# Growing Media Alternatives for Forest and Native Plant Nurseries

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## Introduction

The choice of growing medium, along with container type, is one of the critical decisions that must be made when starting a nursery. The first growing medium was called "compost" and was developed in the 1930s at the John Innes Horticultural Institute in Great Britain. It consisted of a loam soil that was amended with peat moss, sand, and fertilizers (Bunt 1988). Soil was heavy and variable, however, so it was difficult to achieve consistency from batch to batch. In the 1950s, researchers at the University of California developed the first true artificial growing media using a series of mixtures of fine sand, peat moss, and fertilizers (Matkin and Chandler 1957). The Cornell "Peat-Lite" mixes, the predecessors of modern growing media, were developed at Cornell University in the 1960s using various combinations of peat moss, vermiculite, and perlite (Mastalerz 1977). Following the publication of the first comprehensive manual for growing forest tree seedlings, a growing medium of 50% Sphagnum peat moss and 50% coarse vermiculite became the basic standard (Tinus and McDonald 1979).

In recent years, a number of factors, including variability in the quality and availability of components, have caused container growers to consider new materials.

1. The cost of Sphagnum peat moss, vermiculite, and other components are becoming increasingly expensive (table 1). Fuel for extraction, processing, and transportation is a major factor in these increasing costs, especially for nurseries far from the source. Diesel fuel costs have almost doubled in the past 3 years (fig. 1), and there's no sign of them going down anytime soon.

2. Some growers have health concerns about the traditional media components of vermiculite and perlite. The WR Grace mine in Libby, MT contained a unique type of vermiculite that had asbestos as a co-mineral. Although it closed in 1990, and other asbestos-free vermiculite sources are now being used, many growers still have concerns. A recent report on a series of tests of vermiculite sources by the National Institute of Occupational Safety and Health stated: "The use of commercial vermiculite horticulture products presents no significant asbestos exposure risk to commercial greenhouse or home horticulture users" (Vermiculite Association 2005). Perlite dust can be an irritant to eyes and lungs, but the Occupational Safety and

**Table 1**. The cost of growing media has increased significantly in the past 4 years.[a]

| Component or Additive | Price Increase (%) |
|---|---|
| Sphagnum peat moss | 45 |
| Vermiculite | 38 |
| Perlite | 28 |
| Sawdust | 30 |
| Composted bark | 24 |
| Wetting agent | 8 |

[a]Courtesy of Sun Gro Horticulture.

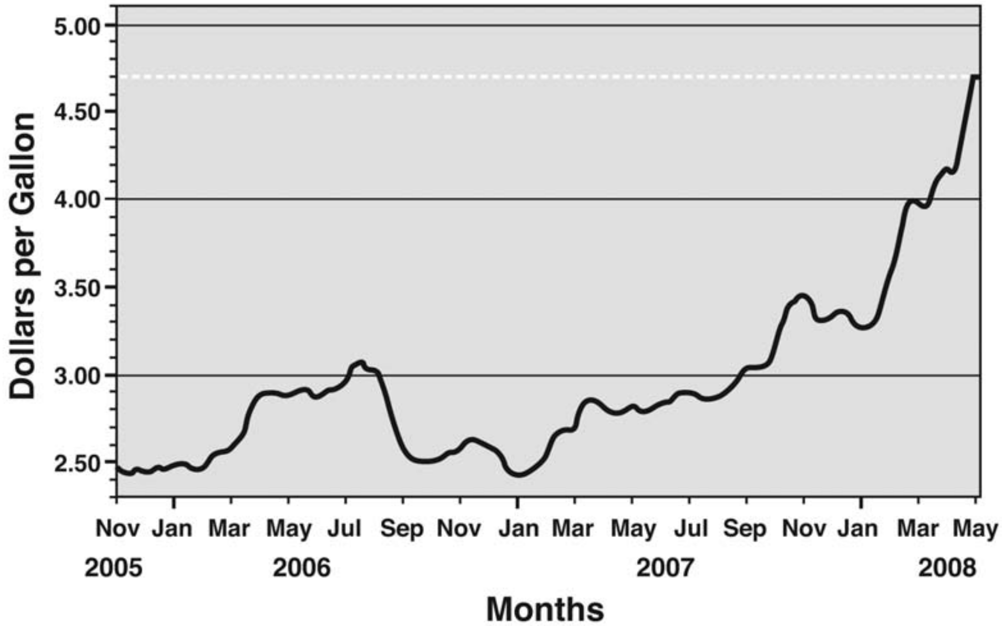


**Figure 1**. Much of the increasing costs of growing media is from fuel costs, and diesel costs have almost doubled in the past 3 years.

