THE UNIVERSITY of TENNESSEE Extension

The Pot-in-Pot (PNP) Production System

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Definition of Pot-in-Pot (PNP, may be seen as PIP): One container is nested inside of another, with both recessed in the ground up to the rim of the bottom one. The first container is referred to as the holder or socket pot and is usually injection molded for greater durability. The stiffness and strength of this pot helps to prevent the soil from compressing and pinching the two containers together. It might have a ten year life, if another pot replaces the harvested pot immediately, to prevent sunlight degradation. The container with the plant is generally blow molded, less expensive and will be sold with the plant. The sides of a blow molded container are not as stiff as an injection molded container.

Advantages: no blow-over, overwinter in place, no overwintering structures required, little irrigation water required, no run-off, no gravel, late summer-early fall cash flow, can harvest PNP when field digging would be impossible, labor can pot when weather is too inclement to work outside (if a facility is available), foliage is not wet by irrigation (skip laurel, photinia and dogwood will have less disease potential), cooler root temperatures than conventional containers, higher population per acre than field is possible.

Disadvantages: Set-up costs: a drain tile is required under each row, 2 pots required per plant for first crop, an irrigation line is required for each row, 1-2 irrigation emitters per container, irrigation water must be very clean, (disc or sand filters), a high level of management (much greater than field, irrigation lines must be checked daily during operation), a good quality media, root escapes on some species, spacing is inflexible once holes are drilled.

Anticipated Costs: “$20,000/acre set-up cost. $15-25 set-up cost per #10 container.”--a local PNP producer after 3 expansions, 2002.

Container Size: gallon verses # class

Nursery containers are no longer being sized or measured by gallons. The variation in size between container brands was tremendous. Our container industry was challenged for selling container plants by a gallon volume that did not measure up to the volume of the container.

Many containers were not of actual gallons, but either more or less than the ‘gallon’ volume. The reference to gallon, a liquid volume, was not reflective in what the nursery industry was selling. Standardization was needed to base the container size on dimensions not volume.

In 1995, the container class specifications were updated in the ANSI (American National Standards Institute) 60.1, which is used to define the size of the container based on the dimensions of the container.

Each container class is defined with the minimum and maximum cubic inches or centimeters of the container. The symbol ‘**#**’, along with the container class number is used to reference the container size.

Container classes are #1, 2, 3, 5, 7, 10, 15, 20, 25, 45, 65, 95/100. For small plant containers, i.e. quarts or 4-inch, the designation SP appears in front of the class number. Currently, there are 5 SP classes in the ANSI 60.1 standards.

ANSI (American National Standards Institute) is a private not-for-profit association that promotes and publishes ANSI standards for industries. The adherence to the Standard is voluntary, rather than controlled by the federal government. However, due to the approved ANSI 60.1, any reference to gallons when referring to container size will be an unaccepted practice in the nursery trade.

Type the '**#**' symbol in front of the number and delete any reference to gallon. Ex. **#**15 or #25. There is no space.

Container sizes commonly produced in PNP: #7, #10, #15, #25 sizes. The #15 is the most common and the 25 second.

Definition of Pot-in-Ground (PNG): Only one container is used.

Advantage: less investment with only 1 container. Actually, 50% fewer containers. Would be more financially significant if the blow molded was the one used.

Disadvantage: Harvesting is much more difficult on the species that "root out" excessively and require a spade to cut the escaped roots just outside the container wall. The integrity of the hole is lost during harvest and while the hole is empty. Holes must be re-angered every year or two.

Soil Selection **for Pot-in-Pot Production** by Paul Denton, UT Ext. Soil Scientist

Because Tennessee soils are generally silty or clayey, they are not in general as freely drained as the sandy soils of the southern Coastal Plain. It is very important to select deep, well structured soils with no restrictive layers to avoid ponding of water in pots during wet periods. Regardless of how well the surface drains, the concern is the internal drainage and potential root rot.

Soils with restrictive layers in the subsoil such as fragipans or very heavy, poorly-structured clay should be avoided, as should low-lying bottomland soils with high water tables.

Subsoil color, texture and structure are used to estimate drainage class. Well-drained soils should have brown, reddish-brown or red color in the subsoil to a depth of at least 30 inches, with no gray layers or mottles. Colors such as gray, grayish-brown or yellow with gray mottles indicate problems with drainage. Subsoils with these colors should be avoided.

