Cultural Perspectives

Managing Soil Tilth With Organic Matter
by Thomas D. Landis

Soils can be managed by their physical, chemical and biological properties. Nursery managers do a good job of managing the chemical characteristics of their soils by testing for pH and mineral nutrients and correcting with lime, sulfur, and fertilizers. However, the physical properties of nursery soils are managed less effectively. Many nursery managers only think about physical soil properties when a problem develops, such as when ripping must be used to break-up a plow pan.

The third and least appreciated aspect of nursery soils is biological **-** the microscopic animals and plants that live there. The biological properties of a good nursery soil are managed little or not at all. Like most things, there are good soil microorganisms and bad ones. Unfortunately, modern nursery management is geared almost exclusively to managing the bad ones **-** damping-off and root rot fungi. The fumigants and fungicides used to control soil pathogens also eliminate or reduce the beneficial critters. Beneficial microbes exist exclusively on the organic matter in the soil, which they use as a food source. Hold that thought until we have a brief discussion about the differences between soil texture and structure.

Texture vs. Structure. The physical characteristics of a soil can discussed in terms of texture and structure. Soil texture involves the basic size class of soil particles and their relative proportions, whereas structure is concerned with the arrangement of these particles into larger aggregates. Some types of soil structures such as crumbs are good for seedbeds, whereas others such as clods (blocky) and hardpans (massive) make farming difficult (Figure 1). It is instructive to compare the relative sizes of the textural and structural classes (Table 1). Traditionally, the ideal soil texture for a forest or conservation nursery is considered to be a sandy loam with “single-grain” structure. Realistically, however, many nursery managers have to deal with medium-textured silt soils and even some areas with a high percentage of clays.

While the ideal nursery soil has a sandy loam texture, what is the ideal structure for a forest and conservation nursery soil? The ideal seedbed should consist of firmly packed soil “crumbs” (Figure 1), ranging in size from 0.5 to 1.0 mm with few larger “clods” (Table 1). This compressed crumb structure provides moisture to the germinating seed while allowing good root penetration and drainage of excess water. Several forces act to break-down the crumb structure including the physical impact of rain or irrigation drops and the erosive effects of water.

Figure 1 - Various types of soil structure; in nurseries, a crumb structure is ideal but blocky (clods) and massive (hardpans) cause problems.

