Evaluating Alternative Growing Media Components

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Abstract: Alternative components for soilless container media are continually being evaluated to improve or replace existing materials. These alternative materials are often mixed with other components to provide forest and conservation nurseries with a high quality media. Nursery managers should follow a process to evaluate new materials to avoid causing losses due to unacceptable plant growth and development. A desirable growing media is non-toxic to plants, provides a reservoir for water, allows oxygen and gas exchange for roots, retains nutrients for uptake, and provides anchorage for the plants. It should also be available and cost-effective, while matching the nursery production system. This paper explores this process and offers suggestions on evaluating the desired properties of container media.

Key Words: nursery, Douglas-fir bark, media properties, air space, water-holding capacity, phytotoxins, pH.

Introduction

Forest and conservation nurseries have used container-grown plants for decades to produce diverse crops for specific purposes. While there are advantages and disadvantages to growing plants in containers, many out-planting markets prefer container-grown plants. But growing plants in containers is not as simple as it may sound. Growers can manipulate the growing environment by using greenhouses, mechanizing production practices, changing the size of the container, and selecting different media for the roots to grow in.

Container media continues to evolve as the use of new or different materials (components) are investigated. A couple of reasons for change might be the cost and availability of the currently used components. Additional reasons might be if the current component is considered a health risk, or if harvest of the component is not viewed as an environmentally sound practice, or it no longer fits with changes made to the nursery production system.

This paper will address some of my thoughts that a nursery manager should consider when deciding whether or not to change their container media. These thoughts are partially based on studies conducted at the Oregon State University North Willamette Research and Extension Center located near Aurora, Oregon. Container media studies have been conducted there for over 40 years collectively by Dr. Robert Ticknor (deceased), Dr. David Adams (retired), Dr. James Altland (USDA-ARS, Wooster, Ohio), Dr. Jim Owen (Virginia Tech, Virginia Beach, Virginia) and myself.

Organic and Inorganic Components of Growing Media

Container media provides a crucial balance of air, water, pH and soluble salts that is impossible to obtain using a mineral soil. Therefore, to successfully grow plants in a container a soilless media is used instead of soil. Soilless growing media are composed of organic and inorganic components that are regionally supplied.

The primary organic component used by the landscape plant industry in the Pacific Northwest is both aged and fresh Douglas-fir bark (50% to 100% of the growing media by volume). Sphagnum peat moss is usually the major organic component for small containers and plug type trays. The Cornell Peat-lite mixes are a good example of a media used for floriculture and forest tree seedling crops. Other organic media components used in this region include coir (coconut husk), rice hulls, and various composts.

The inorganic component that is used extensively in the Pacific Northwest, especially for larger sized containers, is pumice (volcanic rock). Perlite and vermiculite are two inorganic materials that are components of the Peat-lite mixes. Sometimes other inorganic materials are added to the container media for a specific purpose. For example, Zeolite is used to help absorb excess amounts of ammonia fertilizer; or sand is used to increase container weight to help avoid tall plants from tipping over; or pelletized clay can be used to increase the cation exchange capacity (CEC) of the media to help retain certain nutrients and avoid losses due to leeching.

Matching Media with the Nursery System

Fit with Container Types Used

A container nursery develops a system of growing plants that is unique to their operation. Plants are grown in various sizes of containers ranging from narrow and long tubes for young seedlings to short and wide containers used to grow eight-foot tall trees. Some growers use plug trays or containers designed to encourage good root development by air pruning roots. The Peat-lite mixes are very useful in plug trays due to the relatively small size of perlite, vermiculite and sphagnum peat moss grades that are available. Some grades of coir may not be suitable for this use due to their long, stingy fibers.

The value of an alternative media component is directly related to its ability to be used in more than one type of container. Different media components may not work as well depending on the type and size of container. For example, while coarse Douglas-fir bark (3/8 – 1 inch) particles work well in containers greater than six inches, they will not even fit into a plug tray. On the other hand, Douglas-fir bark can be hammered, ground and screened to a smaller size that will fit into a plug tray.

Fit with the Nursery Production System

It is not just how the media fits in the container, but also how the media is handled within the nursery system. How well the media flows through filling machines or if the alternative material requires special handling, such as breaking up Coir bricks before it is mixed with the other components. Another consideration is whether or not a nursery mixes their own media on site of if they purchase media from a supplier. If the latter, then the value of an alternate material is also dependent on the ability and willingness of a supplier to work with this material. Some practices observed at different nursery operations can lead to increased compaction of the media and should be accounted for when changing media components.

Ability to Anchor Root Systems

Since the roots anchor a plant, the media must allow roots to explore the entire container space and be stable enough to prevent shifting. If the plant wobbles in the pot then either the media is not stable and/or the roots are having a difficult time growing. After Douglas-fir bark is ground, the pieces tend to lock together and provide good anchorage for the roots. In this way, Douglas-fir bark is very similar to other tree barks used for container media. Sphagnum peat moss also has this ability to help bind and stabilize a media. This binding of the media particles depends upon their shape. A round, smooth particle tends to shift around more. The shape of tree bark particles used for media are angular and irregular. Along with particle shape, the size of the solid particles will determine the porosity of the media.

