Physical properties of container media

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Introduction

What kind of media are you putting in your containers? Why? Earlier this year we held a workshop at the North Willamette Research and Extension Center, and asked all participating growers what they are using and why. Most were using Douglas fir bark as the primary component and adding other components such as field soil, pumice, peat, sand, perlite, and others. When asked why all these extra components were added, nobody had a definitive answer, but someone jokingly responded, ñBecause it makes us feel better.ò This person approached us after the seminar and commented that he really wasnõt joking, and they had no good reason for adding the extra materials. So think about it. Do you really know why youõre adding the things you add? Maybe the answer is, it works, so leave well enough alone. Maybe thatõs a good answer, maybe not.

Container media is made by mixing several components. The physical properties of the mixed media are different from individual components.

This article addresses the important physical properties of container media and focuses on the relationship between air and water.

4 functions of media

Container media must perform 4 functions: 1) provide a stable substrate for root anchorage, 2) provide a reservoir of nutrients, 3) provide oxygen (gas exchange) for roots, and 4) provide water for roots.

Root anchorage

Media that uses bark as the primary component provides adequate anchorage for plant roots, especially when potting small liners into 1 or 3 gallon containers. However, when potting tall trees, or any plant with a large canopy relative to root-ball size, consider adding sand to the mix to enhance root anchorage. Coarse sand makes the media heavier; which will better anchor roots in the containers and result in less liner or container blow-over. But because sand makes medias heavier, moving plants will be more energy consuming, and shipping plants may be more expensive.

A common misconception is that sand improves drainage. When using bark as the primary component, adding sand will decrease drainage. Small sand particles settle between large bark particles, thus decreasing pore space and drainage. This concept is discussed more thoroughly below.

Nutrient retention

When using bark-based media, providing nutrients for plant uptake is not a major concern. Micronutrients are supplied in special micronutrient packages (MicroMax, STEM, Apex Micronutrient Package, and others) which bind readily to organic matter. Controlled release fertilizers (CRFs) provide nitrogen, phosphorus, and potassium over an extended period of time.

CRFs generally release more nitrogen than what is used by the plant, and this nitrogen is lost through the bottom of the container. Research is being conducted to determine methods for reducing nitrogen leaching, mostly for environmental purposes. The most promising research involves the use of clay materials (similar to kitty litter) that absorb phosphorus and ammonium. Zeolite is currently used for this purpose, although the jury is still out on whether or not it's effective. Suffice it to say that with current fertilizer technologies, bark-based medias provide sufficient nutrient retention for producing high quality plants, despite the fact that N is leached at higher than desirable rates.

Gas exchange

Container medias must have sufficient pore spaces to allow free movement of gases. Plant roots constantly undergo respiration. Respiration is a cellular process that burns sugars to create energy (sugars are generated by photosynthesis in leaves). Cellular respiration consumes oxygen and releases carbon dioxide (CO_2) as a byproduct. There must be sufficient pore spaces in the media for plant roots to acquire oxygen and expel CO_2. This tradeoff between CO_2 and O_2, called gas exchange, is an often-overlooked aspect of selecting container media. After containers are completely saturated and allowed to drain, 10 to 30% of the container volume should be air space for gas exchange.

Water supply

Container media has to retain water for plant roots. All medias retain water, some more than others. For example, peat retains a great deal of water while sand retains very little. Bark can be purchased in a wide spectrum of particle sizes, with smaller particles holding more water than large particles. After containers are saturated and drained, 45 to 65% of the container should be filled with water.

Of water held by container media, some is available to plants and some is not. Through physical processes called adhesion and cohesion, water is bound to media to form a thin film over particle surfaces. This thin film of water is generally unavailable to plant roots. Available water content is the portion of the water in a container accessible to plant roots. In most bark-based medias, 50% of water is available while the other 50% is not.

Defining container physical properties

Providing sufficient gas exchange and water are the most important, yet the least understood aspects of container media. Fill a container with any media and there will be solid particles, with small spaces called pores between the particles. The percent of container volume composed of pore space is referred to as total porosity (TP). Pores in a media can be filled with either air or water. The fraction filled with air is called air space (AS) and the fraction filled with water is called water holding capacity (WHC).

Media particle size influences the size of pore spaces and TP. Consider filling a basket with apples and a similar basket with peas. The size of the pore spaces in the pea basket will be much smaller than that in the apple basket, and the overall TP will also be much less. Similarly, coarse bark (large particle size) will have larger pores between particles than fine bark (small particle size), and will also have more TP.

Bark particle size influences media physical properties. As particle size increases from left to right, so does total porosity.

Pore size affects available water content, drainage, and the distribution of water in containers. Small pores (<0.01 mm) hold water so tightly that it is unavailable for plant uptake; pores between 0.01 and 0.8 mm in diameter contain water that is readily available for plant uptake; and pores between 0.8 to 6 mm are so large that they do not hold water and are mostly filled with air.

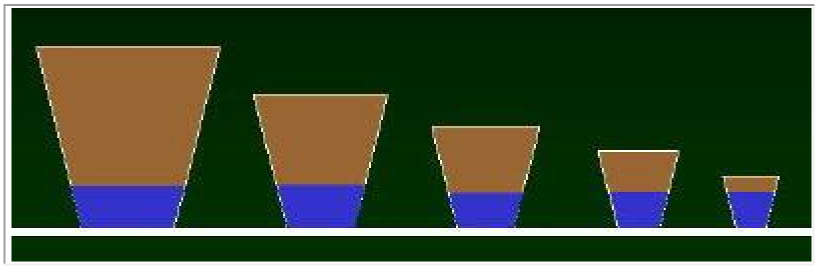
When using coarse bark as the primary component, adding sand decreases pore size and TP. Sand particles are small enough that they settle between bark particles, thus decreasing pore size and TP. Coarse pumice added to bark is generally too large to fit between bark particles; therefore it increases pore size and TP. Increased pore size increases drainage. So if your goal is to increase drainage, consider using pumice instead of sand. If you goal is to improve root anchorage and prevent liners and/or containers from blowing over, consider adding sand.

Air vs. water

Container media should contain 50 to 85% pore space (TP). Total porosity of container media is important, but probably more crucial is the portion that is AS versus WHC. Some plants prefer wet soils while others prefer dry soils. On average, 10 to 30% of the container volume should be composed of air space while 45 to 65% should be water. Consider two different medias, both with 75% TP. A media with 10% AS and 65% WHC would be ideal for plants that prefer wet soils, while a media with 30% AS and just 45% WHC would be better for plants that prefer drier soils.

Water is not distributed evenly throughout the container. Adhesion, cohesion, and capillary action attract water to particles and resist gravity. The ability of media to "hold" water through adhesion and cohesion is referred to as *matric potential*. Matric potential is the same throughout the container. Gravity pulls water down through the container and out of the drainage holes. While gravity is constant throughout the container, *gravitational potential* is greater at the top of the container and lower at the bottom. Because of this gradual decrease in gravitational potential towards the container bottom, matric potential is higher at the container bottom and media particles are able to hold more water. This causes water to form a perched water table at the container bottom. The perched water table is a layer of saturation on the container bottom. Container height affects the relative amount of water versus air. With the same media, the perched water table occurs at the same height, regardless of the container size. Short containers will have the same perched water table as large containers, thus a greater percentage of container volume is filled with water. This explains why a 5-gallon container holds less water than a 5-gallon squat container.

The volume of water held at each level of the container is listed. Water is not distributed evenly; the contaienr bottom is saturated while the top is drier.



For a given media, the perched water table remains the same regardless of plant height. It is therefore unwise to use the same media in large containers as small.