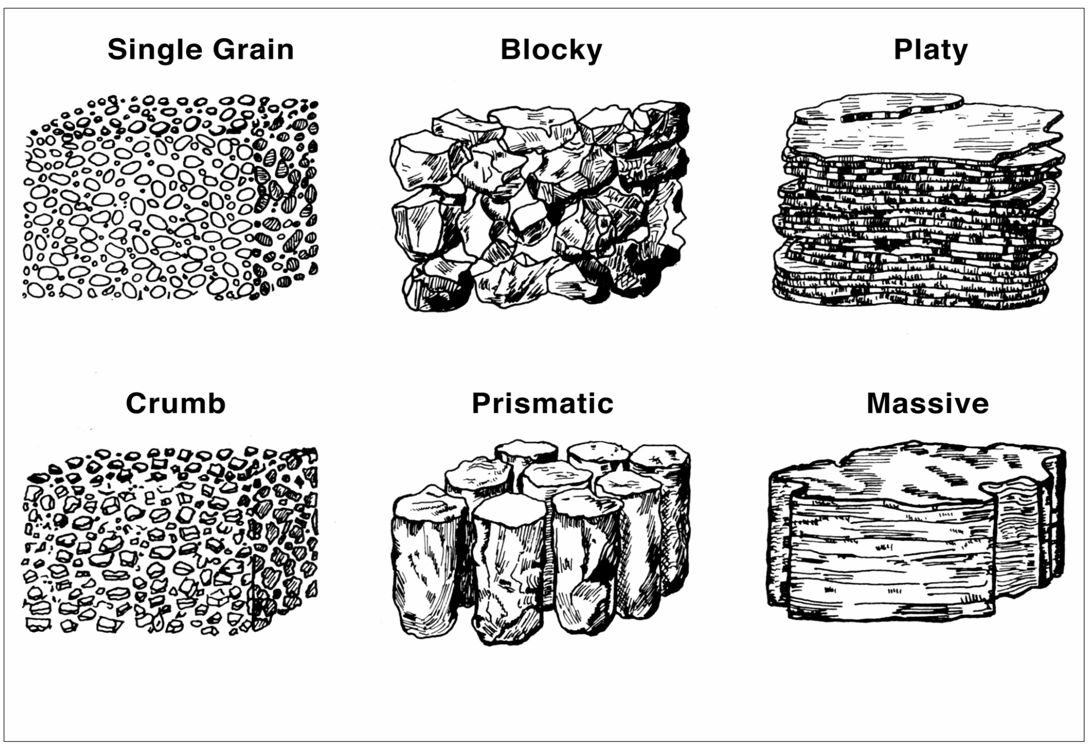


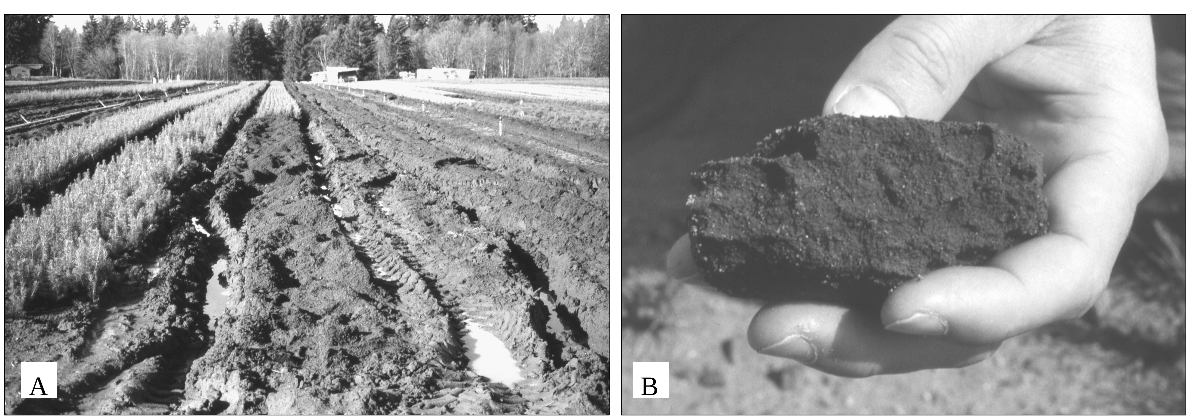
Table 1 - Size Comparison of Soil Texture and Structure Classes

Texture Class	Size Range Diameter (mm)	Structure Class	Size Range Diameter (mm)
Clay	Less than 0.002		
Silt	0.05 to 0.002		
Very fine sand	0.10 to 0.05		
Fine Sand	0.25 to .10		
Medium Sand	0.50 to 0.25	**Granules**	Less than 0.5
Coarse Sand	1.00 to 0.50		
Very Coarse Sand	2.00 to 1.00		
		Crumbs	2.00 to 10.00
		Clods	Larger than 10.00

The most damaging force to our ideal crumb structure, however, is the use of heavy equipment. Due to the necessity of harvesting during the wet winter dormant season, bareroot nurseries continually damage their soil structure (Figure 2A). Sandy soils drain faster and so suffer relatively less damage than finer-textures silt or clay soils. The small size and flat shape of silt and clay particles makes them much more prone to forming compacted soil layers called hardpans (Figure 2B). These pans restrict seedling root growth and inhibit good drainage and so nursery managers must continually rip their seedbeds to break-up them up. Unfortunately, they rather quickly reform unless your soil has good tilth.

A definition of tilth. When I think about the ideal properties of soils, one word comes to mind - tilth. My dictionary list several definitions mostly dealing with tillage, but the last one pertains to the current discussion: "the state of aggregation of a soil". Good nursery managers may not be able to define it but they can feel tilth when they pick-up a fistful of soil when their seedbeds are in the perfect condition for sowing. A soil with good tilth feels light and spongy in your hand because it is well drained, and the crumb structure resists compaction. Friable is another good description for a soil with good crumb structure. This subjective feel is humorously related in the "Boke of Husbandry" which was published in 1523. The grower was instructed to go out into the fields to determine whether the soil was ready for sowing: "If it synge or crye, or make any noise under thy fete, then it is to wete to sowe: and if it make no noyse, and wyll beare thy horses, thanne sow in the name of God".

Figure 2 - The use of heavy equipment, especially harvesters, during wet winter weather (A) shears and compacts the soil, destroying good crumb structure and creating hardpans (B).



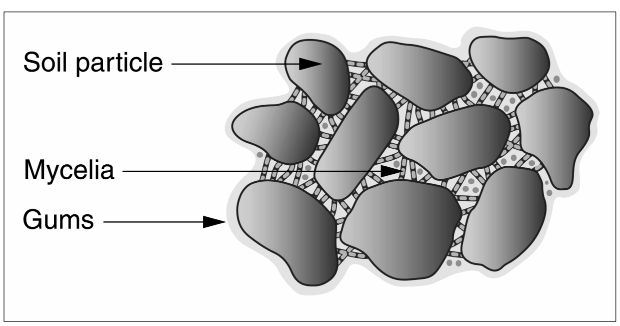
In 1937, a classic paper was published called “The significance of soil structure in relation to the tilth problem” and its author’s observations still ring true today. This insightful article states that a soil with ideal tilth should:

1. Offer minimum resistance to root penetration
2. Permit free intake and moderate retention of water
3. Encourage an optimum soil air supply through gas exchange with the atmosphere
4. Achieve a balance of soil and water in soil pores
5. Provide maximum resistance to erosion
6. Promote microbiological activity
7. Provide stable traction for farm implements

The structure of a soil can be affected by physical, biological and especially cultural forces. Most forms of modern agriculture are geared towards mechanical tillage as the primary means to manage structure. Experienced nursery managers appreciate the importance of proper tillage. For instance, if a rototiller is used to form seedbeds, then the moisture content of the soil must be ideal and the RPMs must be kept low. While proper cultivation can help create good tilth, this condition is often transitory and does not last through the crop rotation.

