Growing Media for Containers
Part III: Chemical & Physical Properties

Successful container gardening is largely dependent on the physical and chemical properties of the potting media. Understanding these properties and what effects them allows a gardener to evaluate various container media mixes and choose one best suited for the plants they want to grow. It can also allow a gardener to create their own mix by looking at the properties of available mix components and creating a recipe that best suits the needs of their plants.

Most soil testing labs, including the LSU Soil Lab, have special procedures they use to test container potting mixes which are often referred to as Soilless Media because they contain less than 20% field soil. It is a good idea to have your container media tested if you use large amounts of the same product. Knowledge of the base properties of your potting mix is just as important as knowing these properties of field soil. When submitting these samples for testing, it is important that you use the correct submission form that clearly identifies your sample as a "Soilless Media". At the LSU Soil lab, commonly tested parameters include nitrate, and soluble phosphorus, potassium, and magnesium as well as, media pH. Let's look each of these properties and why they are important.

pH

As most gardeners know, soil/media pH is a very important parameter to the health of our plants. What is pH? The pH scale is logarithmic and inversely indicates the concentration of hydrogen ions in the solution. In common language, pH indicates the acidity or alkalinity of something, in our case, of our growing medium. Media pH is very important because it plays a major role in determining the availability of plant nutrients contained in the medium. Additionally, the optimum pH for plant health and growth varies with different plant species.

Most commercial media mixes are composed mostly of organic materials like peat and bark. These materials are rather acid to begin with resulting in mixes with a low pH. In many cases, these mixes need amendments that will raise the overall media pH. The most commonly used material for raising pH is calcitic ($CaCO_3$) or dolomitic ($CaCO3$ and $MgCO_3$) limestone. These are used at 5-15 lbs./yd^3 but generally less than 8 lbs./yd^3. Some less commonly used materials for raising pH are calcium oxide, hydrated lime, eggshell, oyster shell, and wood ash.

On the rare occasion that you may need to lower the container mix pH, elemental sulfur (S_8), ammonium sulfate ($(NH_4)_2SO_4$) and ferrous sulfate ($FeSO_4$) have all been used.

EC (Electrical Conductivity)

EC is a measure of the total salts concentration in a solution but doesn't give details of the individual salts present or their concentration. To test container media, a pour-through solution is collected and the EC measured. The higher the "total salts" concentration in a substrate the higher the EC. An EC will only be registered when inorganic ions are present in solution. Examples of inorganic fertilizer ions are N, P, K, Ca, Mg, etc. EC is expressed as microSiemens (uS/cm) or micromhos (umho/cm). Fresh media, without any added fertilizers, should have an EC of less than 750 umhos/cm. Higher EC indicates the presence of high levels of soluble salts which may be injurious to your plants. The extent of injury will be determined by the plant type, lifestage, length of exposure and identity and concentration of salt. With high salt concentrations, burning occurs on leaf tips and margins; yellowing progresses to brown and then black. Leaf shed and 'die-back' of growing tips can also occur and young plants can become stunted.

Soluble salt concentrations in a medium can come from the materials used to prepare the media, amendments added to the media, or from irrigation water source. You should try to identify the source to aid in remedying the problem. In general, the best way to reduce the amount of salts is to leach them from the media by watering in excess – keeping the leaching fraction high (20-30 percent). Leaching fraction (LF) is the proportion of applied water that leaches from a container after an irrigation event. Determining the LF isn't the simplest procedure; therefore, if you want to leach salts from your container of potting medium, the water to excess. But remember, if you water excessively, you are also leaching out plant nutrients, especially nitrogen. These will need to be replenished.

