Tired Soil: Using Inorganic Soil Amendments to Perk up Your Root Zone

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Poor growing conditions are often the result of problem root zones. Compaction, lack of structure, or inadequate porosity are just a few of the stresses that can reduce the productivity of your soil. Landscapers, sports turf superintendents, and nursery owners are constantly striving to find solutions for stressed, tired, and compacted root zones. Soil amendments are proving to be invaluable tools for enhancing some of the most common soil problems.

Compaction

Mechanical forces from cultivation or heavy traffic move soil particles closer together. Compaction destroys natural soil structure, increases the bulk density of the material, as well as creates numerous other problems. As more force is added, the number of larger pores begins to decrease and the movement of air and water is restricted. This is especially true for fine textured soils—soils with a high percentage of clay and silt-sized particles.

The inherent properties of some soils may make them more vulnerable to compaction. Soil, water content, type and amount of clay or organic matter, and particle-size distribution can all determine the susceptibility of soil to compactive forces. Severe compaction leads to poor drainage, lack of soil aeration, and restricted root growth. Therefore, it is important to understand how you can manage the forces on top of your soil and the physical properties in your soil.

The Need for Structure

Soil structure also influences the movement of water and air in the soil. The term soil structure refers to how primary soil particles (sand, silt, and clay) are arranged into aggregates. Plant roots, wetting/drying, or freezing/thawing cycles move primary particles closer together. Sticky residues from microbes, organic matter, iron oxide, and clay then act as cementing agents and hold the particles in place. The amounts and types of binding agents will determine the stability of the aggregate.

Clearly a soil with a well developed crumb-like aggregate structure will contain a lot of large pores creating the best pathways for exchanging gases, moving moisture, and growing roots. A soil with an abundance of large pore spaces will also occupy a large volume and hence have a lower bulk density when compared to a poorly structured soil of the same type.

Problems with Porosity

Adequate pore space is essential to a healthy soil environment. Air and water move through the root zone via spaces between solid soil particles and soil aggregates. Porosity is vital for plant transpiration, nutrient uptake, and root movement. However, knowing the total porosity of your soil is not as important as knowing the ratio of pore sizes. Pore space in the soil is generally divided into larger and smaller pores.

Larger pores are vital to drainage and remove excess water from the soil to allow aeration of plant roots. For this reason, large pore space is often referred to as aeration porosity. Smaller pores hold water needed for plant growth. Water in smaller pores cannot be drained by gravity, but is slowly taken up by plants along with nutrients. Networks of tiny pores can move water upward like the wicking effect of small tubes. This characteristic gives this void space its name, capillary porosity. However, there are limits. Very tiny pores may hold water so tightly that they are unavailable for plant use.

Preferred ratios of air and water filled pore space vary with the application of the growing media (Figure 1). Generally, the total porosity should occupy about 50% of the volume of the root zone. The remaining volume consists of solid mineral and organic materials. Several analytical methods can be used to measure the relative ratios of pore space in soil. However, most techniques require the use of suction or tension apparatus to draw water from the soil. Laboratories or universities specializing in soil analysis can usually provide this service.

Uses for Amendments

Poor soil fertility can be corrected easily using fertilizers or organic amendments. Nutrients are added when needed. However, without the right soil composition, those nutrients may not be enough to satisfy all of the plant's needs. A good root zone will provide physical properties necessary to optimize all the constituents required for growth.

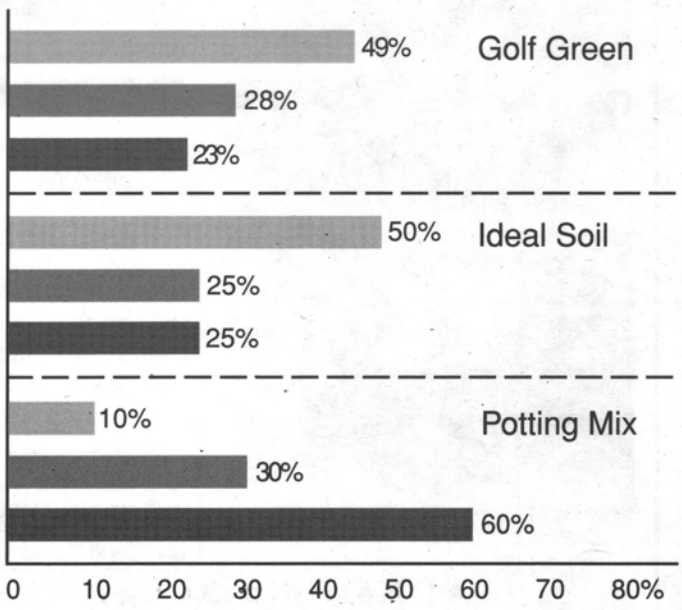

Figure 1: Preferred ratios of air and water filled pore space. water air solids

Generally, soil amendments are used to improve plant growth by enhancing the physical characteristics of the root zone. Superior drainage, better gas exchange, and increased tilth optimize access and use of soil nutrients by plants. Continuing interest in the management of problem soils has led to the commercialization of numerous products. Amendments can be split into three categories: organic supplements, soil conditioners, and inorganic amendments.