Managing tilth with organic matter. Less appreciated is the role of soil organic matter in the formation and maintenance of the ideal crumb soil structure. While soil crumbs can be formed by proper cultivation at the right soil moisture content, these mechanically-formed crumbs are not stable. The actinomycetes and bacteria that live on soil organic matter leave polysaccharide gums on the surrounding sand, silt, and clay particles which glue them together. In addition, the mycelial strands of soil fungi grow between particles and bind them together (Figure 3). So, organic matter will not only help create good soil structure, it will provide a measure of resilience to resist breakdown.

Figure 3 - The decomposition of organic matter by soil microorganisms leaves polysaccharide gums and fungal mycelia which bind soil particles into “crumbs”.



These beneficial effects on soil structure normally occur when the organic matter level is around 2%. One problem with the ideal sandy nursery soil is that it is difficult, if not impossible to keep the soil organic matter above 1% for very long. In fact, the productivity of a sandy loam soil decreases progressively after initial cultivation because the organic matter contributed by the original plant cover is quickly depleted. This is a function of soil temperature and moisture and so organic matter maintenance is more of a problem in the South than in the North. It is important to remember that soil organic matter levels are never stable and so it is important to continue to add organics whenever possible.

1. Organic amendments **-** I consider all materials added to soil to increase the organic matter content to be amendments. Organic materials added as mulches to protect seed or seedlings or control weeds can also be consider amendments, but they will not affect soil structure until they are incorporated. Another difference is that these surface applications will not breakdown until they are incorporated into the soil and so do not require simultaneous applications of nitrogen fertilizer.

Composts are the best choice for an organic amendment but most commercial sources are still too expensive for bareroot nursery applications. Many nurseries make their own composts or buy uncomposed material like sawdust or bark and mix them with supplemental nitrogen into fallow fields. Other nurseries add organics before sowing a green manure or cover crop. This additional nitrogen fertilizer is needed to compensate for the initial microbial tie-up during the decomposition process. It is important to realize that this nitrogen is not lost, it is merely tied-up in the bodies of the soil microbes and will be gradually released back to the seedlings as the microbes die. You are actually converting inorganic nitrogen fertilizer into a more stable organic form.

Unfortunately, little formal research has been published on the affects of organic amendments to soil tilth,especially on forest and conservation crops. Rose and others (1995) present a very comprehensive discussion of organic amendments and cover crops along with anecdotal information from nurseries. Davey (1984) also does an excellent job of discussing organic matter management in forest nurseries. Both contain handy tables to help with calculations, especially how much nitrogen fertilizer to add for various materials.

2. Green manure crops **-** Some nurseries prefer to grow their own organic matter and this is an effective practice when the field can be taken out of tree production for

one or more years. While green manure crops are grown primarily for their organic matter, they can also serve as cover crops to protect against wind or water erosion, or as catch crops to fix mineral nutrients. A wide variety of legumes, grasses, and other agricultural crops such as corn and Sudangrass grass have been used for green manure crops. Remember that the main objective is to grow as much organic matter in as little time as possible. Some nursery pathologists question the wisdom of green manure or cover crops, because some can cause an increase in soil pathogens. Organic growers would strongly disagree and point out that the well-chosen green manure crops encourage the populations of beneficial microbes. Like all cultural practices, their use depends on the local conditions and tests should always be done before operational practice. McGuire and Hannaway (1984) discuss common cover and green manure crops for forest nurseries in the Pacific Northwest.

3. Organic Fertilizers. I may be going a little far afield here but it occurs to me that the change from organic fertilizers may be related to the loss of soil tilth in modern nurseries. Before the advent of modern chemical fertilizers in the 1950's, nurseries used various types of organic materials to provide mineral nutrients to their crops. These organics had a very low fertilizer analysis, compared to modern products. Milorganite, for example, contains only 7% N and P compared to urea which has 34% N. In the case of Milorganite, the other 93% of the weight was pure organic matter but with many inorganic fertilizers, the filler is clay. To get sufficient mineral nutrients, nursery managers had to add tons of organic fertilizers to their crops each year which resulted in a huge amount of organic amendments to the soil. Our modern fertilizers are efficient in supplying mineral nutrients to our crops but we have lost a tremendous source of organics which helped to maintain soil tilth.

Summary. Good soil tilth can be managed by careful cultivation and organic matter maintenance. While soil can be cultivated into the ideal crumb structure, it takes the products of organic matter decomposition to give them resiliency. Some nursery managers question the financial benefit of adding organic amendments and growing cover crops, especially in warm climates, because it is so hard to show a significant rise in soil organic matter. Remember that the beneficial effects of organic matter decomposition on soil tilth will not be reflected in standard soil tests that only measure % organic matter. The improvement of soil tilth is one of those things that is difficult, if not impossible, to measure but experienced nursery managers can "feel" the difference in their soils - even from the tractor seat. Organic matter is also a wonderful buffer and makes the soil much more resistant to a range of possible problems.

Sources and Recommended Reading:

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