The Myth of Soil Amendments

One of the most common misconceptions in the horticultural world involves soil amendments. A long held belief holds that when transplanting trees or shrubs, it is wise to amend the hole with organic matter. While this can be beneficial for container-grown or frequently rotated (e.g. crops or annuals) field-grown plants, amendments do not benefit field-grown woody plants. This myth stems from the adage to "dig a five dollar hole for a fifty cent plant." It seems logical that adding peat, compost, or similar materials will improve soil aeration, nutritional value, and water holding capacity. This does occur, but only in the amended portion of the soil, and only in the short term. In the long term, amended soils will harm plant health and survival.

Origins of the Myth

Adding organic matter or otherwise amending soil in the planting hole is one of the most widely practiced horticultural myths. Despite the fact that an ideal soil contains only 5% organic matter, many people amend planting holes with 25%, 50%, or even more organic matter. This practice extends far back in the literature, and seems quite logical to many. Amending the soil would seemingly help create the desired "five dollar hole" and help roots establish more rapidly, leading to vigorous plant growth. Organic amendments are often thought the best way to improve a soil's physical structure, increasing both water holding and ion exchange capacities. In fact, soil amendments have actually been required for some governmental work (as well as many private projects). The Iowa Highway Department, Kansas Highway Commission, and Florida Department of Transportation once required amending planting holes with 15, 25, and 50 percent organic matter, respectively (Whitcomb 1986).

Unfortunately, such recommendations are not based on scientific studies of field-grown, non-agricultural (woody) plants. It is rare to find literature advocating soil amendments that references any controlled studies supporting this practice. Garden centers, horticultural literature, and even landscape and ecological professionals still advocate soil amendments, often encouraged by the industries that produce and promote these wasteful amendments. Despite an increasingly large body of research showing that soil amendments are not helpful and can actually injure plants, such information is not widely known or incorporated into the practices of landscape professionals or home gardeners.

The Myth Debunked

There is a substantial and growing body of research showing that organic amendments provide no real benefits to woody perennials. Starting as early as 1929, numerous studies have shown that a variety of amendments (including sawdust, manure, bark, peat, and perlite) are detrimental to or have no benefit for plant growth (Whitcomb 1986). Amendments have rarely proved to physically benefit plants or soils, even in the first years after installation. Although the amendments may contain some beneficial nutrients or organisms, they are rarely the most efficient or best way to provide such benefits. Experiments have shown that root growth in unamended soil is better than or no different from that in soils amended with perlite, sawdust, or other materials (Phillips 1993; Hartman et al. 2000). Adding organic matter to infertile, extremely acid, or poorly drained soils can lead to disappointing or even damaging effects; such poor soils must be fixed using something other than soil amendments (Hartman et al. 2000). Attempts to find the optimal application rate of four organic amendments (peat, pine bark, vermiculite, and colloidal phosphate) showed that the optimal amendment volume was consistently none (Byrnes 1976). No amount of any of the amendments benefited plant growth, and roots were unable to grow outside the amended soil. In nine years of experimentation on six woody species in clay soil, Corley (1984) found no consistent, positive response to soil amendments; effects on plant growth were usually negative or neutral. Amending with 50% by volume of peat moss did not reduce the negative impacts of compaction as was hoped (Day et al. 1995). There were no significant differences in root length between amended and unamended soils. The amended soils did nothing to help roots grow across the planting hole interface and actually had slightly lower oxygen levels than native soils.

Hoover and others (1999) investigated the ability of native plants to survive and revegetate degraded serpentine soils at former mine sites. They found that none of the four species studied (*Pinus jeffreyi*, *Chamaecyparis lawsoniana*, *Rhododendron occidentalis* and *Rhamnus callifornica*) benefited from or required topsoil amendments. By simply choosing species adapted to site conditions, they negated the need for amendments.

