmark of healthy soil. If soils are healthy, then healthy turf can follow.

An easy way to determine soil structure quality is to collect surface soil between 5 centimeters (cm) and 10 cm deep. Gently toss the soil in the palm of your hand to break up the soil. Take a representative soil clod and gently try to break it apart. If the clod breaks or fractures along a plane, it means you have some structure. If the clod tears apart, then it's a clear indication you have very poor or no structure.

It's well known that soils with high soil organic matter are of better quality, in part, because of their effect on soil structure.

Likewise, soils with good structure will break apart when dry, but will not turn into a powder. The best kind of soil structure for plant growth is granular structure, which resembles cookie crumbs and is usually less than 0.5 cm in diameter. This structure maximizes soil's water infiltration, fertility, rooting, gas exchange, decomposition, and the biodiversity of soil fauna and flora (Brady and Weil, 2008). Likewise, soils with good structure are porous and have low bulk density. However, soil compaction will destroy soil structure. Poor soil structure will appear plate-like or blocky with sharp edges when broken apart and can be over 5 cm in diameter. Water infiltration is slow in these soils compared to granular structure. Moreover, because plant roots grow between aggregates, poor soil structure will limit the ability of plants to root.

Fine-textured soils are prone to poor structure, especially in high-traffic areas. Very sandy soils typically have no structure. Without tilling, there are two ways to improve soil structure: adding organic matter and liming. Organic matter will work on virtually all soils, whereas adding lime primarily works on acidic heavy soils.

The main reason why lime is added to soils is to reduce soil acidity by raising pH. However, to a certain extent adding lime (CaCO3) or even gypsum (CaSO4) can improve soil structure through a physical-chemical process. This is especially true for heavy (i.e., clay) soil with low calcium or pH. To understand how this can work, you need to know a bit about the structure of crystalline silicate clays. Clay is actually composed of microscopic sheets of primarily silicon and aluminum oxides that form layers. A collection of layers form a micelle that is negatively charged. Calcium or other di- and trivalent cations can help clay flocculation by bridging micelle together to create very stable microscopic floccules (Brady and Weil, 2008).

It is these floccules that bind together other soil particles (e.g., sand, silt, organic matter) to form microaggregates. However, monovalent ions like sodium can cause clay particles to repel each other and encourage dispersion.

It's well known that soils with high soil organic matter (SOM) are of better quality, in part, because of their effect on soil structure. It's important to know that partially or undecomposed plant litter has little influence on soil structure. It's the by-products of decomposition that have the most effect. What really happens is soil microorganisms will break down plant material and leave behind or exude compounds like proteins, polysaccharides or humus. These compounds will coat soil particles allowing them to stick together in clumps.

One important compound worth mentioning is glomalin, a sticky glycoprotein that facilitates the formation of water stable aggregates (Wright and Upadhyaya, 1998). Without this compound, the ability of soil to form aggregates would be severely limited. Adding clippings, compost or degraded manure will increase the amount of these compounds and promote aggregate formation. In short, you're "feeding" the soil microorganisms in order for them to facilitate soil aggregation.

While adding organic matter can feed soil microorganisms, the application of artificial nitrogen fertilizer can alter their activity. Excessive or over-fertilization may inhibit the activity of these important organisms. The glomalin producing microorganism is actually arbuscular mycorrhizae (AM), a fungus that forms a symbiotic relationship with plant roots. Plants supply the mycorrhizae with energy (i.e., carbon) and the mycorrhizae supplies plants with nutrients mined from organic matter.

If grasses have excess amounts of nutrients, they generally allocate more photosynthate to leaves and less to roots or AM fungi (Johnson et al., 2003). In regards to soil structure, research shows that adding just 100 kilograms of nitrogen per square hectare (kg N ha-1) is known to increase the growth of AM fungi that excretes glomalin (Wilson et al., 2009).

However, another study found that adding 200 kilograms of kg N ha-1 can decrease the AM fungus that produces glomalin, but not always (Treseder et al., 2007). Nevertheless, a general rule of thumb is excessive fertilization will reduce AM fungi biomass (Johnson et al., 2003), and thus could reduce the production of glomalin and the formation of soil aggregates.

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