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Greenhouse and Nursery Series

Growing Media for Container Production in a Greenhouse or Nursery

Part II – Physical and Chemical Properties

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Introduction

Successful greenhouse and nursery production of container-grown plants is largely dependent on the chemical and physical properties of the growing media. A number of critical chemical and physical properties need to be evaluated before making a final media decision.

Media Chemical Properties

Some typical ranges are listed in Table 1. These values may be used for the Saturated Media Extract (SME) method. The University of Arkansas Cooperative Extension Service can assist in collecting and analyzing the chemical properties of organic media (consult Horticultural Growing Media Analysis in the UofA Diagnostic Services handbook). SME is the method used by the University of Arkansas laboratory.

Table 1. Typical ranges based on a saturated media extract (SME) analysis.

Parameter	Typical Range
pH	5.0-6.5
EC	500-3,000 umho/cm
NO^{3-}-N	40-200 ppm
P	5-50 ppm
K	50-200 ppm
Ca	30-120 ppm
Mg	20-75 ppm
Na	4-80 ppm

An alternative to the SME method is the Pour-Through (PT). This method is well documented on the North Carolina State Extension website. SME and PT values must be evaluated independently. Typically SME values are twice those produced using the PT method.

pH

Optimum pH of a container medium differs with plant species, but generally a range between 5.0 and 6.5 is desirable. For example, most of the Ericaceous plants like florist azalea, rhododendrons and blueberries like an acid pH in the range of 5.0 to 5.5, while plants such as junipers, geranium, lupine, daylilies, carnation and arborvitae prefer a pH in the 6.5 to 7.0 range. The challenge with most modern container mixes is that they rely heavily on organic components such as peat and bark that are rather acid to start with. Raising the pH in these organic mixes can be a tremendous challenge for some growers.

Media pH is a critical issue because it plays a major role in determining the availability of many nutrients. A common problem occurs in *organic*-based mixes when the pH falls below 5.0. Below this pH, the availability of Zn and Mn increases dramatically and often results in foliar toxicities from these elements. While aluminum toxicity is recognized as a common concern in *mineral* soils at a low pH, this is usually not a problem in *organic*-based mixes.

Soluble Salts

Similar to media pH, the level of soluble salts that may be tolerated is crop specific. The extent of injury will be determined by the plant type, stage in production, longevity of exposure, concentration of salt and irrigation practices. In general terms, fresh media without fertilizers should have a *pour-through* EC of less than 750 umho/cm. The addition of fertilizer may mean this value is much higher and normal for a particular crop at a specific stage of production.

Cation Exchange Capacity (CEC)

While CEC is a critical chemical property of media, it is not generally something a grower intentionally manipulates or monitors to achieve a specific result. CEC can vary widely depending on the type of component. For example, perlite (1.5 meq/100 gm) and sand have very low CEC values relative to peat and vermiculite (125 meq/100 gm) components. Some growers have started to use small volumes (2 to 15 percent) of clay-type amendments (e.g., zeolites) in their soilless media. These clay amendments may increase a medium's nutrient retention and improve its physical properties. It is important to understand which components have a higher CEC to help develop fertility programs and troubleshoot certain nutrient disorders.

C:N Ratio

A high carbon-to-nitrogen ratio can be a concern to a grower since it may reflect a tendency for the media to experience rapid decomposition and subsequent decrease in volume and aeration. Significant composting, or decomposition in the pot, not only causes concerns for a deterioration in physical properties, but nitrogen that would normally be available for plant growth will be utilized by the microorganisms involved in the composting process. This nitrogen draft can cause serious yellowing and stunting of plants and will cause a grower to compensate by increasing the amount of nitrogen used in growing the crop.

Sawdust and wood shavings are the components with the greatest concern. These components typically have a higher C:N ratio than other organic components such as bark and peat. Sawdust might have a C:N ratio of 1,000:1 while bark might have a ratio of 300:1. It is important to check bark supplies to make sure excess amounts of wood are not left on the bark, otherwise similar nitrogen draft concerns may develop. Most small growers have the time to compost wood sources and bark prior to use, but many larger nurseries use it as it arrives. Many growers that use fresh bark incorporate a starter charge of nitrogen at the rate of 0.25 to 1 pound N/yd^3.

Adjusting Media pH

Raising Media pH

In most cases, nursery and greenhouse growers need to be concerned about raising the media pH since most of the organic media components are acidic. The most commonly used material is either calcitic ($CaCO_3$) or dolomitic limestone (mixture of $CaCO_3$ and $MgCO_3$). The amount of lime required will depend on the starting pH, the desired pH, the particle size of the limestone (i.e., small particles faster acting than large ones), the type of media and the alkalinity of irrigation water used. In general, lime rates generally fall in a range between 5 and 15 lbs/yd^3 with rates below 8 pounds most common. Calcitic or dolomitic limestone is most reactive when incorporated into the media prior to planting. Note that many of the pelletized granular limestone materials are actually fine powders that have been glued together with a binder. When these granules or prills are exposed to water, they fall apart into a fine powder. These fine powders are faster acting than coarser prills but may also wash out of the bottom of the pot if the media is coarse textured. It is absolutely critical that growers know the starting pH of their mix and then monitor the pH over time to see how their fertilizer and irrigation water influence media pH.

