Agricultural Extension Service
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Growing Media for Greenhouse Production

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Growing Media for Greenhouse Production

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This publication is one of three in a series that covers the basics of developing a nutritional program for producing container-grown plants in greenhouses. A complete nutrition program encompasses the fertilizers, media and water used. The first publication, **Plant Nutrition and Fertilizers for Greenhouse Production** (PB 1616), develops background information about plant nutrition and discusses the important characteristics of fertilizers used in greenhouse production.The second publication, **Irrigation Water Quality for Greenhouse Production** (PB 1617), examines the effect of water quality on a greenhouse nutritional program. This publication, **Growing Media for Greenhouse Production**, describes the important physical and chemical properties of growing media, media testing procedures and interpretation of test results. The objective of this series of publications is to provide basic information that will allow greenhouse operators to develop a nutritional program for their specific business.

Properties of Growing Media Affecting Air/Water Relations

Growing media consist of mixtures of components that provide water, air, nutrients and support to plants. All media provide plant support, while the nutrients are provided by added fertilizers. Water and air are provided in the pore spaces in the media. Four main factors affect air and water status in containers: the media components and ratios, height of the media in the container, media handling and watering practices. Watering practices are discussed in PB 1617, **Irrigation Water Quality for Greenhouse Production**.

Media Components

Most greenhouse media contain 30 to 60 percent peat moss alone or in combination with composted pine bark. Other materials are added for drainage and aeration. In terms of air/water relations in the root zone, the quality of the peat used is very important. Peat that has been milled too much has a smaller fiber size. Media settling may result in loss of plant-rooting volume. Also, aggregates such as vermiculite may or may not improve drainage and air space, depending on the size and shape of the particle. Fine-grade vermiculite particles may actually decrease media aeration.

Only a portion of the water added to media is available for root uptake. Available water-holding capacity is the amount of water held in the root zone and available to plants between irrigating and when the plant wilts. In a 6-inch pot, approximately 65 percent of the pore space is filled with water after the pot has been saturated and allowed to drain. Generally only about 70 percent of that water is available; the rest is called unavailable water.

The amount of available water depends on how tightly the water is held to the particles of materials that make up the media (matric tension). For example, peat has relatively higher unavailable water contents at a given matric tension compared to rock

Table 1. Percent volume air space of a 1:1 peat:vermiculite media in various growing containers.

Container	Percent Volume Air Space
648 tray	0.5%
288 cell	2.8%
4” pot (3 1/4” tall)	13%
6” pot (4 1/2” tall)	20%

wool. This variability in the availability of water in different types of media components means no two media are exactly alike in terms of providing water to plants. This makes knowing when to water difficult. Another important characteristic of media components that influences watering practices is wettability, i.e., the ability of dry media to rapidly absorb water when moistened. The choice of media should be influenced by irrigation systems and practices.

Media Column Height/Containers

Another factor relating media to air/water relations in the root zone is the size of the growing container. With media in containers, the amount of air and water held in a given media is a function of the height of the column of media. The taller the column, the smaller the ratio of water to air spaces. This is most important in plug production where the small cells drain very poorly or not at all, resulting in poor root zone aeration. The dramatic effect of container height on air space is evident in Table 1, which shows the change in percent volume air space of a 1:1 peat:vermiculite media in various growing containers.

In all containers, there will be a certain amount of saturated media at the bottom of the container after drainage. This is due to what is called a >perched water table. The saturation zone is a larger part of the total volume of the growing media in a very short container, such as a plug cell.

A good way to illustrate the effect of container height is to use a sponge. A sponge of the dimensions 2@ x 4.25@ x 8.5@ (72.25 cubic inches or 1,184 milliliters) represents the media in a container.When fully saturated, the sponge holds 950 ml; that is, the total porosity is 80 percent. Holding the sponge so it is 2 inches high results in about 50 ml water draining out, resulting in a volume air space of 4.2 percent. If it then is held so it is 4.25 inches high, another 125 ml drains out, resulting in a volume air space of 14.8 percent. If the sponge is then held so it is 8.5 inches high, another 375 ml drains out, resulting in a volume air space of 46.5 percent. Starting with the same volume of media (sponge), the effect of container height (sponge height) on media air space is dramatic. We can conclude that the choice of containers is important in managing water/air relations in the root zone, especially of plugs.