Properties of Container Media

Organic and inorganic components are mixed at various ratios to create container media with unique physical and chemical properties. Total porosity (TP) is the percent by volume of empty space in the container media that is created by the arrangement of solid particles. This empty space will be filled with either air or water depending on the size of the pores created. The large pores (macro-pores) provide air to the plant roots, while the small pores (micro-pores) hold most of the water needed by the plant. Air space (AS) and water holding capacity (WHC) are terms used to characterize a container media. Good root and shoot growth depends on the relative amount of water and air that a media will hold.

Both the physical and chemical properties of any organic component based container media are dynamic in nature. Organic matter decomposes rapidly in a container as the requirements for microbial activity is usually ideal. Warm temperature, high air exchanges, plenty of moisture, and proper levels of nutrients allow these decomposers to chew through organic matter in a short amount of time. This is one of the reasons that fresh straw stubble (grass seed or wheat) has not worked well as a container media.

As the media organic matter decomposes, the particle size decreases, which increases WHC and decreases AS. In addition, the decomposition process alters the pH of media and can release certain compounds that could affect plant growth. I once observed abnormal growth of plants grown in a media that used mint compost as a component. The release of the herbicide (clopyralid) used in mint production was the suspected causal agent of this disorder. For these reasons, media components should have a level of stability that resists decomposition.

Douglas-fir bark and sphagnum peat moss have general properties or characteristics that make them a superb component of container media. Both these components resist decomposition, are generally uniform, and have been available and cost effective. But for various reasons, growers are always looking for alternatives for these organic materials. Most often these alternative components are waste or by-products from another activity, such as composting. These materials must be able to show stable and reproducible physical and chemical properties season after season. The source of the material should be consistent and abundant enough to continue a steady supply.

Physical Properties

Guidelines for the physical properties of container media will vary greatly depending on the nursery system and growing region. For instance, the general range for container media AS is 10% to 30% but that does not mean that the best AS is 20%. Plants with high transpiration rates grown in tall containers will do well with an AS of 10%. Likewise, plants grown in plug trays prefer an AS of 7% to 10%, as they need the media to hold as much water as possible due to the limited amount of media in each cell. A plant grown outdoors in a larger container (>3.0 liters) in western Oregon would likely prefer an AS of 20% to 30% due to abundant winter and spring rains. In addition, some plant pathogens, such as *Phytophthora* and *Pythium*, are more problematic with a lower AS, compared to a media with 25% to 30% AS.

Growing plants in high AS media increases irrigation frequency during the summer months and will generally lower the WHC. The addition of 30% sphagnum peat moss (by volume) to a Douglas-fir base media can drop AS from 30% to 20% and increase WHC from 50% to 70%. The recommended range for WHC is 45% to 65%. But not all of this water is available to the plant. Usually, only about half of the WHC is readily available as the rest is held to tightly by the media particles and micro-pores.

An important point to consider is how the alternative material you are considering would be used. Will it be a major component of the media or serve as the base component? Or, will it be used as a minor component to enhance or improve another base material? The physical properties of a single media component is not as important as how it interacts with the other components. The overall physical properties of the media mix (blend) are what count. Of course, if the alternative component is going to be the base for the media (>60%), then determining it's specific physical properties will be useful.

There are few labs across the country that will determine the physical properties of container media. Their results are accurate but not necessarily standardized between them all. However, determining the AS and WHC of a media can be done at the nursery or greenhouse using a simple method. First determine the volume of media the container will hold by taping off the drainage holes and filling it with water to the level the media would reach. Measure the amount of water and this is the TP. Then fill the container with media and pack slightly by tapping it on a top of a table. Slowly pour water into the container filled with media until the water level is even with the media and air no longer bubbles out. Pull the tape and allow the saturated media to drain. Collect and measure the volume of the drainage water (leachate) in milliliters (ml). This value is the AS and represents the amount of macro-pores in the media. You can calculate the percentage of air space by dividing this value by the TP and multiplying by 100. To determine the WHC, weigh the wet media in grams (g) minus the weight of the container. Then spread the media in a metal pan and allow it to dry completely in a warm greenhouse or room. Weigh it again after it is dry. The difference between the wet weight and the dry weight is the total WHC. Using the simple conversion that 1.0 g of water is about equal to 1.0 ml, you can calculate the percent WHC by dividing it by the TP and multiply by 100.

Determining these basic physical properties of media will provide you with information to make sound decisions when considering an alternative media component. You can measure the AS and WHC of your current media and either make changes to them or try to keep them the same, especially if your plants grow well in it.

