Potting Media Constituents©

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INTRODUCTION

Major advances in potting mix formulation and nutrition have taken place over the past 30 years. In my early horticultural training in Scotland I was indoctrinated into the delights of working with the loam-based John Innes composts. I can recall potting up plants into clay pots using John Innes composts that resulted in a very heavy end product.

The move into plastic pots in the mid 1960s was a great step forward but it took growers quite a while to come to terms with the watering required with the non-porous plastic pots. The next major trend was the move to loamless composts. This trend was the result of the success of the University of California (U.C.) mixes of the 1950s. These soil-free mixes performed well in plastic pots and there was a major international movement away from soil-based mixes in the 1960s and 1970s.

The UC mixes consisted of varying proportions of peat and sand. The most widely used mix comprised peat and sand (3 : 1, v/v). This was widely used in Australia during the 1970s as a result of the efforts of Dr. Ken Baker from the University of California. The absence of any domestic Australian supplies of sphagnum peat meant that Australia was reliant on importing peat. The cost of imported peat gradually rose until it was no longer cost effective to utilise peat as a constituent of general potting mixes.

This meant that the Australian nursery industry was a leading innovator in the search for low-cost substitutes for sphagnum peat.

REQUIREMENTS OF GROWING MEDIA CONSTITUENTS

Freedom from Pathogens. A wide range of fungal, bacterial, and viral organisms can be troublesome in container plant production. Many of these pathogenic organisms are naturally found in some materials, which are suited to use as potting mix ingredients. Pasteurisation and fumigation techniques are able to eliminate pathogens from growing media but this adds to the overall cost of the media. Pathogen-free constituents are preferable.

A Uniform and Consistent Particle Size. Particle size of ingredients determines the air/water balance in the growing medium. Excessively fine materials will retain high water volume and have low air volume. Excessively large particles will reverse this balance. We need materials with a consistent and uniform range of particles so that we get an acceptable balance between air and water. My preference for air-filled porosity in a general potting mix is in the range of 15% to 20%. In a propagation mix I would be looking for 25% to 30% air-filled porosity.

Nutrient Status. If an ingredient contains a significant amount of nutrients it may be necessary to adjust the rate of fertilizers used in the medium to prevent the risk of damage to young newly potted plants. If a new material is being considered for use it is advisable to have a nutritional analysis carried out. Checking the electrical conductivity on receipt of a new batch of a medium ingredient is advisable. It can draw attention to a potential problem straight away.

Weight. Many of the early soil-based growing media were very heavy but since the trend to soilless growing media in the 1970s there has been an important trend towards reducing the weight of mixes. This is largely a Workplace Health and Safety (WH&S) issue. Workers compensation claims for back injuries caused by lifting heavy trays of potted plants are common and employers must give attention to this issue. Sand is the heaviest of the media constituents and the volumes used now in media are being reduced to reduce the overall weight.

Electrical Conductivity (EC) and pH. EC and pH meters are important tools in the management of growing media. All new deliveries of media materials should be checked and regular monitoring of batches of plants in production should be carried out. The information gained from regular pH and EC testing provides a valuable update on the fertilizer status of growing media.

Toxic Compounds. Tannins and other phenolic compounds found in wood waste products can cause problems of toxicity for young newly propagated plants after they are potted up. It is not advisable to use hardwood sawdust and bark products, which have not been subjected to a composting process. The composting process makes the phenolic compounds on the outer layer of the particles soluble and they can be flushed out of the mix during the first watering of newly potted plants.

Weed Seeds. Weed seeds in a potential media material can present a major problem in adding extra labour to the production process for regular hand weeding. Even growing media that is pasteurised to 64 ºC may still have weed problems, as many weed seeds need much higher temperature treatment for their elimination. Australia does not have access to many herbicides that are registered for use in nursery crops so long-term weed management in nursery containers can be a challenge.

Biological Stability. With the organic ingredients of a potting mix, biological decomposition is an on-going process as a result of bacterial activity in the container. The rate of decomposition varies considerably with different materials. Most organic agricultural-waste products decompose rapidly, while wood-based ingredients have a much slower rate of decomposition. Generally, the faster the rate of decomposition, the smaller the amount of a particular organic material should be used.

Decomposition of organic ingredients results in a decrease in the particle size of that ingredient and this reduces the size of the pore space structure within the mix with a significant alteration to the air/water balance of the mix.

The potted colour grower who is selling plants 8 to 10 weeks after potting has a wider range of media materials to choose from compared to a kentia palm grower who has to keep plants growing in the same pot for a year or more prior to sale.