Incorporating manure into soil did not lead to any significant growth increases or other benefits for *Prosopis cineraria*, a desert tree (Gupta and Sharma 1998). Research on *Liquidambar styraciflua* also found that soil amendments provided no significant increase in growth or post-transplant survival (Hummel and Johnson 1985). The study compared controls to soils amended with peat moss, fired montmorillonite clay, and superabsorbant hydrogels. The backfill amendments had no significant impacts on height and caliper growth, leaf water potential, root dry weights, visual ratings (based on the percent dieback), or root extension into the backfill soil. While the amendments didn't seriously harm the plants, they also provided no real benefits, making them a costly and unnecessary practice.

In a study of *Acer saccharinum*, Schulte and Whitcomb (1975) found that the trees derived no benefits from soil amendments. The authors studied combinations of nine amendments and three fertilizer rates, comparing them to native clay loam and a nutrient-poor native silt loam subsoil. Results varied, but offered no support for the use of soil amendments to help new trees grow or establish in the landscape.

In studying more recently developed soil amendments, Smalley and Wood (1995) found no benefits for red maple. They tested a compacted clay loam with four different backfills: native soil; 50:50 native soil: Mr. Natural CLM; 50:50 native soil: Nature's Helper (aged pine bark); and 100% CLM. The CLM is a mix of topsoil, pine humus, granite sand; crushed granite; expanded shale; and composted poultry litter. The amended and native soils showed no significant differences in small or large root concentrations, shoot growth, or root penetration outside the root hole.

Sawdust tends to immobilize nitrogen, causing plant deficiency and making it a potentially harmful soil amendment (Starbuck 1999). In greenhouse and field studies with tomatoes, both fresh and aged sawdust amendments almost always caused reduced plant growth compared to controls. Sawdust amendments led to decreases in both nitrate and phosphate, but increased potassium, likely because the plants were growing less and therefore using less potassium. Regardless of the sawdust type or fertilization level, sawdust never benefited plant growth, making it yet another useless amendment.

Hydrophylic polymers, or hydrogels, are marketed as being able to decrease watering requirements, increase plant growth and nutrient retention, improve seed germination and vigor, and lessen transplant shock. However, hydrogels used as soil amendments have not shown such positive results. Keever et al. (1989) found that hydrogels did not reduce the required irrigation frequency, and either reduced or did not affect plant growth. Placing the hydrogels underneath a liner led to decreased plant growth. In studying hydrogels placed in an annual bed with coarse sand and incorporated pine bark, Boatman and others (1997) found that hydrogels had no positive impact on plant growth, but did increase flowering in drought sensitive petunias. The authors further note that the moisture-storing hydrogels could be detrimental during periods of heavy rains, creating anoxic soil conditions that reduce plant growth. Such detrimental effects were confirmed by Henderson-Cole and Hensley (1992), who found that hydrogels decreased the soil's air to water ratio, thereby impeding root growth and health.

In some studies, plants in amended soil outperform those in unamended soils, but interactions with other factors make it difficult to determine what is actually providing the benefits. For example, Querejeta and others (1998) studied the combined effects of terracing, organic amendments, and mycorrhizal treatments. Organic amendments enhanced growth and nutrient uptake in *Pinus halepensis*, but at least some of the benefit likely came from the terracing. Significant differences in survival and growth were found between the two types of terracing, as well as the amendment status. Not surprisingly, plants in the mechanically terraced areas, which involved excavating and amending a large planting area (not just the planting hole), had better growth and survival rates. For many growth factors, as well as overall survival, significant differences existed between terracing types, but not between amended or unamended soils within a terracing type. The experimental design makes it difficult to say what factor had the biggest effect on plant health, but it appears that the amendments alone provided little real benefit.