A common thought was that adding sand to a media would improve drainage and AS. But this is not the case, as the sand is a small particle size and it decreases AS and increases WHC by adding more micro-pores. Also, it was thought that adding pumice to a Douglas-fir base media would increase AS. This was not the case — adding up to 30% pumice did not change the AS of the media but WHC was reduced. Pumice does appear to help stabilize the physical properties due to the fact that it will not decompose like organic matter does.

Chemical Properties

The most important chemical property of a container media is that it must be free of any substances that are toxic to plant growth. This will include the total soluble salts, specific ions and certain compounds. I have observed numerous plant growth disorders (even plant death) as a result of using composts, improperly stored organic matter, sewage sludge, and inorganic materials.

Any alternative media component being considered for use must be tested for chemical properties using an appropriate analytical lab. This is different than what I suggested for testing the physical properties. While a grower can do a preliminary test for pH and electrical conductivity (EC) for total soluble salts using the PourThru technique (as described in Whipker and others 2001), a more complete analysis is required to determine if certain ions are present at unacceptable levels. Unfortunately, it would be far too costly to test for every possible plant toxin known. For example, you could test for certain heavy metals that are often found in sewage sledge, but it would likely be impractical to test and detect any herbicide residue in composted materials.

If your alternative material passes the chemical analysis, it can be blended with the other media components to obtain the desired physical properties. At that point, re-test the chemical properties of the completed media blend. Test the new media using the PourThru method and a commercial lab. Compare you results to standard guidelines developed for container media. These can be found by searching the Internet or in the reference books listed at the end of this article.

Avoid using any media with an EC reading above the recommended range. EC levels of media components should be less than 0.75 dS/m or 500 ppm using the PourThru method. Plants affected by salinity are stunted and grow more slowly. If it is above, further evaluation is necessary to determine the source of the soluble salts. Sometimes the media can be leached to remove the salts but it may require leaching the media more than once as it is difficult to leach salts from organic matter. In addition, leaching is a process that must be done routinely and the media monitored frequently. It is possible that the specific ions causing the high EC readings are toxic to plants in high levels.

The pH of the media is something that can be adjusted using pre-plant amendments and fertilizer applications during the growing season. In general, a pH range from 5.5 to 6.3 works well for container media. The alkalinity of irrigation water has a great affect on the pH of the media and must be managed to order to stay within the required range. As mentioned earlier, the pH of fresh organic matter changes dramatically during the decomposition process. At first the pH stays about the same or drops slightly before it rapidly increases. Then it will slowly decline often to a level lower than it was initially. Aged Douglas-fir bark just starting the decomposition process is often lower in pH (4.0) compared to fresh Douglas-fir bark (4.5). After a few months, Douglas-fir bark can have a pH close to 5.5 before dropping to 4.0 in about six months. Understanding this pH change that occurs in all decomposing organic matter helps to more accurately monitor and manage container media pH.

The microbes decomposing the organic matter in a container require a significant amount of nitrogen. Unfortunately for the plants, the microbes are more efficient at obtaining the available nitrogen and can out-compete the plant roots. This phenomenon is know as "nitrogen drawdown" and must be accounted for when making changes to the media involving organic matter. A lab can estimate the amount of nitrogen used by the microbes for any giving media and is called the "Nitrogen Drawdown Index." For most bark-based media mixes, it takes about 0.75 lbs of actual nitrogen per cubic yard of media (.44 kg per cubic meter) the first growing season to compensate for the nitrogen used by the microbes. Peat moss, and most well composted materials, generally have a lower nitrogen requirement. Some alternative materials being studied includes cull trees (such as Christmas trees, nursery shrubs and trees, etc.) or timber harvest slash that is hammered and ground to a specific size. The wood component of such a material will usually have a higher nitrogen drawdown compared to Douglas-fir bark or peat moss.

Phytotoxins are natural chemicals in barks, sawdust, or other organic materials that are toxic to plants. One concern is that large heaps of organic matter (such as bark or sawdust) composting under anaerobic conditions cause "charring" creating toxins. This condition can be recognized by the sour smell and very low pH <3.0 of the material. Phytotoxins are not readily removed by leaching. Proper composting usually helps degrade these toxins but it would be best not to use this alternative media source at all.

Conducting a live plant study (bioassay) on an alternative material is always a good practice. A quick and easy test is to germinate and grow lettuce in the new components under greenhouse conditions. If the component passes this test and the lettuce grows with no visible growth disorders, then blend the component with other media components and test again with the lettuce seed. If things still look good, then conduct a longer-term study for at least one crop rotation using several of the plants grown at the nursery.

Summary

The objectives of any container media are to provide anchorage for the plant, allow oxygen and gas exchange for roots, retain nutrients for root uptake, and provide a reservoir for water. In addition, the media components made up of either organic or inorganic materials must be non-toxic to plants, be available and cost effective, and match the nursery production system. There are multiple characteristics to consider as alternative materials are evaluated to improve container media. On-site testing and lab analysis are tools a nursery manager can use to determine the physical and chemical properties of any given combination of media components. In addition to these tests, it would be wise to evaluate crop growth and development on a trial basis before switching over to a new media on a widespread scale.

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