Another issue is whether square or round plug cells are better. In general, square cells with their greater volume make crop management a little easier. As long as the height is the same, however, there is no difference in air space.

Media Handling

How media are handled can greatly influence their air and water characteristics. The major concern is to avoid compaction. Containers, including plug trays, should be lightly filled and the excess brushed off the top. Air space can be drastically reduced by compaction. At no time should any growing containers be stacked. The moisture content of the media prior to filling containers may also be important. Adding water to peat-based mixes before filling plug trays causes the media to swell and helps create more aeration. Water added to about 100 percent by weight of the media is sufficient for cell packs. Plug mixes should have about 200 percent by weight water added before filling plug trays. Moistening of the media before filling larger containers does not have much benefit.

Chemical Properties of Growing Media

The capacity of the media to hold and make available nutrients is affected by the cation exchange capacity (CEC) and the media pH.

Cation exchange capacity (CEC)

Cation exchange capacity refers to the media's ability to hold nutrients having a positive charge, such as NH4, Ca, Mg and K. The term "buffering capacity" is often used interchangeably with CEC. It refers to the ability of the media, as a result of its CEC, to resist changes in pH and nutrient levels.

For soilless container media, CEC is expressed as milliequivalents per 100 cubic centimeters of media (meq./100 cc).Compared to soil, soilless media have low nutrient-holding capacities when considered on the basis of the volume of media in a growing container. Because of this, nutrients for plant growth should be supplied constantly by fertigation. Cation exchange capacity of soilless media should be in the range of 6 to 15 meq/100 cc of media.

pH

The initial pH of the growing should be between 5.8 and 6.2. Since most components of media are acidic, dolomitic limestone (calcium and magnesium carbonates) is added to start at an acceptable pH range and provide Ca and Mg for plant growth. The smaller the particle size of the ground limestone, the quicker is the increase in media pH.

Commercially blended media typically have limestone already incorporated. If unamended media are purchased, then limestone is generally added to media at a rate of 10 to 15 pounds per cubic yard. A more specific recommendation is to add 1 pound of limestone per cubic yard of media for each 10 percent of peat (by volume) in the mix. This may need to be increased to 2 pounds if the irrigation water being used has low alkalinity (up to 50 ppm CaCO3). Alkalinity of materials such as rockwool should be taken into account and may need to be leached before use. The pH of the media should be measured and adjusted before use.

Media Components

Peat

Peat is a main component of most soilless media mixes used today. It is produced by the partial decomposition of plant material under low-oxygen conditions. Differences in peat are related to the climate under which they are produced and the species of plant from which it is formed. Peats from sphagnum mosses have a spongy, fibrous texture, high porosity and water-holding capacity, and a low pH. Peats formed from sedges are darker, more decomposed and contain more plant nutrients and higher CEC than peat from sphagnum mosses.

In the US, the American Society of Testing Materials has designed a system of peat classification based on generic origin and fiber content. Under this classification, sphagnum peat moss must contain more than 75 percent sphagnum peat moss fiber and a minimum of 90 percent organic matter. Hypnum moss peat is composed of Hypnum species with a fiber content of at least 50 percent and an organic matter content of at least 90 percent. Reed-sedge peat must contain at least 33 percent reed, sedge or grass fibers. Peat humus has a total fiber content of less than 33 percent.

The majority of peat moss used for horticultural purposes in the US is sphagnum peat moss from Canada or the southeast US. Peats are classified as light or dark depending on the degree of decomposition. Most peats from Canada sold for use in the U.S. are light peats, having a loose, coarse structure and very little decomposition. More highly decomposed, dark peats have higher CEC and nutrient content. However, the finer structure results in poor media aeration and loss of volume. Media composed of dark peat must be handled carefully to avoid compaction.

Bark

Bark, a byproduct of saw mills, is used extensively in the nursery industry and has a role in greenhouse media as well. It functions to improve aeration and reduce the cost of media. Pine bark is the most widely used bark source, especially in the southeast US where local supplies are plentiful and inexpensive. Bark variability stems from the species and age of tree, method of bark removal and degree of decomposition. Raw bark is screened and wood (tree cambium) is removed before the <0.5 inch fraction is composted.