Soil amendments not only influence plants, but can impact the mycorrhizae associated with plants. In a study with *Trifolium pratense* (red clover) and *Cucumis sativa* (cucumber), Sainz et al. (1998) found that mycorrhizae would not grow in soils amended with either composted or vermicomposted urban waste. Although the crops had some gain in yield, the amendments reduced root length and reduced mycorrhizal activity, which could seriously damage the agricultural systems. In a related study, Roldan and Albaladejo (1993) found that using urban refuse to amend a xeric loamy clay harmed vesicular-arbuscular mycorrhizae (VAM). Adding even small amounts of organic matter caused a decrease in mycorrhizal spore concentrations, root colonization percentages, and production of viable infective propagules. Three years after the amendment was added, VAM populations increased, but remained lower than or no different from those in native soils, suggesting the amendment inhibited VAM growth.

The vast majority of research on woody landscape plants shows that soil amendments are not an economically or ecologically sound investment. Amendments are not only unnecessary and inefficient, they can also be quite costly. Hummel and Johnson (1984) looked into the cost of adding soil amendments, and estimated that they increase the per tree installation cost by 27-30 percent. These costs are not offset by any benefits in plant growth or establishment, making them a wasteful venture. As Corley (1984) says, the real 'five dollar hole' is a wide, well drained, well mulched, amply fertile one, not one with amended soils.

Sometimes, even those who recommend soil amendments admit that they are generally of no real benefit (Watson et al. 1992; Hartman et al. 2000). Watson and others found that amendments neither hurt nor helped *Fraxinus pennsylvanica* (green ash). Instead, they noted that creating wide planting holes with loosened soil provides a greater benefit than amendments, particularly in compacted soils. Henderson-Cole and Hensley (1992) also studied *F. pennsylvanica* and found that soil amendments had little effect on plant growth and did not benefit root establishment.

Similarly, authors may recommend using soil amendments even after performing research showing the amendments are of no benefit for plants. For example, van der Valk and others (1999) studied the effects or organic amendments (compost, topsoil, and fertilizer) on seed germination and seedling growth in five species of *Carex*. They found that no seeds were recruited or grew in any field plots with soil amendments. In addition, only one species showed any growth enhancement from the amendments, and the enhancement may actually have been due to fertilization or other factors. Despite the lack of evidence of beneficial effects, the authors recommend using soil amendments to raise soil organic content, claiming it will enhance *Carex* establishment in created or restored wetlands.

Problems with Soil Amendments

Why don't soil amendments work? Plant physiology, soil properties, and water relations all play important roles. The main reason for inhibited plant growth in amended soils is poor water relations. Amended soil often has markedly different characteristics than the native soil, tending to be more porous and coarsely textured than the neighboring soil. Unless the system is already saturated, capillary action will cause water to move from a coarser material (e.g. bark) to a finer material (e.g. clay). Although the amended soil will absorb water well, it will quickly lose it to the surrounding native soil, leaving plants water stressed. Poorly drained soils will be particularly hard-hit during wet seasons, when water moves quickly through the amended soil, only to be held back by the more slowly drained or saturated native soil. The resulting bathtub effect, wherein water accumulates in the planting hole, suffocates the roots, leaving them more susceptible to disease and death.

Textural differences between amended and native soils can also cause problems, particularly where the soils interface. Plants may have little incentive to leave a well-aerated, nutrient rich amended soil to grow into the less desirable native soil. Instead of penetrating through the barrier, the roots react much the same way they do in containers: they circle the edge of the interface and grow back into the more hospitable environment of the planting hole, becoming kinked and sometimes girdling the plant's trunk. When the roots do not establish in the native soil, reduced growth rates and stability problems occur, leading to top-heavy, hazardous trees.

Organic amendments may alter the balance between desirable and unwanted organisms. Soil amendments, particularly non-sterile ones, may harbor pathogens that harm plant health or kill more beneficial organisms. Decomposing organic matter may produce toxic chemicals or high nutrient levels that kill mycorrhizae (Roldan and Albaladejo 1993; Querejeta et al. 1998). Noxious weed seeds are often introduced with soil amendments. The introduction of organic amendments often benefits weeds as much as desired plants (Dunsford et al. 1998; Owen and Marrs 2000). In addition, the amendments may alter soil pH, salinity, and nutrient status, creating unfriendly or even toxic environments for plants and beneficial organisms (Jim 1996).