Yellow or yellowish-red colors are acceptable for loamy or silty soils if there are no gray mottles present. Well-drained silty or loamy soils are generally preferred over clayey, but the red or dark-red clayey soils work well due to their strong structure. Soils with reddish-yellow, yellow or yellowish-brown clayey subsoils are usually less freely drained and should be avoided.

In the major nursery production counties of Middle Tennessee, some of the common desirable soil series for pot-in-pot include Cumberland, Etowah, Mountview, Sequatchie, Waynesboro, Decatur, Dewey, Hermitage, Holston, Humphreys, Nolichucky, Cookeville, Pembroke, Bewleyville, Curtistown and Lonewood.

Dickson is a very common soil in NW Warren County. Dickson is a poor choice for PNP. Some of the more rolling, better drained slopes may work, but in general, considering the set-up cost for PNP, Dickson soils are best avoided.

Common soils to be avoided are Guthrie, Taft, Lawrence, Lindside, Melvin, Ramsey, Sango, Talbott, Colbert, Mimosa, Purdy and Robertsville.

Baxter and Christian are examples of soils which may or may not be suitable, depending on how tight the subsoil actually is at a particular site.

Well drained, loamy bottomland soils like Huntington, Staser, Emory and Greendale are subject to flooding. Brief flooding might not be damaging if the water rises slowly. Floating debris or a fast current could be very damaging.

On the Cumberland Plateau, in addition to Lonewood, Hartsells or Lilly, other soils might be suitable if the soil is more than 2 feet deep to bedrock.

Soil surveys from the NRCS can be used to determine if an area has potential. Due to limitations of map scale, areas of differing soils smaller than 2 to 4 acres may not be shown on the maps. Considering the high set-up cost for PNP, on-site investigation is wise.

Mountview is a good example of this in Middle Tennessee. Mountview often contains small areas of Dickson or Sango soils that were too small to be shown on the map. While Mountview itself is a very good soil for PNP, those spots of Dickson or Sango areas would likely not drain sufficiently well for PNP. Those areas could be as much as 20 percent of the total area, and might be the majority of any given acre. On-site investigation is wise.

Experience has shown that even on favorable soils, a certain percentage of holes will hold water and plants will be lost unless the pots are raised or moved. This generally involves less than 5 percent of the holes, but increases over time. A wet hole will encourage root loss, followed by reduced plant growth and perhaps even death of the plant. This seems to be more prevalent on Mountview sites, where a Dickson type soil co-mingles. There is seldom any visible reason for the ponding to occur.

Don’t install the plants into a new area until after a good rain to determine how many and which holes will hold water. The irrigation could also be run continuously for a day to make this determination.

Ole timer’s recipe to determine a soils ability to drain internally: Dig a hole 18 inches deep, fill it with water, re-fill an hour later; observe the number of hours for the water to completely drain out of the hole. Less than 3 hours offers good drainage. More than 6 hours is very suspect and more than 12 hours; plant ducks.

Note: Beginning in 2007, after several years of experience, we began suggesting that a 4" drain tile be laid below each row to handle the drainage. More planning and preparation is required. Plan on the bottom of the socket pot touching the tile. There must be an outlet for the effluent. It is not expected that a pond or reservoir will be required to handle the low volume.

Labor

The H2A program is administered by the Tenn. Dept of Employment Migrant Security in Nashville, 1-800-432-5268. Labor is the greatest expense and most constant problem. Consider how to reduce moving containers around; ask labor for input.

Several nurseries are now filling the containers and planting the liner at the edge of the production site and sometimes while it sits in the socket. They are using locally built mobile media wagons with a short conveyor.

Labor is involved in potting, pruning, pulling weeds, applying herbicides, mowing, staking, moving plants, etc. Use pre-emergence herbicides correctly & timely to reduce time pulling weeds.

Plan before Augering the Sockets

A wet spring is not a good time to attempt to install or construct a PNP field. Any spring usually has too many wet days. Fall can be the best time. Summer can be okay if it is not too dry to drill holes or trench.