Bark must be aged or composted before use as a media component to eliminate the presence of phytotoxic compounds. Composting also decomposes the material to a point where further slow decomposition as a media component does not tie up nitrogen needed for plant growth, and does not result in great loss of volume. Bark particles of less than 3/8 inch in size are used in greenhouse media.

In general, nutrient content and pH (3.5 - 6.5) of unprocessed bark are low. However, the Ca content of barks tends to be high, resulting in a gradual increase in pH during composting. Final composted bark CEC is generally low. When using bark as a media component, it is wise to monitor for pH and nutrient changes in the media and be aware of the low water-holding capacity of the material. The presence of bark may also necessitate using higher doses of growth regulator applied as media drenches, since the bark appears to make the growth regulator less available to the plant.

Coir

The media component coir originates from ground-waste coconut husks. After most of the fibers are removed, the remaining coir, or coir dust, is marketed for media. Chemical and physical properties of the coir are variable, depending largely on the amount of fiber remaining in the material. Particle size ranges from about 0.5 to 2 mm, is greater than 80 percent pore space and air-filled pore space at container capacity is 9 to 13 percent. Coir has a high water-holding capacity, higher than peat in some tests, and is as or more easily rewetted after drying than peat. Coir-based media undergo slightly less settling than peat-based media.

Coir contains relatively low levels of micronutrients, but significant levels of phosphorus and potassium. The pH of coir ranges from 5.5 to 6.5. Since no lime is needed for pH adjustment and coir does not provide these nutrients, supplemental calcium and magnesium may need to be added to the fertilizer program. The EC of coir ranges from 0.4 to 3.4 mmhos/cm.

A concern with coir has been the reported high chloride levels (typically 200 - 300 ppm). Since most recommendations for media are 100 ppm or less chloride, coir may not be a preferred media component if non-leaching subirrigation is used. Coir has been suggested as a low-cost replacement for sphagnum peat moss in media. Production trials with a variety of plants indicate that there is great potential for this alternative media component. Because of the variability in the qualities of coir, it is important to purchase it from a reputable dealer with good quality-control practices.

Perlite

Perlite is a volcanic rock that is crushed and heated rapidly to a high temperature (1,800F). The material expands to form a white, light-weight aggregate with high pore space. Water-holding capacity is fairly low, as water is retained only on the surface and in the pores between particles. Perlite is added to media to improve drainage. It is chemically inert with almost no CEC or nutrients, and a neutral pH. Perlite may contain levels of fluoride that are injurious to fluoride-sensitive foliage plants. Maintaining a pH above 6 and reducing the use of fluoride-containing superphosphate fertilizer should avoid fluoride toxicity problems. Fine grades of perlite are available for use in plug production. Perlite dust can pose as a health risk; therefore, dust masks must be worn by workers during handling of this product.

Vermiculite

Vermiculite is a silicate material that is processed much like perlite. Heating causes tremendous expansion of the particles and results in a highly porous lattice structure with good water-retention properties. Vermiculite is available in a number of grades from fine, for seed germination, to coarser grades for use as media amendments. Although the finer material allows the media to flow more evenly into plug trays when filling, the particles are too small to hold much air or water for the developing roots. It is also susceptible to compaction.

CEC of vermiculite is fairly high (2 - 2.5 meq/100cc) and pH varies from slightly to very alkaline, depending on the source. Most vermiculite mined in the US has a pH between 6.3 and 7.8. Vermiculite provides some Ca, Mg and K. Particles are soft and easily compressed, so must be handled carefully.

Rock Wool

Rock wool is made from basalt rock, steel mill slag or other minerals that are liquefied at high temperature and spun into fibers. The fibers are formed into cubes or blocks, or granulated into small nodules for use as a component of horticultural media. The granules have high porosity, air space, water-holding capacity and available water. These qualities, along with its ability to rewet rapidly, makes rock wool a good media component for subirrigated crop. Rock wool is slightly alkaline and has almost no cation exchange capacity or nutrients.

Polystyrene Foam

Flakes or beads of expanded polystyrene foam are added to media to improve aeration, drainage and reduce cost. They supply no nutrients, CEC or water-holding capacity and the pH is neutral.