Other liming materials include calcium oxide (CaO; quick or burned lime, which is very reactive, caustic and more expensive), hydrated lime [$Ca(OH)_2$; also fast acting, caustic and more expensive], marl, egg or oyster shells and wood ash.

Greenhouse growers may wish to try one of the following if the pH needs to be raised once the plants are in production. The first option is to apply a flowable limestone drench. Start with a 1 quart per 100 gallons rate. Avoid getting this mixture on the foliage if possible. The second option involves injecting potassium bicarbonate into the irrigation water. Continued use of this method may require a grower to switch to a lower potassium source fertilizer.

If you are using liquid fertilization (fertigation), you can increase your media pH by switching from an acid-based fertilizer (high percentage of nitrogen in the ammoniacal form) to basic fertilizers that are based on a higher percentage of the nitrogen in the nitrate form.

Lowering Media pH

Only rarely do growers using organic mixes express interest in lowering the media pH. Generally, the problem develops from using an irrigation water source that has high alkalinity (>100 ppm $CaCO_3$). In those cases, growers typically choose to install an acid injector. Others methods are selected if individual blocks of plants require a lower media pH.

Materials such as elemental sulfur, ammonium sulfate and ferrous sulfate have all been used. Caution must be used when considering using ammonium sulfate and ferrous sulfate as you need to account for the nitrogen and iron that accompanies these materials. Aluminum sulfate is also an option but is used only for reducing pH around florist hydrangeas (*Hydrangea macrophylla*). Growers can also affect media pH by selecting specific forms of nitrogen. The use of high ammoniacal-nitrogen based fertilizers can lower the media pH over time.

Rate recommendations take into consideration the change in pH and type of media and may be obtained from grower manuals or your Cooperative Extension Service.

Managing Substrate EC

Electrical conductivity (EC) is a good estimate for the total soluble salts in a media. EC does not provide details on the type or amount of individual salts present. High ECs can contribute to poor shoot and root growth. The first objective is to determine the source for the elevated salts. Typically, this will be from the irrigation water source or from the amount or type of fertilizer used. Once the source has been identified, you will want to determine if you can reduce or eliminate that source. Media salt concentrations are directly impacted by what is called the leaching fraction. This value represents the percentage of water that leaves a container relative to what is applied. High salt conditions can be effectively managed by keeping the leaching fraction high (20 to 30 percent) and not allowing pots to dry out. The danger in keeping pots wet is that it can contribute to secondary problems with root rot organisms. (Consult *FSA6061, Irrigation Water for Greenhouses and Nurseries*, for more information on irrigation water quality.)

Disinfecting Media

Three methods are primarily considered for sterilization of media. Sterilized media is common in plant propagation and greenhouse operations but is not usually considered in an outdoor nursery simply based on the volume of media required and the benefits derived. Remember that certain amendments (e.g., perlite, vermiculite) are sterile and, therefore, do not require sterilization. Composted pine bark and peat contain populations of suppressive microbes that might be eliminated by sterilization techniques.

Steam Pasteurization

Steam pasteurization is commonly found in greenhouse or ground bed production. The general recommendation is the exposure to steam (212°F) for 30 to 45 minutes. The piles should be small enough so all sections reach at least 180°F. Piles too big may take too long to achieve uniform heating. You must have an appropriate thermometer handy to effectively monitor the temperature at various places in the pile or bed. Over-steaming is possible and should be avoided since this kills beneficial organisms and may cause the release of toxic substances, especially when organic components are involved.

An alternative pasteurization process, aerated steam, involves blowing a mixture of steam and air through the media. Aerated steam (140° to 175°F) uses less energy and fewer beneficial organisms are likely to be harmed.

Steam pasteurization SHOULD NOT be used on media that has had slow-release fertilizer blended into it!

Chemical Fumigation

Chemical fumigation is usually limited to ground beds in cut flower production. The primary chemicals used were methyl bromide and vapam. Methyl bromide uses were phased out in 2005. Consult your Cooperative Extension Service for current recommendations.

Solarization

Solarization is rarely used because the process may take up to one month even under summer conditions requiring tremendous planning for future media needs. Solarization is accomplished by spreading moist media to a depth of 6 to 10 inches on a clean surface. The pile or row is then covered with clear plastic sheets with the edges sealed to the surface to prevent the loss of heat and moisture.