Health Administration (OSHA) considers it a nuisance dust. A Material Safety Data Sheet from a perlite supplier states that: "although there are no published reports of adverse health effects from exposure to perlite dust, dust levels should be maintained below the OSHA Permissible Exposure Limit for perlite and respirators used when airborne dust is present" (EaglePicher Filtration and Minerals 2004). Still, many growers would like alternatives to vermiculite and perlite.

3. Growers would like to use environmentally friendly growing media. Peat moss has been the most popular component over the past several decades, but growers have concerns about the destructive and non-sustainable harvesting of peat (Rainbow 2004). For instance, the European Union has issued directives to reduce the use of peat in growing media, and encouraged research with composted organic wastes (Bragg and others 2006).

Changing to a new growing medium will, however, require adjusting irrigation, fertilization, and other cultural procedures—sometimes drastically.

## Characteristics of a Growing Medium

The ideal growing medium for forest and native plant nurseries should have the following characteristics.

### Physical

Any medium consists of the solid material and the pores between them. The total pore space is expressed as a percentage, and can be divided into large pores ("macropores") that provide for gaseous exchange and root growth, and small pores ("micropores") that control the water-holding capacity.

### Chemical

The important chemical properties of a growing medium include pH and electrical conductivity (EC). Media particles also contain mineral nutrients, and electrical charges on their surfaces hold nutrients applied as fertilizer.

### Biological

Growing media can harbor pathogenic fungi and bacteria. "Suppressive" media contains beneficial microorganisms that can reduce the chances for disease.

### Economic

Availability is a major cost factor. Local materials are usually the most cost effective.

## Alternative Media Components

Substrates containing only organic components often lose macroporosity over time. Decomposition of organics creates an overabundance of small particles that hold excessive water and reduce air porosity. A mixture of organic and inorganic components, such as pumice or perlite, can help maintain the percentage of large pores later in the growing season (Bilderback and others 2005).

## Organics

Because of the increased cost and decreased availability of Sphagnum peat moss, numerous organic substitutes have been studied. Some types of peat moss and organic composts have been found to be antagonistic to pathogenic fungi. The least-decomposed "blonde" Sphagnum peat has been shown to suppress damping-off fungi, such as *Pythium* spp. (Wolffhechel 1988). Organic composts have also proven to have suppressive properties (Nameth 2002). Those composts with a high carbon-to-nitrogen ratio (C:N) have proven most effective (Hoitink and Cooperband 2008). Early trials found that composted bark could suppress Phytophthora root rot, and pine bark can also be inoculated with bacteria (*Bacillus* spp.) and fungi (*Trichoderma* spp.) to enhance suppression of root disease organisms (Castillo 2004).

**Composts**—"Compost," like "organic," is one of those words that is generally assumed to be beneficial, and more research has been done with composts in growing media than with any other component. It is difficult, however, to draw conclusions because of the wide variety of raw organics used for composting. Chemical and physical analyses of four common composts used in growing media illustrate this variation (table 2).

As can be seen, soluble salt levels were excessive for both total salts (as measured by electrical conductivity) and sodium, which can cause serious problems with germinating seeds and young plants. Leaching these composts with fresh water before use can effectively lower soluble salts below damaging levels (Carrion and others 2006). The pH of these composts is slightly alkaline and was, therefore, not considered a limiting factor (Miller 2004).