Styrofoam® should not be steam heated. The beads can migrate to the top of the media and may become a nuisance if dispersed by water or wind.

Mixing Your Own Media

The decision to mix one's own media, as opposed to purchasing commercially-blended formulations, is basically an economic one. Costs include mixing equipment, raw materials, skilled labor and quality-control testing. In general, mixing media from scratch is not considered economical for growers with less than 100,000 square feet of growing space.

Mixing equipment can range from the highly sophisticated (and expensive) laminar flow systems to a cement mixer. Uniformity is the main goal in using any type of equipment. The best option for most growers may be a 1- or 2-cubic yard batch mixer with continuous ribbon turners for minimum degradation of the fragile components. When mixing your own media, the choice of components should be based on component properties. Fifty to 75 percent of the media will be peat or coir. Bark, perlite, vermiculite, rock wool and polystyrene may add to the remaining 25 to 50 percent. Lime and fertilizer amendments (including micronutrients) should be selected on the basis of the chemical properties of the media. Wetting agents should be added by following the manufacturer's directions, since high concentrations may be toxic to plants.

Commercial Formulations

The most common media used in greenhouse production today are mixtures of peat, vermiculite and perlite. The media are designed to achieve high porosity and water retention while providing adequate aeration. A nutrient charge is added and the pH adjusted to approximately 6.0. A non-ionic wetting agent is generally added to peat- and pine bark-based media to improve initial wetting. Both can become hydrophobic when the moisture content drops below 40 percent.

Formulations without wetting agents are available for growing sensitive plants, such as seedlings.

Variations in the recipes result in media designed for particular situations. For example, a formulation for plug production may have high porosity for adequate aeration in small growing cells, be buffered against rapid pH changes and contain a light nutrient charge and low level of wetting agent. Applications requiring rapid drainage, such as outdoor-grown mums and perennials, benefit from a high-porosity medium based on pine bark.

Growing Media Testing and Interpretation

Growing media should be tested weekly during the entire cropping period. Pre- plant media analyses provide an indication of potential nutrient deficiencies, pH imbalance or excess soluble salts. This is particularly important for growers who mix their own media. Media testing during the growing season is an important tool for managing crop nutrition and soluble salts levels. To use this tool effectively, you must know how to take a media sample to send for analysis or for in-house testing, and be able to interpret media test results.

Sampling

Effective media sampling involves making decisions on the number of samples to be taken, when to take the samples relative to fertilization and the sampling location within the pot. The sampling unit might reasonably be a particular crop planted at one time and grown under the same conditions. Once the sampling unit is determined, a pooled sample can be assembled by taking small samples from randomly chosen pots within the unit and mixing them together into a large collective sample. This will give an overall estimate of the crop's nutrient status with the fewest number of samples.

For potted plants, a minimum of three pots should contribute to the pooled sample. Subsamples are chosen randomly on the bench, including the edges, since differential drying of these pots can affect salts accumulation. The media sample should be taken from the root zone at a consistent depth, preferably from the lower one-third. There are significant differences in EC readings for media from different depths within a pot, especially at high fertilization rates, under subirrigation and when pots are not well leached.

For plugs and small cell packs, five to 10 representative flats should contribute to the pooled sample. A plant from each flat should be sacrificed and its media collected for the pooled sample. Having separate flats for sampling purposes avoids the problem of having empty cells.

It is important to be consistent in sampling. One sampling every week or two should be sufficient. Take samples at about the same time in relation to fertilization. About four to six hours after fertigation is considered acceptable because drier samples are easier to handle. However, waiting too long after fertilization increases the variability between pots.

If a sample is to be sent to a lab, at least two full cups of media should be mailed immediately. If a plastic bag is used, poke a few holes in the bag to allow for gas exchange.

In-house Media Testing

Determining pH and soluble salts is a useful crop management tool that can be performed by the grower. Two ways of extracting media solution for analysis are the saturated media extract SME) and 2:1 extraction. The SME is used by media testing laboratories and gives the most reliable results. This is because the results are not as affected by variations in moisture media as are those from the 2:1 dilution. Another advantage of the SME method over the others is that the volume of media used in the SME method does not need to be known to perform the test correctly.

