Nursery Crop Science
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Managing Container Substrates

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Managing Potting Supplies

How organic potting components are stored and managed can have great effects on the chemical and physical properties of the container mix. Organic potting materials such as pine bark, hardwood bark, rice hulls, leaf and yard waste composts, animal waste composts and sphagnum peatmoss require moistening and turning if they are stored or maintained as bulk inventories. Organic potting materials, even after they have been composted and stabilized, require moistening and turning if they have been undisturbed for more than 3 to 4 weeks. Organic components dry out, particularly if they heat up and lose moisture through steam.

Also, moistening potting components before blending with other components creates much more desirable physical properties compared to mixing dry components. For example, if dry sphagnum peat moss is mixed with dry pine bark, prior to adding water, the mix will have low aeration and water may actually puddle on the surface of the substrate. If the components are moistened prior to mixing, the sphagnum peat moss becomes spongy and well hydrated and the pine bark holds additional available moisture; when the components are blended the spongy peatmoss holds the aeration and the particles do not collapse together or fit as tightly. Aeration of pre-moisten components will be higher than components mixed dry.

Chemical characteristics of potting substrates are also affected by storing and inventorying practices. The more unstable an organic potting component is, the more it needs to be turned and moistened. Essentially, good composting practices need to be followed on unstabilized components, turning inventory windrows and keeping the height of the windrows below a maximum of 10 feet. Windrows can be turned daily, weekly or by monitoring temperatures and turning inventories when temperatures reach 140^{o} to 160^{o} F. Unstable potting components should be turned and re-moistened until they no longer heat beyond 140^{o} F.

Pine bark is utilized by the nursery industry as a green / fresh or aged / composted product. Wood splinters and cambium contained in green / fresh pine bark enhance rapid decomposition, heat and moisture loss in inventories. Excessive heat can char bark particles, creating charcoal characteristics and altering chemical and physical characteristics of the bark. Aged or composted pine bark supplies have reached a more stable state, however unless conditions were managed during the aging process, problems may be present. However, both products require management including turning and re-wetting. Green/fresh pine bark supplies will rapidly develop dry bands and anaerobic pockets. Dry bands 24 to 30 inches from the top of the pile are frequently accompanied by a grey mycelium seen as clumps when the pile is disturbed. This band creates a impervious layer above the interior of the pile. The impervious layer deprives microbial decomposers of oxygen. When oxygen is depleted, the microbial flora changes to anaerobic organisms which generate acetic acid and in the presence of moisture in the middle of the pile, extracts many salts, including potassium. The result is that anaerobic pockets may have pH as low as 2.3, EC levels as high as 2.5 mmhos/cm and potassium concentration as high as 200 ppm. If plants are potted in pine bark with these characteristics, plants will die or be stunted. The key is to turn inventories of pine bark at the nursery and inspect supplies when they are delivered. Look for gray mycelial clumps and test for pH and EC.

Samples can be collected for testing by filling small containers, pouring distilled water over the pot. Wait approximately 20 minutes for equilibration and then pour water over the surface again and collect the leachate that drains from the pot. Check the pH and EC. If pH is less than 3.8 or EC higher than 0.5 mmhos, consider not potting in the inventory immediately. Place sprinklers or a soaker hose over the pile, wet the inventory, turn it 2 to 3 times over the next month and check the pH and EC again.

Mixing Up Potting Mixes

There are no "one size fits all" recipes for growing containerized ornamental plants. However, not all nursery crops thrive under the same cultural practices related to irrigation frequency, nutritional regimes or potting mixes. The predominant potting components in nurseries in most of the eastern U.S. are pine bark, sand and sphagnum peat moss. Some alternative materials that are being used include shredded coconut husks (coir), composted yard wastes and animal wastes, composted cotton gin wastes, composted hardwood bark, mushroom compost, municipal compost, rice hulls, peanut hulls, and pecan shells. The stability and chemical and physical characteristics may limit the volume of alternative materials that can be used in a potting substrate. Unstablized organic components decompose rapidly, leaving a full container, 3/4 full in a few weeks. Composted materials often lack the large coarse particles necessary for adequate aeration and can not be used in volumes greater than 50% for most container substrates. Animal wastes characteristically have high electrical conductivity (soluble salts) and nutrient levels, therefore are usually limited to 10 to 30% volume in potting substrates. Potting mixes containing compost components will generally have higher pH levels ranging from 6.0 to 6.5 in contrast to pine bark or sphagnum peat moss substrates which even with dolomitic limestone addition frequently range 5.0 to 6.2. The higher pH is generally not a problem for growing most nursery crops but, since composts have a "liming effect" dolomitic limestone should not be added to compost containing potting mixes and usually, no minor element packages are required.

Physical properties of substrates

Physical properties for container potting substrates include, particle size distribution, total porosity, air space, water holding capacity (container capacity), available water capacity and unavailable water content and bulk density. There are no distinct physical property standards for container substrates, however, normal ranges for nursery containers substrates after irrigation and drainage are easiest to manage within the normal ranges shown at the bottom in Table 1. A balance between aeration and moisture content is necessary for optimum growing conditions. Fewer problems related to over-watering during production would be expected with potting mixes that have at least 15% air space in test samples. A perched or saturated water table is created by the bottom of the container. In a container, air space increases as height increases above the bottom of the container. Air space also increases as water is lost.