Organic amendments from plants or animals are the most commonly used. They supply nutrients to the soil, aid soil structure, and are often considered a hybrid between a fertilizer and a soil amendment. Most people have used organic supplements such as manure or compost. However, waste-based supplements from food and industrial processors are receiving more attention. Now your plants can dine on grain by-products, crab and fish meal, and beer residue.

Synthetic materials and starches are often referred to as soil conditioners. They can be designed to increase water absorption, stabilize soil aggregates, and control erosion. Conditioners such as surfactants, polysaccharides, and humic derivatives are all useful tools to the horticulturist.

Typically, the third category consists of inert granular material. Sand, heat-treated minerals, plastics, and rubber are designed to influence soil texture and improve its physical characteristics. Inorganic amendments can reduce the bulk density, break-up heavy soils, and enhance the number of large pores in the soil.

Table 1: Common Amendment Properties

Amendment	Bulk Density (g/ccm)	pH	CEC
Sand	1.45 - 1.70	4.5 - 8.5	Low
Vermiculite	0.07 - 0.12		High
Perlite	0.10 - 0.14	7.0 - 7.5	Low
Calcined Clay	0.60 - 0.80	6.0 - 8.0	Low-medium
Diatomite	0.39 - 0.70	7	Low-medium
Zeolite	0.48 - 0.85	8	Medium-high
Expanded Shale	0.80 - 0.95	6.8 - 9.5	Low
Pumice	0.09 - 0.20	7.0 - 7.4	Low
Slag	0.70 - 0.80	High	Low
Crumb Rubber	0.44 - 0.46	6.7 - 6.9	Low
Polystyrene	0.02 - 0.03	7	Low

Choosing your Amendment

The main objective of most coarse inorganic amendments is to create more pores. Increasing the amount of large pores will promote drainage and aeration, while enhancing the soil's capillary porosity will aid water retention. Some soil amendments also have a high cation exchange capacity (CEC) which can help prevent nutrients from being leached out of the root zone.

Some experts believe the choice of soil amendment should be based on its ability to improve soil aggregation and structure. Others debate that the most important characteristics of coarse amendments are their particle size, uniformity of particle size, and durability. Another view is that the most efficient amendment is the material that can provide the greatest improvement of soil characteristics per unit volume or weight. However, some amendments are more effective for enhancing one particular property. The amount of supplement added also depends on the texture and relative state of the soil you are amending.

In short, there is no cure-all amendment. However, there are a number of factors to take into consideration before buying an amendment. Below are a few areas to examine when purchasing a soil amendment:

Stability

Is the material physically, chemically, and biologically stable?

Materials that breakdown or change shape due to compaction or weathering may slowly lose their ability to enhance the soil's physical conditions.

Consistency

Is the product of consistent quality?

Uniformity from batch to batch provides you with assurance that you will get the desired result when applying the amendment at the manufacturer's suggested rate.

Suitability

Is the supplement physically and chemically suitable for your needs?

A material that is difficult to handle, hard to mix, has an unacceptable pH or CEC may lead to unanticipated problems.

Viability

Is the material readily and economically available?

The product should be easy to obtain and relatively inexpensive. When examining costs remember to amortize the benefits of the product over its estimated life span. Unlike fertilizers, inorganic amendments are designed for the long-term.

Amendments

More and more amendments are being introduced into the marketplace under various trade names. Manufacturers use different processes, feedstocks, and quality control methods to produce their materials. Variability in production along with a wide range of products can make choosing an amendment a difficult task. If you are unsure about a certain product ask the manufacturer for more information, talk to colleagues who have used the material, or consult an expert. Table 1 outlines some of the properties of common inorganic amendments.

Sand

Sand is the most commonly used amendment. It is available from a wide variety of sources, obtainable in many grades, and is inexpensive. Coarse, well-graded quartz sand with the proper pH and few weatherable impurities is preferred because it is chemically stable and highly resistant to physical weathering. The high bulk density of sand makes it ideal for adding weight to soil-less mixes. Sands also enhance air porosity and water movement, but decrease water retention. Their effectiveness is largely dependent on their particle size distribution and sometimes large quantities must be used to achieve the desired effect.

Processed Mica

Vermiculite is a layered mineral that is crushed and graded before it is heated to expand (exfoliate) the particles. Exfoliated vermiculite has a very high water holding capacity. In fine-textured soils this amendment can enhance water movement and air porosity, however, in coarser mediums vermiculite can have the opposite effects. It is a major constituent in most soil-less mixes because it has a high CEC, contains potassium and magnesium, and aids rewetting. Vermiculite is extremely vulnerable to collapse from compactive forces and will break down when mixed wet.