Finally, all organic matter eventually decomposes. Planting holes containing large volumes of organic amendments may start out fine, but microbes will eventually break down the organic matter, creating a sunken garden. This process, which can occur within six months of planting, will only serve to exacerbate any flooding problems.

Mulch: A Good Alternative

Although soil amendments are not recommended, one good alternative exists that can provide many of the benefits previously attributed to amendments. That alternative is mulching or applying the organic materials atop the soil. Natural, healthy forests typically have a litter layer composed of leaves, twigs, bark, and other organic matter. Microorganisms live in and decompose this organic mulch, gradually pulling some of it into the soil, improving the soil's aeration and nutrient status. The same thing happens when you add a mulch layer, which will gradually decompose and function like a litter layer. A well-aerated mulch with good drainage will help to buffer the soil against temperature changes, absorb and slowly release water, reduce runoff and erosion, provide a buffer against soil compaction, reduce weed growth and provide many other benefits. Both natural and synthetic mulches can help to decrease or block germination and establishment of invasive species while also helping desired plants to grow faster or better (Haywood 1999). Available nutrient concentrations and cation exchange capacity may be greater under mulched soils, leading to increased plant growth and biomass production (Singh and Singh 1999). Organic mulches may also provide a competitive advantage to desired species by altering nutrient availability (Zink and Allen 1998). Mulch can also help to reduce erosion, especially in areas with little vegetative cover, and can be more effective than direct seeding in reducing disturbance while a vegetative cover is establishing (Provencher 1999).

After studying both mulch and soil amendments, Whitcomb (1979) recommends that organic amendments not be incorporated into the soil, but rather used as a mulch layer. He notes that soil amendments don't help plant growth or establishment, but mulch does. In studying four different species with or without mulch, he found non-irrigated, mulched plants grew more and responded better to fertilizer than did the same plants without mulch. At the end of three growing seasons, plants that had been mulched were much larger than plants that hadn't been mulched. Whitcomb also found that using a plastic layer underneath the mulch didn't enhance weed control, but did restrict root development, and is therefore not advisable.

Conclusion

If you are working in an urban landscape or other area utilizing "permanent" plantings, amending the soil upon transplanting is not advisable. Doing so will at best provide a temporary boost to the plants, and at worst seriously harm or even kill your plants and other beneficial organisms. To provide the benefits attributed to the soil amendments in a more natural, sustainable manner, apply wood chips, compost, or other organic matter atop the soil as a mulch.

Works Cited

Boatman, J.L., D.E. Balint, W.A. Mackay, and J.M. Zajicek. (1997). Incorporation of a hydrophilic polymer into annual landscape beds. Journal of Environmental Horticulture, 15, 37-40.

Byrnes, R.L. (1976). Effects of soil amendments in variable ratios and irrigation levels on soil conditions and the establishment and growth of *Pittosporum tobira*. MS Thesis, University of Florida, Gainseville, Florida.

Corley, W.H. (1984). Soil amendments at planting. Journal of Environmental Horticulture, 2, 27-30.

Day, S.D., N.L. Bassuk, and H. van Es. (1995). Effects of four compaction remediation methods for landscape trees on soil aeration, mechanical impedence and tree establishment. Journal of Environmental Horticulture, 13, 64-71.

Dunsford, S.J., A.J. Free, and A.J. Davy. (1998). Acidifying peat as an aid to the reconstruction of lowland heath on arable soil: a field experiment. Journal of Applied Ecology, 35, 660-672.

Gupta, J.P. and A.K. Sharma. (1998). Integrated effect of water harvesting and manuring on growth and establishment of *Prosopis cineraria* (khejri) in hot arid region of Rajasthan. Indian Forester, 124, 54-58.

Hartman, J.R., T.R. Pirone, and M.A. Sall. (2000). Pirone's Tree Maintenance (7th Ed.). Oxford University Press, New York.

