Container production greenhouse and nursery businesses do not grow plants in native soil but in mixes of media/substrate components that are free of mineral soil components. Some of these components could be used alone to grow plants (such as bark), but more often, growing substrates are made with different portions of various components, each contributing to the chemical and physical properties of the final product. The physical and chemical properties of each substrate component are not as important as those of the final product.

Generally, the substrate should be free of any pests (weeds, diseases, and insects). It should be heavy enough to hold the plants from frequent tipping over and yet light enough so you do not have to pay a substantial shipping and handling charge.

The substrate should hold enough water to reduce the need for frequent watering and drain well to prevent waterlogging in the root zone. Whether purchasing substrate components to make customized mixes or ordering it ready mixed, you need to consider the availability, cost, and consistency between batches. Container-grown plants get their water and nutrients directly from the substrate, and a proper substrate is very important for successful container production.

Organic Media Components

**Peat**

Peats used in container production are usually divided into three types, from the least composted light brown peat moss to reed-sedge moss to the highly decomposed dark brown to black peat humus. The pH of peats ranges from 3.0 to 4.0 for peat moss to 5.0 to 7.5 for peat humus. Sphagnum moss peat is the most commonly used peat in container substrates. The large cell structure of sphagnum peat provides good water holding capacity and the cation exchange capacity (CEC), a measure of the capacity for absorbing nutrients, ranges from 7 to 13 me/100 cc. Peat moss is lightweight and normally sold in compressed bales that can expand to two or three times its original volume when properly fluffed up.

When peat moss is used in container substrates, several issues need to be addressed. The low pH of peat
requires addition of lime to bring up the pH for most crops. Peat moss is hydrophobic (repels water), so a wetting agent needs to be incorporated if the peat moss supplier has not already done so.

Most peat moss products used in the US are harvested from living US and Canadian peat bogs, and the natural regeneration of the bog ecosystem is very slow compared to the rate of peat harvesting. There is increasing pressure from environmentalists to ban peat moss mining and search for an alternative substrate component.

**Bark**

Bark is a byproduct of forestry production. It is removed from the trees, milled, and then screened to various sizes for different purposes, including landscape mulch, container production substrate, and soil conditioner. Bark used as container substrate is normally three-eighths inch or smaller. In the southeast US, pine bark is the main bark available, while redwood bark and fir bark are commonly used in the Pacific northwest. Hardwood bark is not as commonly used, probably because some of its chemical compounds are toxic to plant growth. Bark was once very inexpensive, costing only the transportation from the forest site to the nursery and milling.

Reduced timber production, largely because of a sluggish housing market and alternative demands for bark (such as for alternative fuel), has raised bark prices and limited its availability for container production. When used in container production, bark can be used alone or amended with up to one-fourth (by volume) peat moss to help with water holding capacity (to hold water better). Normally, adding lime is also needed to bring the pH up to a desirable level.

Based on the level of decomposition, bark could be categorized as fresh or composted. Although fresh bark could be used directly in container production, growers normally use at least partially composted bark, since volume shrinkage and nitrogen tie-up are more associated with fresh bark.

Two ways to compost bark are with or without addition of nitrogen. During decomposition, microorganisms need both carbon (for energy) and nitrogen (for cell structure building). If there is too much carbon in the material, nitrogen is rapidly used up.

Adding nitrogen helps speed up the decomposition. Bark can be used in container production after as soon as 4 to 6 weeks of decomposition if nitrogen (commonly ammonium nitrate) is added to the composting bark pile, compared to 3 months to a year when no nitrogen is added. Nitrogen deficiency sometimes happens in container production when using incompletely decomposed bark.

Microorganisms use nitrogen fertilizer applied to the plants for decomposition and is not available to plants. When stripped from the log, some wood components can come off with the bark. The wood component normally decomposes faster than bark, and enough composting (depending on the amount of wood content) is definitely needed to bring it to a stable rate of decomposition.

**Coir**

Coir, sometimes called coconut coir dust, is the mesocarp pithy tissue plus short-length fibers left from the husk of coconut fruit after the long fibers are extracted to make other products. It is brown and looks like shredded peat moss.

Coir is mainly supplied by countries where coconuts are grown, including Africa, South and Southeast Asia, and Central America. Its physical and chemical properties are probably closer to peat moss than any other existing substrate material. Coir has been used as a partial substitute for peat moss because of environmental concerns mentioned earlier. When substituting peat moss with coir in bark-based mixes, you can add a light substrate component, such as vermiculite or perlite, to reduce the bulk density of the final mixes. Most carbon in coir is in the form of lignin (suppressing decomposition) and cellulose. The decomposition of coir is slow and steady despite its 75 to 186 C/N ratio.