Roadways are required regardless of floor management or plant spacing. Roadways are required to haul plants in and out on wagons or trailers and to spray with air-blast sprayers from. Run the rows on the contour if possible to avoid the irrigation lines from draining into the low pots.

Lay a non-woven needle-punched Geotextile fabric with a minimum tensile strength of 150 lbs. and minimum weight of 8 ounces per square yard under the roadways to support the gravel. Most of it is on 15 foot wide rolls, but narrower widths are available. Current prices may be around 0.66 cents per LF. (8-08) Ray Underwood, at 451 Gassaway Main St., Liberty, Tenn, 615-330-6620 is a good source according to our NRCS office.

A block is several rows separated by a roadway. A block could be as narrow as 4 rows or as wide as 30 to 40 feet.

If ditches or wet areas are within the area, don't even bother to drill holes. Avoid those areas and leave it in grass. Small areas can be graveled to avoid rutting and possibly getting stuck.

Spacing

Determine container sizes and spacing (width of the so-called middles and the in-row spacing). It is not necessary to have row middles wide enough for a tractor; but how weeds will be controlled must be considered. Will the weed control strategy involve a back-pack sprayer or a small tractor and sprayer to band pre and post-emergent herbicides? The operator of a back-pack sprayer must have a clear area to walk safely and clear vision; not cluttered with branches or irrigation lines. The use of a Geotextile fabric floor will prevent 98.5% of the weeds and allow a closer spacing.

Middles must be wide enough to accommodate the use of any anticipated machinery. Measure the widest implement anticipated and add a minimum of 4 feet to allow for the container and branches. Add another foot for #25 containers, and more for larger sizes.

Adequate space must be provided between plants to allow for the proper growth of plants, with sunlight able to reach the lower branches; for sufficient air drainage to allow the normal drying of foliage; and room to work around the plants. Workers will need to prune, weed, and fertilize. Adequate sunlight needs to reach low branches on evergreens to promote normal branch length.

Traditional field producers initially copied spacing from the field when they started a few acres of PNP. The in-row spacing could be used to determine the width of the so-called middle, but staggered. Staggering is a simple idea; provides more space for each plant to develop a canopy with no additional land. Close attention (measurement) is required to maintain the correct interval between plants as new rows of PNP are created.
The number of rows in a block is determined by the density of the foliage and the ability to penetrate that foliage with an air blast sprayer or perhaps an overhead boom with pesticides. The distance that labor can efficiently carry plants by hand dictates block width also. The size and weight of the containers must be considered. Workers must dodge water lines and empty socket containers (holes).

There may be individual blocks of #7, #15 and #25 containers. Each will require a different size hole, with different in-row spacing and middle width. The larger the container, the fewer plants per acre.

Blocks of #15 containers and larger usually have 4 and no more than 6 rows. Blocks of #10 containers may have 6 to 8 rows. Blocks of #7 containers could contain 10 rows. Must consider water volume required per row and per block.

It is possible to irrigate a double row of staggered containers with 1 lateral line down the middle, between the pots. This reduces the number of irrigation laterals by half, makes walking more difficult and best with a fabric floor. The containers probably should be less than #10 and with a short or narrow type of plant. This can work if the spacing is adequate for the crop and if the row is not too long for the water availability.

Examples of possible spacings and Plant populations per acre:

5 x 5 = 1,742	4 x 4 = 2,723	3 x 4 = 3,630
5 x 6 = 1,452	4 x 4.5 = 2,420	3 x 5 = 2,904
5 x 7 = 1,245	4 x 5 = 2,178	3 x 6 = 2,420
5 x 8 = 1,089	4 x 6 = 1,815	
6 x 6 = 1,210	4 x 7 = 1,556	
	4 x 8 = 1,361	

Floor Management

The floor or ground can have grass middles, bare ground, Geotextile fabric or a combination of these. Black poly is not recommended because it is too easy to slip and fall when moisture is present.

Producers have learned that persistence is required to keep the area weed free. Mowing may contribute to weeds in the containers when the clippings and seed are blown into the containers (rear discharge available). Geotextile fabric seems to be the Cadillac method for the closer spacings when machinery is not required within the blocks. One estimate for fabric was $1000 per acre in 2000.