Haywood, J.D. (1999). Durability of selected mulches, their ability to control weeds, and influence growth of loblolly pine seedlings. New Forests, 18, 263-276.

Henderson-Cole, J.C. and D.L. Hensley. (1992). Influence of field-grown fabric containers and various soil amendments on the growth of green ash. Journal of Environmental Horticulture, 10, 218-221.

Hoover, L.D., J.D. McRae, E.A. McGee, and C. Cook. (1999). Horse Mountain Botanical Area serpentine revegetation study. Natural Areas Journal, 19, 361-367.

Hummel, R.L. and C.R. Johnson. (1985). Amended backfills: their cost and effect on transplant growth and survival. Journal of Environmental Horticulture, 3, 76-79.

Jim, C.Y. (1996). Edaphic properties and horticultural applications of some common growing media. Communications in Soil Science and Plant Analysis, 27, 2049-2064.

Keever, G.J., G.S. Kobb, J.C. Stephenson, and W.J. Foster. (1989). Effect of hydrophylic polymer amendment on growth of container grown landscape plants. Journal of Environmental Horticulture, 72, 52-56.

Owen, K.M. and R.H. Marrs. (2000). Acidifying arable soils for the restoration of acid grasslands, 3, 105-116.

Phillips, L.E. Jr. (1993). Urban Trees: A Guide for Selection, Maintenance, and Master Planning. McGraw Hill, Inc., New York.

Provencher, F.E.Y. (1999). Using mulch mats for slope stabilization. ASAE Paper No. 995045, 5pp. American Society of Agricultural Engineers, St. Joseph, US.

Querejeta, J.I., A. Roldán, J. Albaladejo, and V. Castillo. (1998). The role of mycorrhizae, site preparation, and organic amendment in the afforestation of a semi-arid Mediterranean site with *Pinus halepensis*. Forest Science, 44, 203-211.

Roldan, A. and J. Albaladejo. (1993). Vesicular-arbuscular mycorrhizae (VAM) fungal populations in a xeric torriorthent receiving urban refuse. Soil Biology and Biochemistry, 25, 451-456.

Sainz, M.J., M.T. Taboada-Castro, and A. Vilarino. (1998). Growth, mineral nutrition, and mycorrhizal colonization of red clover and cucumber plants grown in a soil amended with composted urban wastes. Plant and Soil, 205, 85-92.

Schulte, J.R. and C.E. Whitcomb. (1975). Effects of soil amendments and fertilizer levels on the establishment of Silver Maple. Journal of Arboriculture, 1, 192-195.

Singh, A.K. and R.B. Singh. (1999). Effect of mulches on nutrient uptake of *Albizia procera* and subsequent nutrient enrichment of coal mine overburden. Journal of Tropical Forest Science, 11, 345-355.

Smalley, T.J. and C.B. Wood. (1995). Effect of backfill amendment on growth of Red Maple. Journal of Arboriculture, 21, 247-249.

Starbuck, C. [Principle Investigator] (1999). Using sawdust as a soil amendment. Forestry Division Report #6. Missouri Department of Conservation Online: http://www.conservation.state.mo.us/forest/research/ApplyingResearchInForestry/sawdust.htm

Watson, G.W., G. Kupkowski, and K.G. von der Heide-Spravka. (1992). The effect of backfill soil texture and planting hole shape on root regeneration of transplanted Green Ash. Journal of Arboriculture, 18, 130-135.

Whitcomb, C.E. (1979). Factors affecting the establishment of urban trees. Journal of Arboriculture, 5, 217-219.

Whitcomb, C.E. (1986). Landscape Plant Production, Establishment, and Maintenance. Lacebark Publications, Stillwater, Oklahoma.

Zink, T.A. and M.F. Allen. (1998). The effects of organic amendments on the restoration of a disturbed coastal sage scrub habitat. Restoration Ecology, 6, 52-58.