Blending components yields physical (and chemical) characteristics that are intermediate between characteristics of the components. For example, addition of sand to pine bark tends to increase moisture retention and available water content but reduces air space and total porosity (Table 1). The greatest liability is that air space may be reduced too much, requiring careful irrigation management to avoid waterlogging and anoxia of roots. Growers in the Southeastern U.S. frequently add sand to pine bark, but may think that the only reason is to increase the weight of the container, to reduce blowing over of containers in growing beds.

Another less obvious reason to add fine particle components such as sand is that the infiltration rate of irrigation water is slowed down as it moves through the container profile rather than channelling rapidly to the bottom of the container. This promotes wetting of the substrate. However, too much sand can increase weight too much, creating handling and shipping difficulties.

When greatly different particle sizes of potting materials such as fresh pine bark and sand are combined, considerable component shrinkage occurs. In this case one cubic yard plus one cubic yard is not equal to two cubic yards. The shrinkage may yield a volume of 1.5 cubic feet. In this situation a great increase in bulk density which is the solid composition of the substrate would be expected. Particles less than 0.5 mm in pine bark create many of the pores that hold water. Fresh pine bark has very few particles less than 0.5 mm so growers add other components to replace the fines for better moisture retention (Tables 1 & 2). Moisture holding characteristics for organic components are different from soils, since water is held within particles and fibers as well as between particles as in soils. Moisture held within chambers in pine bark particles and inside fibers of sphagnum peat moss are available and explored by plant roots.

Irrigation and fertility must be closely managed to optimize air, water and nutrient characteristics of the substrate to avoid excessive leaching or salt build up or too wet or dry conditions in containers.

Particle size considerations for potting substrates

The age and handling prior to use as a potting component affect the physical and chemical characteristics of pine bark. Loblolly pine is the predominant species of pine used for pine bark potting substrates over much of the Eastern U.S. This pine bark is generally considered to be non-phytotoxic and can be used without aging or composting. Aging produces a more stable material and allows break down of larger particles, degradation of wood, cambium and complex compounds associated with the turpentine like smell of fresh pine bark. Aged pine bark is sometimes referred to as composted bark, although in the strictest sense, unless pine bark is amended with a nitrogen source, moistened and turned regularly as described as composting procedures for leaf yard wastes and animal wastes, true composting may not fully occur. Stability of an organic material is frequently based upon it's carbon to nitrogen ratio. For most organic potting components the ratio should be at least 30 : 1 (C : N), however, even composted pine bark may not have this low of a C / N ratio since most of the pine bark is lignin and not cellulose.

Stability and particle sizes of potting components and how two or more components "fit" in the mix is important and creates the physical properties discussed in Table 1. Stable components are necessary since rapid decomposition will also continually change the physical properties, decreasing air space and increasing moisture retention. Nitrogen applied for plant growth may also be used during decomposition, resulting in reduced growth of container plants. Particle size distributions of potting substrates can be measured. Results generally compliment physical property data, but can be used to diagnosis potential aeration and water retention difficulties if used for crop production (Table 2).

Table 1. Physical properties of selected substrates.[z]

Substrate[y]	Total Porosity	Air Space	Container Capacity	Available Water (% Volume)	Unavailable Water	Bulk Density (g/cc)
Fresh Pine Bark	86	42	44	13	31	0.19
Aged Pine Bark	82	31	51	21	30	0.19
Fresh PB +Sand	81	31	50	19	31	0.34
Aged PB + Sand	82	27	55	24	31	0.36
9PB:1P	79	15	63	39	34	0.19
9PB:1Soil	74	15	59	33	26	0.31
3PB 3/8" 2P:2RH	87	16	72	48	24	0.19
Normal Ranges	50.0-85.0	10.0-30.0	45.0-65.0	23.0-35.0	23.0-35.0	0.19-0.52.0
	(% volume)				(g/cc)	

[z]All analyses performed using standard soil sampling cylinders (7.6 cm ID, 7.6 cm h)
Air Space and Container Capacity affected by height of container.

Table 2. Particle size distribution of selected nursery container substrates.[z]

Sieve no.	Opening (mm)	Substrate[y]						
		Fresh Pine Bark	Aged Pine Bark	8 Fresh PB + 1 Sand	8Aged PB +Sand	9 PB 1 PeatMoss	9PB 1Soil	3PB 3/8" 2P:2RH
0.25	6.3	9.0	13.3	5.0	6.1	7.9	6.1	5.8
10	2.0	47.3	36.2	28.7	26.4	34.6	30.7	29.5
25	0.7	25.7	23.2	34.3	30.5	28.4	30.0	28.7
		82.0%	72.7%	68.0%	63.1%	70.9%	66.8%	64.0%
35	0.50	6.8	7.3	14.3	14.5	8.6	11.1	15.5
60	0.25	7.6	10.0	14.3	14.5	12.1	14.4	14.4
140	0.11	2.8	7.2	2.8	5.7	5.9	6.5	4.8
pan	0.00	0.8	2.8	0.6	2.3	2.5	1.2	1.3
		18.0%	27.3%	32.0%	37.0%	29.1%	33.2%	36.0%

[z]Suggested ranges for fine particles < 0.5mm in size (% weight) is 20% to 30% for pine bark fines and < 50% for multiple component blended potting substrates.