Wastes used for composting are often high in nitrogen and phosphorus, especially those containing animal manure; note that the turkey litter is 10 times above recommended rates. The C:N is one of the most important characteristics to measure in both raw materials and finished compost. The C:N is a good indicator of whether nitrogen will be limiting or excessive; the higher the C:N, the higher the risk of nitrogen being unavailable to plants. The carbon in easily decomposed compounds, such as sugars and cellulose, are quickly used as an energy source by soil microorganisms, which also need nitrogen for growth and reproduction. Because this nitrogen is stored in their cells, it is unavailable for plant uptake. As carbon sources become depleted, the high populations of soil microorganisms gradually die and nitrogen is released for plant growth. When C:N is greater than 15:1, available nitrogen is immobilized. As ratios drop below 15:1, however, nitrogen becomes available for plant uptake. Some composts have C:N ratios as low as 10:1, indicating they are a ready source of available soil nitrogen and are therefore considered fertilizers. A major problem has been the variation in nitrogen drawdown between batches of compost (Handreck 2005).

Wood wastes, such as sawdust, have very high C:N (400:1 to 1300:1). These materials are often composted with manure or supplemented with fertilizer to supply the needed nitrogen. Because of the inherent differences in chemical properties between different woods, however, the suitability of sawdust as an organic growing media component is extremely variable. Mastalerz (1977) stated that sawdust from incense-cedar (*Libocedrus decurrens*), walnuts (*Juglans* spp.), or redwood (*Sequoia sempervirens*) is known to have direct phytotoxic effects, and sawdust from western redcedar (*Thuja plicata*) is toxic to many horticultural plants. In the Pacific Northwest, raw Douglas-fir (*Pseudotsuga menziesii*) sawdust has successfully been used to grow conifer seedlings when it comprised 30% or less of the medium (for example, Sun Gro® Forestry Mix #3 [Sun Gro Horticulture, Canby, OR]). For example, Western Forest Systems, Incorporated of Lewiston, ID, has been utilizing a 30:70 sawdust:peat growing medium for 10 years without major cultural problems, although large wood splinters or chips need to be removed by hand during container filling and seeding. Still, the new medium has resulted in a cost savings of more than 40% (Schaefer 2009).

The C:N of tree bark can be considerably lower than sawdust (70:1 to 500:1), and has become a preferred material for horticultural composts. Composed pine bark (CPB) has become the standard growing media component for horticultural nurseries, especially in the southern United States where the cost of Sphagnum peat moss is prohibitive (Pokorny 1979). At a reforestation nursery in northern Mexico, pine bark is composted on-site and inoculated with benefical microorganisms. Not only do seedlings grow well in CPB, but the bark was found to suppress root-rot fungi and the use of fungicides was reduced (Castillo 2004). Fresh and aged bark

**Table 2**. Chemical and physical analysis of raw materials commonly used in growing media composts (modified from Chong 2003; Chong and Purvis 2006).

| Characteristic tested | Ideal range | Mushroom waste | Turkey litter | Municipal waste | Paper Mill sludge |
|---|---|---|---|---|---|
| pH | 5.5 to 6.5 | 8.2 | 8.7 | 8.4 | 7.2 |
| Electrical Conductivity[a] (ds/m) | <1.0 | 4.0 | 4.1 | 3.0 | 1.2 |
| Ammonium nitrogen (ppm) | <10 | 15 | 103 | 4 | 37 |
| Nitrate nitrogen (ppm) | 100 to 200 | 89 | 232 | 0.02 | 0.02 |
| Phosphorus (ppm) | 6 to 9 | 6 | 27 | 2 | 8 |
| Sodium (ppm) | 0 to 50 | 511 | 501 | 139 | 387 |
| Total Porosity (%) | > 50 | 71 | 73 | 66 | 72 |
| Aeration Porosity (%) | 15 to 30 | 40 | 45 | 32 | 40 |
| Water-holding Porosity (%) | 25 to 35 | 31 | 28 | 34 | 31 |

[a] EC measured as dilution of 1 part substrate:2 parts water.

of Douglas-fir is being widely used as a major component of growing media in the Pacific Northwest (Altland 2006). Bark of other tree species may also prove useful, but tests should be conducted before operational use.