Cation Exchange Capacity (CEC). The ability for potting mix ingredients to attract cations of nutrient elements has always been considered of great importance in the selection of potting mix materials. Brown coal, clay minerals, peats, aged pine bark, and sawdust have cation exchange capacities of a sufficiently high level to contribute to the nutrition of plants. Most other materials have low or non-existent CECs.

The fertilising strategy of a nursery determines exactly how beneficial a high CEC will be. Nurseries that rely heavily on the use of fast-acting soluble fertilizers, particularly liquid fertilizers, require high CEC's in potting mixes. However, nurseries, which use controlled-release fertilizers do not consider the CEC to be of great importance since the resin coating around the fertilizer granules limits the rate of release and minimises leaching.

Continuity of Supply. It is very important to reassure yourself that a prospective ingredient is available in sufficient quantities to justify its use and that no major disruption to supply is likely.

Cost. To many nursery producers this is the most important factor in the selection of materials and it is the main reason why nurseries seek substitutes.

MATERIALS FOR USE IN GROWING MEDIA

Soil. Soil is not widely used as an ingredient for potting mixes for a number of reasons:

- It is a heavy material;
- It usually requires sterilisation or pasteurisation;
- The nutritional content varies from place to place.

If good quality sandy loam with high organic matter content can be obtained, it can be beneficial in potting mixes.

Peat Moss. The term peat is used to describe a variety of materials. Sphagnum peat, which is derived from the partially decomposed remains of sphagnum mosses is the highest quality peat. Most sphagnum peat deposits occur in cool climates under the influence of waterlogged bog conditions. Centuries of accumulation of submerged sphagnum moss remains have led to the development of deep profile deposits of partially decomposed tissue. Most of the cellular structure of the leaves of the mosses remains intact and it is this botanical feature, which makes sphagnum peat so capable of good moisture retention.

Large sphagnum peat deposits exist in Europe, North America, and New Zealand. Currently, most of the sphagnum peat used in Australia is imported and the gradual cost increases over time have forced growers to look for lower cost substitutes. Many propagation nurseries still use sphagnum peat as the basis of their propagation and tubing mixes.

Mining of sphagnum peat deposits is usually surface collection by the cutting of blocks or by the use of large surface scrapers. The pH of sphagnum peat is low — 3.5 to 5.0 depending on source. Waterholding capacity is high; air-filled porosity can be good, depending on particle size. The cation exchange capacity is high. Most sphagnum peats are relatively free of pathogens but they are not sterile.

Modern processing techniques for peat extraction are creating a packaged peat product with a very fine texture. This can reduce the air-filled capacity of the product.

The European horticultural industry is now under considerable pressure to lessen its dependence on the use of sphagnum peat. The industry is seen as a serious threat to the wetland regions of northern Europe and growers are now being pressured into finding alternative materials for growing media.

Sedge Peat. Most Australian peat deposits are derived from partially decomposed remains of reeds and sedges, rather than from mosses. These sedge peats are highly decomposed which results in a reduction in aeration and makes them less suitable for nursery use. Many Australian sedge peats have a high mineral soil content, which increases their bulk density considerably, and they also frequently have a high ash content which increases their moisture-holding capacity.

Most Australian sedge peat deposits have developed in coastal areas and they are very likely to be highly saline, especially in lower sections of the deposit.

Pine Bark. In Australia, pine bark is the most widely used bark-based material. In other countries bark from a variety of other conifers is available, and the use of hardwood bark from species such as oak, hickory, maple, and walnut is increasing.

In Queensland F_1 hybrids derived from *Pinus elliottii* (slash pine) and *P. caribaea* var. *hondurensis* (Carribean pine) form the basis of the softwood timber industry. In the other states of Australia and in New Zealand F_1 hybrids of *P. radiata* are most widely used. Most nursery-based research has been carried out on radiata pine bark and it is not clear to what extent Carribean and slash pine hybrid barks may differ.

Throughout Australia pine bark is available in large quantities. It must be hammer-milled to reduce the particles to an acceptable size and this provides the opportunity to "customise" bark-based potting mixes to suit the air/water requirements of the grower. The air/water ratio of any potting mix is directly influenced by the relative sizes of the particles and pine bark is the only raw material which allows this "customising" to be carried out.