Perlite

Perlite is a porous, lightweight, siliceous material produced by quickly heating obsidian-like volcanic rock. It is chemically inert and resistant to weathering. However, perlite is also brittle and can be crushed by compactive forces. Its low bulk density makes it useful for reducing the weight of container mixes, such as those used for roof top gardens, but particles often float to the surface upon irrigation. Fine grades can effectively increase total porosity and water retention in soil. A coarser material can improve aeration porosity but is not thought to be as effective as other amendments in increasing permeability in fine-textured soils.

Calcined Clay

Heating (calcining) clay minerals such as montmorillonite and attapulgite to extremely high temperatures creates these porous ceramics. Calcined clays are available in a variety of grades and are used frequently as industrial absorbents and cat litter. Coarse grades are suitable for renovation work or potting soils while finer materials are generally used for top-dressing turfgrass. Calcined clays can increase aeration and drainage in finer soils, but these benefits may be reversed when added to some sands. They are extremely porous and can hold large volumes of water. Unfortunately, materials with a high percentage of very small pores hold water so tightly it may not be available for plant growth.

Diatomite

This amendment is made by calcining diatomaceous earth, a silica-based mineral derived from the skeletons of diatoms (microscopic algae). The lightweight granules are stable and relatively inert. This amendment is available in a number of particle sizes and shapes. Fine materials are designed for topdressing turf while coarser particles are more suitable for landscaping or speciality mixes (i.e. orchid and bonsai). Diatomite is effective in increasing aeration porosity and drainage in fine soils and improves capillary porosity in coarser root zones. Similar to calcined clay, however, if the majority of pores are very fine then not all of the water held will be available to plants.

Zeolite

Clinoptilolite zeolite is a naturally occurring aluminosilicate mineral. It has a porous crystalline structure that helps to retain plant available water, reducing water consumption. Well-graded material can also aid drainage. Zeolite has a high CEC, which increases nutrient retention within the soil and can reduce leaching of potassium and ammonium. Nitrogen is more efficiently used by plants because zeolite reduces ammonium conversion into the more leachable nitrate form. The most desirable zeolites are those that are derived from deposits low in sodium.

Expanded Shales

Heating shale to extremely high temperatures produces crystallized, expanded particles. When properly graded, these particles can increase soil aeration and infiltration. Shales can also have a high CEC and provide some nutrients. Their high pH should be considered when using large quantities of material.

Pumice

Pumice is a siliceous and remarkably porous volcanic rock. Fine grades increase water retention in fine-textured soil while coarser materials enhance both total porosity and air porosity. Pumice can enhance permeability and its amendment characteristics have been compared to those of perlite.

Slag

Blast furnace slag is a by-product from the steel-making industry. Porous aggregates are created when the material is rapidly cooled with water. Slag can increase air porosity and water movement in the soil. However, the material often has a high pH and brittle particles can be broken down in high traffic areas.

Crumb Rubber

Crumb rubber is a secondary resource recycled from scrap automobile tires. This amendment contains graded rubber granules and sometimes additional components, such as compost or mineral materials.

While crumb rubber is not truly inorganic, it behaves much in the same way. Coarse grade rubber crumb amendments reduce compaction stress in soil, increase total porosity, and enhance water movement. Finer particle sizes are being used for topdressing and can protect the crown tissue of plants from abrasion.

Polystyrene

This inert material is a by-product of polystyrene processing. Beads or flakes of polystyrene can reduce the bulk density of root zones and increase aeration and drainage. However, like perlite it tends to separate from the mix and rise to the surface during irrigation. ♦

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In Memory of Bill Carnochan

It is with great sadness that we advise the passing of William (Bill) Carnochan of R.R. #4, Seaforth on February 14, 1999, following a courageous fight with cancer.

Bill has been a valued member of the Oseco team since 1983. Bill's strong work ethic, professionalism, and positive attitude inspired us all. We at Oseco were honoured to have known Bill and to have counted him as both a friend and colleague. Bill will be dearly missed by all who knew him.

Bill is survived by his wife Sharon and four children, Robyn, Jill, Jared, and Kate.

Memorial tributes to the Brain Tumor Foundation, the Canadian Cancer Society, or a charity of your choice are appreciated. A Bill Carnochan Memorial Trust Fund is being set-up by the Carnochan family to be used within the community for scholarships and awards. If you wish further details, please contact the Carnochan family.

— Paul Eros, OSECO INC.

Editor's Note: The STA again extends condolences to Bill's family and friends. He was not only an excellent salesman and highly respected in the industry, but a kind friend.