The physical properties of the waste materials in table 2 were generally good, as all measures of porosity met or exceeded the ideal ranges. This varies considerably, however, with the raw material used for composting. When composted green waste was mixed with peat moss in ratios from 10% to 50%, total porosity and water-holding capacity were reduced (Prasad and Maher 2001). Some municipal wastes containing tree leaves and lawn clippings have particles so small that they can seriously reduce aeration porosity (McCloud 1994). Composts should be screened to remove excessive fine particles before use; the percentage of fines passing through a 100-mesh screen should not exceed 15% of the total volume (Miller 2004).

One recent trial in Finland compared the growth of Norway spruce (*Picea abies*) in the traditional medium of 100% sphagnum peat moss versus mixes of peat with composted nursery waste. The nursery waste compost consisted of cull container and bareroot seedlings and weeds that had been composted for 4 years and then filtered through a 4-mm screen. At harvest, the seedlings grown in the compost-amended medium were smaller than those grown in pure peat moss (fig. 2). Survival after outplanting was comparable, but seedlings grown in the compost-amended medium were still significantly shorter after 4 years. The authors concluded that changes in irrigation and fertilization could correct for these growth differences (Veijalainen and others 2007).

Compost-based media should be tried with other native plants. In Florida, a variety of native plants grown in biosolid:yard waste compost were as large or larger than those grown in a peat-based growing medium (Wilson and Stoffella 2006).

**Coconut Coir**—Coir is a waste material made from the fiber in the shell of coconuts. During the late 1980s, a method was developed to process coconut husks by grinding, washing, screening, and grading. Because it is only found in tropical areas, however, its main cost is transportation.

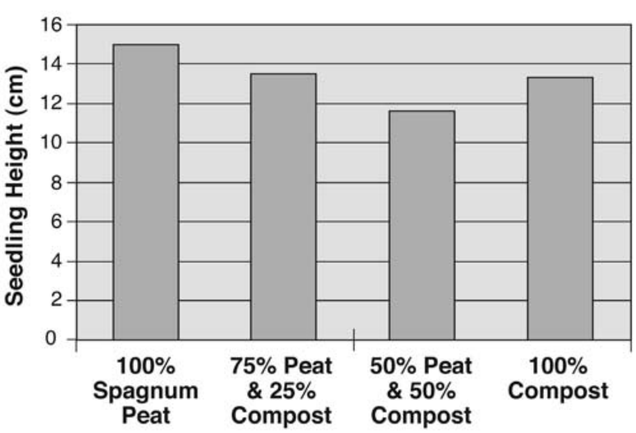


**Figure 2**. Conifer seedlings grown in composted nursery waste were smaller than those from the traditional 100% peat medium, but had good survival after outplanting (modified from Veijalainen and others 2007).

Coir is being used as a substitute for peat moss because it has a high lignin content, decomposes slowly, wets easily, and holds water. The pH of coir is ideal, ranging from 5.8 to 6.5, but the EC can be high if the husks have been stored in salt water. In this case, the product needs to be thoroughly leached with fresh water, although reputable suppliers will have already done this. Coir has a moderate CEC of 39 to 60 meq/l (less than peat moss), and can adsorb mineral nutrients (Newman 2007). Coir improves the aeration and wettability of peat media, and is an excellent root medium. Few trials have been done with forest and native plants, although Rose and Haase (2000) found that Douglas-fir seedlings in a coir-based medium were significantly smaller than those grown in peat moss.

**Composted Rice Hulls**—Several nurseries have used rice hulls in place of composted pine bark. Rice hulls are the sheath of the rice grain and a waste product of rice processing. The hulls are run through a hammer mill with 0.5-cm (0.2-in) screens, and then composted in piles for at least 18 months. The pH of the finished product ranges from 5.4 to 5.7, with a total porosity around 30%. Media containing rice hulls were less conducive to fungus gnats (Laiche and Nash 1990; Lovelace and Kuczmarski 1994).