CEC (Cation Exchange Capacity)

Cation exchange capacity (CEC) is the total capacity of a soil to hold exchangeable cations. Cations are positively charged ions. The most common soil cations are: calcium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^{+1}), ammonium ($NH4^{+1}$), hydrogen (H^{+1}) and sodium (Na^{+1}). CEC is an inherent medium characteristic and is difficult to alter significantly. It influences the medium's ability to hold onto essential nutrients and provides a buffer against acidification. CEC can vary widely depending on what components are used to make the container mix. For example, sand and perlite have low CEC values in comparison to peat and vermiculite. Clay and organic matter have high CEC values. Adding organic matter or use of clay or claylike amendments such as zeolite and bentonite, will increase the CEC value of your container mix. However, increasing the CEC of a good container mix with high organic matter content is seldom necessary.

Bulk Density (Dry Weight)

Bulk density is a physical property that is calculated as the dry weight of soil divided by its volume. In common vernacular, bulk density can be thought of as the weight of a given volume of media. If a gallon of dry container mix A is heavier than a gallon of mix B, then A has a higher bulk density. Bulk density is important in container mixes for two reasons. First, since the primary stabilizing factor for container plants is the weight of the container of soil, higher bulk density means the plants aren't easily tipped over. Conversely, high bulk density means the container and plant will be heavier if you need to lift or manipulate the plants.

In general, materials with lower bulk density also tend to have higher total porosity. A medium's total porosity is very important contributing to drainage, water-holding capacity and gas (air) exchange.

Total Porosity

Total porosity refers to the fraction of the total soil volume that is pore space. Pore spaces facilitate the availability and movement of air or water within the media environment. With most container growing media, the total porosity should be in the 50-70% range. The pore spaces in growing media are filled with either air or water. Saturation is the threshold at which all the are filled with water. The percentage of pore spaces in a moistened medium (one that has been allowed to drain) filled with air is referred to as the air-filled porosity. The air-filled porosity of a medium is greatly influenced by the pore size which is directly affected by media particle size. For quart-sized and larger containers, the desired air-filled porosity ranges from 10-20%.

You can get a rough estimate of your media total porosity and air-filled porosity with the following.

1. Take a cup and fill it with 100 ml of water and mark the level on the cup.
2. Empty the cup and fill it to the 100 ml line with your potting media. Bounce it lightly and fill to the 100 ml line again.
3. Take 100 ml of water and pour into the cup until the water level reaches the 100 ml line.
4. Subtract the water volume remaining from the

total beginning volume. This will give you the amount of water used which represents the pore space.

5. Divide the pore space volume by the total volume (the volume of soil in the cup, in this case 100 ml) and multiply by 100. **This is your total porosity.**
6. Allow the water to drain from the filled cup and measure the volume of water that drains. This represents the volume of your air-filled space. Divide the air-filled space volume by the total porosity volume and multiply by 100. **This is your percent air-filled porosity.**

Water-Holding Capacity

A media's water-holding capacity (WHC) (sometimes called volumetric moisture content) is the percentage of pores filled with water after allowing for free drainage. This is best expressed as a percentage but is sometimes expressed along the lines of "holds 10X its weight in water". The preferred expression method is as a percentage. A rough estimate of WHC can be determined from the previous experiment by subtracting the air-filled porosity from the total porosity. This would represent your percent water-holding capacity.

Addition of media components with high total porosity or high water-holding capacity will increase the water-holding capacity of your final container mix. The water-holding capacity of a container mix directly affects plant available moisture (PAM). This directly translates for a gardener as to how often we need to irrigate – the higher the WHC, the less often we need to irrigate. However, a medium's WHC would be ideally in the 45-65% range but can be different with different plant species. WHCs higher than 65% usually means there is not enough air exchange happening and the roots may drown.

Summary

Understanding these different chemical and physical properties, how they interact, what affects them, and how they affect the quality of a potting mix is important in understanding and evaluating different potting mixes. Knowing these properties about the individual mix components will help a gardener know how to change these properties in a container mix and even how to formulate a recipe that best fits the needs of their individual plants.

Speaking of recipes, in next month's Part 4 of this series, we will provide some time proven recipes for various container mixes. We will also have recipes for mixes for specific purposes.

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