Media Physical Properties

Media physical properties may be determined using simple laboratory methods. Media samples can be analyzed by commercial laboratories, or you can make the physical measurements yourself using simple tools. Procedures for determining physical properties of horticultural substrates are available at *https://projects.ncsu.edu/project/hortsublab/pdf/porometer_manual.pdf.*

Weight (Bulk Density)

Media weight is kind of a double-edged sword. Ideally growers would like a heavy mix when containers are on the ground in an outdoor nursery to minimize blow-over, but during plant movement and shipping, a lightweight mix is desired. Weight or bulk density is usually expressed as lbs/ft^3 and reported on a dry basis. For outdoor container nurseries, *dry* bulk density of media might range between 12 to 24 lbs/ft^3 (*wet* bulk density of 70 and 90 lbs/ft^3). A nursery media that uses a significant percentage of mineral soil will have a dry bulk density of 40 to 50 ft^3. For a greenhouse media, the dry bulk density will be lower and in the range of 8 to 18 lbs/ft^3.

Air-Filled Porosity

When we fill a container with media, the total volume of space in that container is filled with two things: the solid media components and the spaces or voids between all of the solids (Figure 1). Ideally the total volume of empty pores should be in the range of 50 to 70 percent. This is referred to as *total porosity*. The remaining container volume would be filled with the solid growing media (i.e., 30 to 50 percent). The total porosity of a media is further composed of two parts: air and water. Both components are critical for good plant growth, but not enough of either can limit growth.

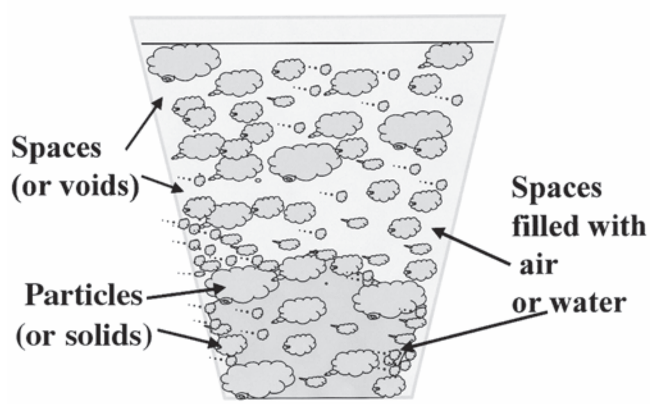

Figure 1. The container is filled with the solid media components and the spaces or voids between all of the solids.

For one quart and larger containers the *air-filled porosity* (percentage of pores filled with air) typically ranges from 10 to 20 percent by volume. For a 280-plug tray, an acceptable range in air-filled porosity may fall in the range of 3 to 6 percent by volume. Obviously, the container volume influences the interpretation of the acceptable values. The higher the percentage of air-filled porosity, the more frequently watering will be required. Propagation media where aeration and drainage are critical may have an air-filled porosity in the range of 15 to 25 percent.

Volumetric Moisture Content (sometimes referred to as Water-Holding Capacity)

As described above, the bulk volume of a container will be filled with either solids or pores. These pores or voids are then either filled with water or air. A typical range in values for the *volumetric moisture content* (percentage of the pores filled with water after allowing for free drainage) will be between 45 and 65 percent by volume. Volumetric moisture content (VMC) gives a grower some indication of how wet or how dry a media will be. Sphagnum peat moss that retains water quite well typically has a VMC of 60 percent, while coarse sand, which does not hold water, might have a VMC of 25 percent. As was the case with air-filled porosity, the actual values for VMC need to be interpreted relative to the height of the growing container. For example, an acceptable VMC for a 6-inch container might be 45 percent, while for a plug tray 68 percent would be a more typical value. The effect of media height on the saturated zone is illustrated in Figure 2.

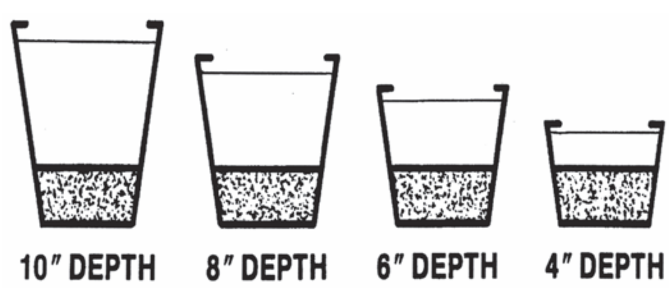

Figure 2. Containers contain the same media. Notice, saturated zone (textured area at bottom of each container) is the same regardless of the container height.

All of these physical parameters can be determined in-house with the aid of a scale or balance. The measurements can also be determined by an outside commercial laboratory or with the help of the Cooperative Extension Service.

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