Advantages of coir over peat moss include its superior rewetting ability and slightly higher pH. As mentioned in the “Peat Moss” section, peat moss is very hard to rewet once allowed to dry to undesirable level. Coir does not have this problem and will continue to absorb water. The higher pH of coir requires less lime to counteract the acidity than peat moss. Make sure to note the salt content of different sources of coir. Salinity of coir from various sources can vary almost 20 times (39 to 597 mS m−1 in the saturated media extract). Although nitrogen, calcium, magnesium, and micro-element contents are low, phosphorus (0.28–2.81 mol m−3), potassium (2.97–52.66 mol m−3), chloride, and sodium contents can be very high, and you should consider them in fertilization programs in production.

Coir is normally dried for the convenience of shipment and compressed into coir bricks. It has to be rehydrated before use. After hydration, the volume expands to several times its dry volume.

**Wood and Wood-Containing Products**

Alternative substrates, including wood and wood-containing products, have been investigated because of the shortage of bark and concerns of environmental impact from harvesting peat moss. Examples of wood substrates include ground melaluca tree; wood chips produced by grinding entire trees, including leaves, twigs, bark, and wood of post oak; Siberian elm and young pine trees; and noncomposted sawdust from Douglas fir and western hemlock. In addition, red-
wood sawdust has been used in container production where it is available. In general, wood and wood-containing products have a considerably high C/N ratio, which may result in rapid decomposition, volume shrinkage, and nitrogen tie-up. Therefore, adequate nitrogen needs to be incorporated into the substrate through a pre-planting or post-planting fertilization program. Growers without much experience growing in these types of substrates are recommended to conduct their own trials before switching from traditional substrates.

**Animal Manures and Composts**

Animal manures were the main source of fertilizer before the invention of chemical petroleum-based fertilizers. Cattle, pig, chicken, and horse manures, among others, are available from various farms. Fresh manures are not pleasant to handle, considering the odor and the high water content. Fresh manure often contains high levels of soluble salts and ammonia, which can “burn” plant roots so, normally, composted but not fresh manures are used.

When composting, make sure the temperature at the center of the manure pile is high enough to kill any weed seeds and most pathogens. Different manures require different composting times. For instance, 40 to 60 days of composting is usually enough for cow manure. Technology has been developed to reduce odor and to dry and pelletize manure for use as compost and fertilizer.

Composted manure is a very good source of nutrients (low amounts of nitrogen, phosphorus, potassium and an array of micronutrients) and has good water holding capacity and high CEC that helps hold applied nutrients. High content of organic matter in manure helps improve the substrate physical properties such as porosity, bulk density, and water holding capacity. Some concerns associated with manures include weed seeds, high salt content, and ammonia content.

Vermicomposting is another way “composting” animal manures by involving specific earthworms to digest fresh animal manures. The end product, called vermicompost, has considerably different physical and chemical properties from natural manure composts. It can be incorporated in container substrates up to 25 percent (by volume). Increased microbial activities and improved physical properties are considered its major advantage. The source of manure affects the physical and chemical properties of vermicompost and consistency could be a problem for container production.

**Crop Byproduct**

Mississippi is a big agriculture state, and a lot of agronomic crop byproducts can be used in container substrates. In addition to rice hulls and cotton gin trash, peanut hulls and pecan hulls can be used as container substrates.

**Rice Hulls.** The rice industry in the Mississippi Delta supplies plenty of rice hulls in fresh, parboiled, carbonized, and composted forms, all of which can be used as substitutes for perlite. Parboiled, carbonized, and composted rice hulls have less weed problems than fresh rice hulls. You have to check stored rice hulls more frequently than the others to prevent mice nesting in rice hulls.

**Cotton Gin Trash.** Cotton gin trash is the waste product from cotton gins and is readily available in Mississippi. It contains mainly the cottonseed hulls after the linters and the kernels inside of the hulls are removed. Composted gin trash can increase the water- and nutrient-holding properties of the substrate. High soluble salts and high pH are potential concerns but, you can correct this quickly through leaching with water and less addition of lime. Research has shown that cotton gin compost can be amended with bark or replace bark in container production.

**Inorganic Media Components**

**Perlite**

Perlite is probably the most commonly used substrate component in greenhouse production and nursery propagation. Perlite is white, about one-tenth of an inch in size, very lightweight (6 to 8 lb/ft³), chemically inert, pH neutral, sterile, and odorless. It is produced by heating silicaceous volcanic rock under high temperatures (1,100 to 1,600° F). Different from vermiculite, perlite has a closed structure that does not absorb water but provides air space and it is commonly incorporated in container substrates to improve the drainage or aeration.