Preparation of field for augering:

To keep grass middles when starting with established sod – Determine the width of the so-called middles, the number of rows per block, the container size and the width of the roadways. A 2 or 3 shank sub-soiler can be used to scratch the soil surface after spacing the shanks to the correct middle width – to mark the rows.

Band spray 18-24 inch wide bands, centered on each future row. Spray glyphosate (Roundup). Plan this so that the spraying can be done when the glyphosate (Roundup) will be effective (April-October), and at least 1 month ahead of the anticipated drilling in case 2 sprays are required. A neat appearance can be achieved with regular mowing and a weed free row.

Bare/Weed-free – Determine the width of the so-called middles, the number of rows per block, the container size and the width of the roadways. A 2 or 3 shank sub-soiler can be used to scratch the soil surface after spacing the shanks to the correct middle width – to mark the rows.

Spray the entire block with glyphosate (Roundup), Princep and Surflan or another combination of pre-emergence herbicides prior to drilling (April-October).

Keep the roadways in grass. Bare ground can become muddy at times, erosion is a major concern on slopes and weed control will be a constant battle.

Geotextile fabric -- This is a UV treated, 20 ml woven polypropylene, with an estimated life expectancy of 5-6 years when shaded.

Determine the width of the so-called middles, the number of rows per block, the container size and the width of the roadways. Plan to stagger the holes. Keep the roadways in grass or gravel if necessary.

It is not necessary to have the middles wide enough for machinery; but weed control practices for in the container must be considered. Space must be allowed to walk steady, down each row to spray a pre-emergence herbicide with a back-pack sprayer across the top of the container. Also, consider adequate spacing for air drainage, proper growth of plants, sun to reach lower branches, room to walk around plants to prune, etc.

Preparation will depend on condition of field. If smooth, a 2 to 6 shank sub-soiler can be used to scratch the soil surface after spacing the shanks to the correct middle width. If vegetated, spray the entire block with glyphosate (Roundup), Princep and Surflan or another combination of pre-emergence herbicides prior to drilling.

If rough, with depressions, etc; consider a shallow tilling or disking to smooth it out. It is very important that the ground be smooth and all debris removed prior to covering; to make it less dangerous to walk on. The soil augered from the holes must be spread out evenly. Walking on the fabric can be tricky later if the cloth is stretched tight over an uneven and rocky surface.

One producer plows and roto-tills the block to level the ground, augers the holes, and installs the holder pots immediately. The cloth is stretched and held in place with gutter nails or commercially available staples made for the purpose. It may be best to fold the edge 1-2 inches, to provide 2 thicknesses for the nail or staple to go through around the edge. A small scrape piece can be used like a washer to cushion the nail head.

An 'x' is then cut with a knife over the pots. The 4 corners fall into the holder pot and will be held in place by the second pot, which is placed in some holes immediately to prevent the wind from getting under it.

Great Western Bag Co. in McMinnville can sew pieces together for the width desired. For example, widths of 3,4,5,6,10,12 feet are available and can be sown together for blocks 20 or 24 feet wide, or whatever.

The augering / drilling process Accurately measure and precisely mark where each hole is to be dug. A spot of lime, paint, 4 inch white or yellow plastic stake can be used for visibility.

A skid-steer loader has more maneuverability than a wheel tractor. The operator of a skid-steer is able to drive forward, facing forward with the row and markers in plain view.

The auger: It seems best to use an auger with a flat bottom bit. It is also best to use the correct diameter auger bit for the container diameter used. An oversize hole will invite surface water to enter around the outside of the container and cause root mortality unless extra effort is made to keep the void filled with soil. I observed the mortality of Prunus when a rocky soil gave the impression the void was filled, but the soil settled from between the rock and water later filled the void, killing cherry trees. The diameter of a #7 container is approximately 14 inches. A #10 is approximately 16 inches wide.

Weld or bolt an adjustable stop on either side of the auger to act as a depth gauge, to prevent drilling too deep. (Image available upon request.) Weld a piece of angle iron to extend 6 or 8 inches out from the side of the auger; so that it will sling and scatter the soil as the auger reaches the desired depth. Its location is critical to allow the correct depth, but leave enough soil to fill in around the container. Large containers placed in holes dug too deep and back-filled will settle and may become too deep, allowing surface water to enter the container.