**Fresh Rice Hulls**—In a forest nursery in Greece (Tsakaldimi 2006), uncomposted rice hulls in a 1:3 mixture with peat were an effective substitute for perlite for growing Aleppo pine (*Pinus halepensis*) seedlings (fig. 3). In another study with the same species, a growing medium of 70% Sphagnum peat moss and 30% fresh rice hulls produced quality pine seedlings that performed well after outplanting (Marianthi 2006).

## Inorganics

Growers have also been looking for alternatives to traditional inorganic components, especially vermiculite and perlite.

**Pumice**—Pumice is a natural volcanic material that is readily abundant in Oregon and other areas in the western United States. Pumice has been used as a substitute for perlite in growing media because it resists compaction and has minimal water-holding capacity. Chemical analysis has shown that pumice is chemically inert, with a slightly alkaline pH and low salt content; due to its negligible CEC, pumice contributes little to plant nutrition. Particle size will

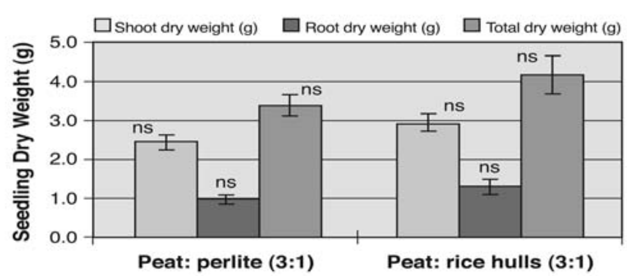


**Figure 3**. Fresh rice hulls were found to be a good substitute for perlite when mixed 1:3 with peat moss (modified from Tsakaldimi 2006).

determine physical properties, especially porosity. The total porosity of #6 grade pumice from Bend, OR, was 52%, and was almost equally divided between aeration and water-holding porosity. Horticultural nurseries incorporate up to 33% pumice into their bark-based growing media with good results (Buamscha and Altland 2005). Pumice has not been widely used in forest or native plant nurseries, but should prove to be a good way to increase porosity.

## The Return of Steam Pasteurization

Steam pasteurization is a tried-and-true method to eliminate pathogenic fungi and bacteria from growing media. The standard recommendation is to heat the medium to 60 to 82 °C (140 to 177 °F) for a minimum of 30 minutes (Bunt 1988). Although it has been used for more than 50 years, pasteurization is not common nowadays. This may change with the discovery that the virulent new fungal pathogen known as sudden oak death, or ramorum blight (*Phytophthora ramorum*), has been shown to survive in growing media as resistant sporangia or chlamydospores (Linderman and Davis 2006). Although this pathogen is only found naturally in coastal California and Oregon, it has been shown to affect a wide variety of host plants, and transportation of infected growing medium could be catastrophic. Recent research has shown that steam pasteurization can effectively eliminate *P. ramorum* and other root rot fungi from growing media by heating at 50 °C (122 °F) or higher for 30 minutes (table 3).

## Summary

Nurseries are looking for alternatives to many of the traditional growing media components, such as Sphagnum peat moss, vermiculite, and perlite. Because transportation costs are a major factor in the cost of growing media, growers should consider more local components, including composts, coconut coir, fresh or composted rice hulls, and pumice. A growing medium affects many aspects of nursery culture, and changing to a new growing medium will require adjusting irrigation, fertilization, and other cultural procedures. It is always best, therefore, to test any new growing medium before full operational use.

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**Table 3**. Steam pasteurization is effective against fungal pathogens in growing media, including the virulent new pathogen *Phytophthora ramorum* (modified from Linderman and Davis 2008).

| Fungal pathogen | Unheated | Temperature[a] treatments for 30 minutes | | | | |
|---|---|---|---|---|---|---|
| | | 45 (113)[a] | 50 (122) | 55 (131) | 60 (140) | 65 (149) |
| *Cylindrocarpon scoparium* | 97 | 56 | 0 | 0 | 0 | 0 |
| *Phytophthora ramorum* - Isolate A | 77 | 0 | 0 | 0 | 0 | 0 |
| *Phytophthora ramorum* - Isolate B | 85 | 7 | 0 | 0 | 0 | 0 |
| *Pythium irregulare* | 98 | 23 | 0 | 0 | 0 | 0 |

[a] °C (°F).

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The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.