**Vermiculite**

Similar to perlite, vermiculite also originates from mined rocks that are heated to produce a finished product – small, silver-gold cubes containing numerous thin plates stacking together, which hold water and nutrients well. Just like perlite, vermiculite is sterile, lightweight, and odorless. Vermiculite from various sources has neutral to slightly alkaline pH, so proper adjustment (such as less lime, water acidification) is needed when incorporating vermiculite with other components in the container substrate for different growing purposes.

Asbestos-contaminated vermiculite used in house insulation has been a concern. Although this has not been reported on vermiculite used in container production, it might be wise just to assume that all vermiculite contains asbestos and wear a dusk mask to avoid inhaling the material when handling vermiculite.

**Sand**

Sand can provide drainage and aeration and is a common substrate component mainly used in propagation.
applications. For that purpose, coarse sand is preferred over fine grade sand. Sand is similar to perlite in that it is inert and pH neutral, but it has much greater bulk density, which increases shipping and handling costs. But you can use it to add weight and reduce container blow-over in outdoor production.

**Rock Wool**
Having similar origin to perlite and vermiculite, rock wool has negligible CEC and almost no available nutrients. Except for a slightly alkaline pH, it does not “act” or “react” when used as a growing medium. Rock wool, available in forms of slabs, cubes, or strips, are used extensively in hydroponic production, mainly providing support for the plants’ root structure.

Although it is not used extensively outside of hydroponic systems, it might find its way in producing mini-plants (less than 2-inch containers) where substrate retention could pose a problem.

**Soil**
Mineral soil was slowly phased out of container production with the introduction of soilless substrate components. Soil is too heavy for long-distance shipping. Soil-borne pest problems and huge variations between batches of soil prevented its use as a major component in container substrate. But mineral nutrients and active microorganisms might be helpful in container production when incorporated at a very smaller percentage (less than 10 percent).
Other Inorganic Amendments
Other amendments Mississippi growers might hear about but are generally not used extensively include polystyrene foam, calcined clay, and composted garbage.

Typical Greenhouse Mixes
The most common substrate components used in formulating greenhouse substrates include peat, perlite, vermiculite, and bark. You have two primary options when considering greenhouse mixes for production: buying premixed or mix-your-own.

Premixed
Purchasing premixed media is a common practice for greenhouse container production. Substrate suppliers offer the mixes in various package sizes (2.8 cu. ft. bags, 3.8 cu. ft compressed bales, 60-80 cu. ft mini bulk, 55 cu. ft. compressed big bales, and 135 cu. ft. compressed mega bales). Recipes are specially formulated to meet different production needs, for instance, propagation, specific crops (such as bedding plant mix, poinsettia mix, and mum mix), or general crops.

In addition to the major substrate components (peat moss, bark, perlite, and vermiculite), starter nutrients (sometimes including micronutrients), lime (dolomitic, calcitic lime, or both), and wetting agents are common components of the premixed media recipes. Now suppliers are offering mixes containing incorporated slow release fertilizer, fungicide, and/or growth promotion products (such as mycorrhizal fungi).

You can also purchase media custom-blended to meet the demands of your specific operation by requesting specific ratios of various components and amendments, including lime, wetting agents, fertilizer, and fungicide.

Mix Your Own
With the physical and chemical properties of each substrate component in mind, you can mix your own container substrates. This is not recommended unless you have experience mixing substrate.

Typical Nursery Mixes
The most common components in an outdoor nursery container mix include bark, peat, and sand. Bark typically comprises from 75 to 100 percent of a mix. You can add peat to increase the water-holding capacity of the mix and reduce watering frequency, or you can add sand to increase the weight and reduce container tip-over. You can add lime to counteract the acidity of bark and peat. You can also incorporate fertilizer, fungicide and pre-emergent herbicide during the mixing process. A cement mixer should be able to meet the needs of a small- to medium-scale nursery.

General Mixing and Handling Recommendations
Wear a dust mask and gloves when handling the substrates to avoid contact with hazardous materials. Proper “fluffing” is needed for compressed bales, and sprinkling with water during fluffing helps water absorption after the substrate is potted.
Test the substrate pH total soluble salts (electrical conductivity) and wettability before use to avoid adverse effects on plants because of variation between batches. Thoroughly mix components, but don’t over-mix, especially if a medium contains vermiculite or plastic-coated slow-release fertilizer, to avoid grinding the particles.

Avoid contamination of components or finished substrate by keeping amendments in closed bags or by covering outdoor piles. Do NOT make changes to your current growing substrate without experimenting first to see if the changes will affect your cultural practices. Do NOT store substrate that contains fertilizer for long periods of time, especially if the substrate is moist. Do NOT allow mixes containing a significant amount of peat moss to dry out.
References