Don't attempt to auger when the soil is too wet. Do not allow the auger to spin extra revolutions. The fear is that the inside of the hole will glaze or seal and hold water. Some holes may glaze when others won't. Moisture and clay content affects the ability to glaze. Place the socket/holder pot into the hole immediately. Placing drain tile under each row will remove this potential problem.

Pot placement: Position the holder pot in the hole vertical and to the rim. Use a level. Surface water will be able to enter the container if it is too deep. Work the loose soil back around the pot. Tamp it good. Check after a few rains. Ensure that surface water will not be able to enter around the pot. Use caution if a blow-molded container is used as the holder pot, as the tamping may cause the container walls to give and pooch in.

Finishing the job: Scatter the loose soil, lay the 1" black lateral irrigation line, punch in the spaghetti tube, and install the spray stakes. Cut the spaghetti lines at least 18-24 inches long to allow for the daily stretching that the lines do with temperature changes. Flush the system prior to installing the micro-sprinklers and plan on flushing the system each spring after removing the micro-sprinklers. Anchor each end of the lateral to a stake; secured with a expandable/stretchable tie-down strap or a loop cut from a discarded tractor inter-tube because temperature changes over a 24 hour period cause the laterals to stretch or snake or move. Some adjustments may be required.

Water Quality

Have an irrigation suitability test run of the water source before starting and investing in a container operation. See the parameters that should be tested and desirable ranges for specific elements in irrigation water. The BMP manual offers suggestions for high bicarbonates (high pH); sodium induced problems; and residues on foliage.

The test may cost $50, but could help avoid serious problems. Several labs are available: A&L Lab 1-800-264-4522; Scott's 800-743-4769 ext 46; MicroMacro 800-TEST-MMI. Contact them to learn the collection procedure they prefer, etc. Collect the sample on Monday or Tuesday and send it immediately. Allow a well to run for 30 minutes if new or seldom used. Obtain the sample from where the intake would be positioned in a stream, lake or pond. Rinse the container several times with the irrigation water. Fill the container absolutely full and tighten the lid. It would be good to sample twice during the first year; following wet and dry periods to obtain base line data, for future reference.

The pH of surface water collected from a pond, stream, or lake during extremely warm conditions, can be very high. Why? Because there is a constant exchange of oxygen and carbon dioxide from the surface of water, due to the photosynthesis of aquatic plants and the exchange from wind. Often the alkalinity of the water will dictate just how high the pH can go. For instance, in low alkalinity water the pH may climb over 9.0 in the afternoon, but high alkalinity water may only get to around 8.5 --- another reason to test irrigation water!

The water sample from surface water sources should be collected using a grab sample technique. Collect the irrigation water about 2 feet below the water surface if the pumps are not running. If the pumps are running, just collect the water from a nozzle or faucet. A simple and unique water sampler can be made using an 8-foot long piece of 2-inch diameter PVC pipe, with a string through it, and attach a tennis ball to the string. Pull the string tight and drop the tennis ball end of the pipe into the water and allow the ball to float lose at the desired depth. Pull the string and tennis ball to the PVC pipe. This will prevent water from leaking out of the pipe. Release the water into a bucket and pour it into the bottle to send to the lab.

Irrigation Water Modification

Use a professional to determine what needs to be done if the irrigation water is not suitable to use. A professional may know how to modify the water chemically or physically. Installation of a proportioner to inject chlorine or sulfuric acid or filters to eliminate particles in the water may be required. Sulfuric acid is used to lower the pH and chlorine to reduce algae and pathogens. Several options should be tried before resorting to injecting acid. Link to pH adjustment.

Irrigation

Group plants into irrigation zones by water need to maximize plant growth and increase irrigation efficiency. The Best Management Practices manual provides a list of plants by their moisture needs. Link Small containers do not require as much moisture as larger. Plan to increase the rate during the season as plants grow larger and temperatures increase.

Inspect the root growth and media moisture of several containers frequently. Don’t be afraid to knock a few plants out of their containers and get your hands dirty. Much can

be learned by doing this, i.e. media saturation, quality and amount of root growth. Perform this practice over a box or flat surface so media and fertilizer can be used to re-pot the plant. Never request assistance without knowing the condition of the roots.