To perform the saturated media extraction, approximately 1 cup of media is placed in a glass beaker and brought just to saturation level, preferably with distilled or deionized water. Saturation occurs when the surface of the media glistens but there is no free-standing water on the surface. For dry media, the slurry should be mixed as the water is added. The saturated media is then allowed to equilibrate for about 30 minutes. After equilibration, the media solution can be squeezed out of the slurry. Soluble salts and pH of the solution are measured using portable pH and electrical conductivity meters. The meters range from in expensive pen types to more sophisticated electrodes. It is best to get instruments that can be calibrated using standard solutions. Interpretation of results is discussed in a later section.

Media Testing by Commercial/ University Laboratories

There are many commercial and university laboratories that will conduct media analyses and interpret the results for a fee. You can send your media to be analyzed to The University of Tennessee Soil Testing Laboratory in Nashville. Forms are available

Table 2. General guidelines for saturated media extract (SME) test results.

Analysis	Low	Optimal	High
Soluble salts (mmhos/cm)	< 1.5	2.0-3.0	> 3.5
pH	< 5.6	5.8-6.	> 6.4
Ammonium-N (ppm)	-	10-20	> 20
Nitrate-N (ppm)	< 50	100-200	> 250
Phosphorus (ppm)	< 3	6-9	> 12
Potassium (ppm)	< 50	100-200	> 250
Calcium (ppm)	< 100	150-250	> 300
Magnesium (ppm)	< 30	40-80	> 100

from your county Agricultural Extension Service office. Send a sufficient amount of media. At least 2 full cups are required for the saturated media extract procedure.

Media analysis includes pH, soluble salts and individual nutrients measured in samples obtained using the SME method. Sophisticated instruments allow rapid, inexpensive analysis for micro- as well as macro-nutrients. Media should be sampled as described above and sent immediately to the selected laboratory. For an extra $1 per sample, the test results can be faxed to you for a faster turn-around time.

Interpreting Media Analyses

Desirable pH, soluble salts and nutrient levels vary with the crop. All micronutrients except molybdenum become less available with increasing pH. To avoid micronutrient deficiencies, it is important to keep the media solution pH below 6 and to use media containing added micronutrients. General guidelines for important fertility parameters have been established and are presented in Table 2. Note that in many cases, lower concentrations are recommended for plugs. Young plants are more sensitive to salt damage to roots.

Troubleshooting Nutritional Problems

A large percentage of nutritional problems can be identified with soluble salts (EC) and pH measurements. Table 3 describes some of the most common causes and symptoms resulting from pH or soluble salts measurements falling outside the desired range.

Low pH can be remedied by using alkaline-residue fertilizers (Note: See PB 1616 **Plant Nutrition and Fertilizers for Greenhouse Production**). If the conditions warrant an immediate response, then top-dressing the media with pulverized dolomitic limestone will work.

The media pH can be reduced slowly by using an acid-residue fertilizer (Note: See PB 1616, **Plant Nutrition and Fertilizers for**

Table 3. The most common causes and symptom(s) when media tests indicate that pH or soluble salts (EC) are either too high or too low.

		Most Common Cause(s) and Symptom(s)
pH	Too Low (<5.5)	Minor nutrient toxicity = Bronze speckled leaves*
	Too High (>6.5)	Minor nutrient deficiency = Yellow new growth
EC	Too Low (<1.5)**	Nitrogen deficiency = Overall yellow appearance
	Too High (>3.5)**	Salts burn = Leaf tip burn, root death

* Most common on marigolds and geraniums.
** EC (mmhos/cm) measurements based on a saturated media extract test (SME).

Greenhouse Production). If more rapid increase in pH is required, then acid injection can be used (Note: See PB 1617, **Irrigation Water Quality for Greenhouse Production**.)

When media tests that indicate the soluble salts in the media are too low, then either the frequency of fertilizer application can be increased and/or the concentration of fertilizer can be increased.

When soluble salts readings are too high, then the salts can be leached from the media by applying clear water to saturate the media, then reapplying clear water to flush the salts from the media.

If pH and EC are both in the good range and yet the plants still look poor, then you may be experiencing a deficiency or toxicity of a single nutrient. Thus, a media sample (and sometimes a foliar tissue sample) will need to be sent to a media-testing laboratory to determine the specific nutrient that is creating a problem. (Note: See page 9 for information concerning media testing.)

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