Bark, like sawdust, contains a number of phenolic compounds, which can be toxic to plants. It is recommended that bark should be aged for 4 to 6 weeks in a moist condition prior to mixing. Prolonged composting, as is recommended with hardwood sawdust, is not necessary with bark.

There is some evidence that bark contains substances, which are antagonistic to fungal pathogens, and that development of these pathogens is retarded in bark-based mixes. However, at this stage the results are inconclusive and much more work needs to be carried out.

Provided that the particle size range is suitable, bark-based mixes have good aeration and provide good water-holding capacity. The pH of bark is initially low (4.0-5.0), but it rises during the aging process. Cation exchange capacity is also good.

Sawdust. Two types of sawdust are used in Australia as container potting mix ingredients:

1) *Hardwood Sawdust.* In Australia the genus *Eucalyptus* is the only genus of hardwood trees milled in sufficient quantity for commercial supplies of sawdust to be produced.

In the Australian timber industry there is considerable regional variation in the *Eucalyptus* species milled:

Western Australia (WA)	Karri (*E. diversicolor)* and jarrah (*E. marginata*)
South Australia (SA)	River red gum (*E. camaldulensis*)
Victoria (Vic)	Mountain ash (*E. regnans*)
New South Wales (NSW)	variable species milled
Queensland (Qld)	variable species milled

The variable timber species milled in NSW and Qld may include: Spotted gum (*E. maculata*), red ironbark (*E. sideroxylon*), black butt (*E. pilularis*), Sydney blue gum (*E. saligna*), mess mate (*E. cloeziana*), and tallow wood (*E. microcorys*).

Frequently sawdust from local sawmills may be from a mixture of timbers and this may vary from day to day depending on the species of logs being milled. In the states where large amounts of one timber species are milled, sawdust uniformity is greatly improved.

The incorporation of sawdust into a potting mix makes the mix more susceptible to nitrogen drawdown and the grower must manage this. A predictive test, the nitrogen drawdown index test, has recently been developed in Australia to assess the likely problems associated with nitrogen drawdown in organic potting mix materials.

Timbers produce a number of phenolic compounds. These are natural wood preservatives and they can occur in large quantities in some timber species. Many small plants react adversely to the presence of these toxins as they are leached out of the sawdust particles. Plant sensitivity to phenolic compounds varies considerably. Generally, small newly propagated plants such as seedlings, rooted cuttings, and tissue culture plantlets are affected to the greatest extent. Older, larger-sized plants are usually affected less. It is for this reason that sawdust is not recommended as a constituent of propagation mixes.

Nitrogen drawdown and phenolic compound toxicity problems can be overcome by subjecting fresh sawdust to a composting process. The fresh sawdust is placed in an even-sized heap and thoroughly moistened. Urea is added to the pile at the rate of 2.6 $kg \cdot m^{-3}$. The pile should be turned regularly using an end loader to obtain a uniform composting effect. For a rapid acceleration of the composting process the pile should be covered with a clear plastic sheet. With a covered pile, composting will be complete within 2 to 4 weeks, depending on time of year. In an uncovered heap, composting may take 2 to 3 months.

2) *Softwood Sawdust.* This is usually derived from *Pinus radiata* or *P. elliotii* × *P. carribaea* var. *honduriensis* hybrids. Pine sawdusts have a softer texture and therefore decompose more quickly. When used with fast-growing, short-cycle plants, few problems will occur. However, with slower growing plants with a long nursery production cycle decomposition of the sawdust will be a gradual occurrence and this will alter the air/water balance of the mix in favour of a higher water-holding capacity.

With slow-growing plants it is recommended that softwood sawdust should not comprise more than 25% of the total volume of the mix.

Sand. The term sand is generic and it covers a range of materials with a particle size range from 0.05 mm (very fine sand) to 1.0 mm (coarse sand). Recommendations in the U.C. mixes are for sands in the size range 0.1 – 0.5 mm. Sand provides weight or ballast in light plastic pots, provides the aeration requirements, and helps to keep mixes open, so preventing re-wetting difficulties. Avoid using calcareous sands, which raise the pH of the mix, and avoid the use of beach sand or any sand with a high salinity level.

Quartz sands are preferred and crushed sharp particles are better than the rounded particles of river sands, which can settle out during transport or mixing. A recent Nursery Industry Accreditation Scheme Australia (NIASA) audit carried out at the University of Queensland Gatton Plant Nursery indicated the presence of *Pythium* in the sand supply used in our potting media. John McDonald, the Queensland NIASA inspector indicated a preference for sourcing sand from depths greater than 2 m to minimise the infection risk.

In Australia there is a general trend to reduce the amount of sand used in potting media to enable the overall weight of the mix to be reduced. It is common to have the sand component of mixes down at the 10%–20% level. Some media manufacturers are dropping sand out altogether.

Coir Fiber. Coir is a shredded coconut husk based by-product, which is now being widely used in propagation mixes and in some specialised potting mixes. It is also referred to as "coco-peat" which is a smart marketing strategy. It is being widely used as a replacement for sphagnum peat by some cell seedling producers. It is also a lighter weight alternative to sand in potting mixes. The coir industry is based in southern Asia and the Pacific Island region. Some samples imported into Australia have been highly saline so care must be taken to ensure that the electrical conductivity is tested prior to use.

A local Brisbane potting mix supplier is offering a bark-based mix with 10% to 20% coir added. The coir has a fine particle size so it will increase the water-holding capacity of the mix. If the bark has the best blend of particle sizes, the air-filled porosity will not be affected by the presence of the coir.

Coir is expensive by comparison with sand and this will limit the amount used in potting mixes.

Other Organic Materials. A wide range of waste materials resulting from the processing of agricultural and horticultural crops is available locally in Australia and many nurseries utilise these as media constituents because of their low cost. Generally, it is considered dangerous to use these waste materials in too large a quantity and the recommendation that they should comprise no more than 25% of the total volume of any mix is quite sound (Handreck and Black, 2002).

Examples of low-cost organic materials used in potting media include:

- Sugar cane bagasse
- Peanut shells
- Rice hulls
- Garden composts
- Sunflower husks
- Cotton seed hulls
- Vermicompost

OPTIONS IN THE PREPARATION OF GROWING MEDIA

Option 1: Mixing on the Nursery. Many nursery producers prefer to mix all of their own growing media on site. Media quality will be influenced by the conditions under which the raw materials are stored. They should preferably be stored on a hygienic drained concrete slab with concrete block or brick walls surrounding the heaps. The NIASA accreditation scheme discourages the use of timber walls for ingredient storage.

There is reluctance on the part of some nursery producers in Australia from buying pre-mixed media from media suppliers and many producers will continue to mix their own media. It is one way you can be sure you know exactly what has gone into the mix.

Changing WH&S standards have meant that many of the large converted concrete mixers used in the Australian nursery industry are no longer compliant under WH&S requirements. A WH&S safety audit carried out last year in the University of Queensland Gatton Plant Nursery by officers of the Queensland Division of Workplace Health and Safety resulted in a prohibition order being served because the mixer was considered to be unsafe. This ruling was based on the mixer controls being located at the back of the machine, which meant that there was no clear line of sight to the front of the machine where the action takes place. We now have a new mixer, which is fully compliant.

Option 2: Purchasing Pre-Mixed Media Ready to Use. In most major capital cities in Australia there are a number of potting mix manufacturing companies offering pre-mixed media in bulk to nurseries. Many of the better media producers are NIASA accredited and they produce good quality mixes. For nurseries that are well away from the capital cities the freight cost of getting mixes delivered can be prohibitively high.

Media manufacturers are placing great emphasis on air-filled porosity and available water in the formulation of their mixes. Pine bark has become the most widely used component of most pre-mixed mixes. There is no doubt that this is a result of the "customising" of the particle size to ensure consistently uniform air-filled porosity and available water.

Many of the media manufacturers are also placing great emphasis on the nutrition of plants with modern controlled-release fertilizers incorporated in the mixes.

Examples of Media Currently Available from a Brisbane Media Supplier. Note on percentages: Extra material is added to counter the effects of shrinkage with diverse particle sizes, so some mixes add up to more than 100%.

- Premium propagation and tubestock mix:
  100% zero to 10-mm composted pine bark
  10% triple-washed pit sand
- Premium container growing media:
  80% zero to 15-mm composted pine bark
  20% zero to 10-mm composted pine bark
  10% triple-washed pit sand
- Premium sandless growing media:
  100% zero to 10-mm composted pine bark
- Premium fines sandless growing media:
  100% zero to 6-mm composted pine bark

These mixes confirm the dominant role that hammer milled pine bark has assumed in modern potting mix formulation. It is my belief that this dominance will continue as nursery producers strive to attain faster and more uniform growth of crops.

LITERATURE CITED

Handreck, K.A. and **N.D. Black.** 2002. Growing media for ornamental plants and turf. 3rd ed. University of New South Wales Press, Sydney, N.S.W.