Irrigation water for micro-sprinklers must be **filtered** very well to avoid clogging the small orifices. Sand or disc filters are required for open water sources, such as ponds, creeks, and rivers. Well water should be filtered with a screen or disc filter. A screen filter with stainless steel mesh is more effective filtering sand and rock. A disc filter is more effective filtering organic matter, algae, etc. All of these can be manually backflushed or purchased to automatically backflush. Everyone tells me to suggest the automatic. We get busy and forget. Contact an experienced professional for advice and installation.

PNP plants might go 2-3 days without water, where conventional containers could not on the hottest days. Management must keep an inventory of **spare parts**, learn how to make repairs and have 1-2 plumbers willing to come when needed. Pumps may be too expensive to keep a spare in inventory; but know who stocks replacements.

The lines:
Row Length: Generally, 500 feet is the maximum row length for this type of system. If terrain will allow rows 500 feet or longer; feed from the middle to maintain pressure. Approximately 15 pounds of water pressure is required for the microirrigation / spray stakes to operate efficiently.

The laterals are 1 inch black poly; purchased on rolls and is slightly flexible. The lateral can be laid beside the container; on top of the container with a bamboo stake to help; or laid under the fabric or actually buried in the soil, immediately adjacent to the container. Why buried?? Grower preference: one grower thinks it removes or reduces the amount of tubes to walk around and over and also reduces the amount of tubing rabbits could chew on. Must weigh the advantages and disadvantages when repairs must be made.

Bury main water lines and the manifolds. Install a flexible riser for each row. Consider a cut-off on each row and definitely a cut-off for each block. Install a common backyard hydrant occasionally. It will be appreciated many times. Install freeze plug drains at all low points. When the water pressure drops below 2 pounds, a spring mechanism opens a ball valve and allows the pipe to drain; avoiding busted pipes.

The spaghetti tube can be purchased on rolls or precut. It is punched into the lateral and then cut to 18-24 inch lengths, generally, to allow for some movement of the lateral during the day. The spaghetti feeds the micro-sprinkler or spray stake.

Micro-sprinklers are available from several companies, such as Agrifim, NetaFim, Rain Bird, Roberts, etc. and are colored coded for different outputs. Outputs are measured in gallons per hour, not minutes. The least expensive microsprinklers or spray stakes frequently do not provide consistent output and coverage and may have a short life.

Choose the best micro-sprinkler for your needs. Select one that will adequately irrigate the entire surface of the container sizes you have. Pressure compensating micro-sprinklers are available when rows are not level; to avoid pots in low places from being

over-watered; causing root rot; to prevent the lines from draining and having to fill prior to each irrigation event.

Energy will be saved by reducing the time the pump has to run. It will add up over the course of a year. Micro-sprinklers will cost $0.25 to $3.00 each; seek a volume discount. Buy extra to replace failures. Larger containers may require 2 per container initially or later in the season when the plants are larger and the summer heat requires more moisture.

Major emphasis must be placed on **checking** all of the lines and spray stakes **daily**, for leaks and proper placement, during the irrigation event. Micro-sprinklers and spray stakes can easily become clogged; be pulled from the container by feet, critters, etc; stakes can be pushed too deep or too shallow, or lean and interfere with a proper spray pattern over the media surface. Rabbits like to chew the spaghetti tubes. Major damage can occur during one night.

Wetting of the entire media surface or most of it is more critical when the fertilizer is topdressed as opposed to blended or dibbled. (Refer to the Fertility section.)

Irrigation can be **controlled** manually, with time clocks or computerized. The system may possibly be operated as little as 15 minutes per day at one time, or multiple (pulse or cyclic) times. Multiple irrigations (as many as 6 times per day) have been proven by LSU and Auburn to grow a plant faster and better with less water. Cyclic irrigation will require the installation of solenoid valves and automation.

An example of how a #15 red maple might be irrigated during August: 4 minutes at 6am; 3 min. at 11am; 4 min. at noon; 4 min. at 1pm; 4 min. at 2pm; 3 min. at 3pm; 3 min. at 4pm; and 3 min. at 5pm. Computerized systems, such as Wilbur, are available. (Wilbur from World Wide Water, Doug Champion, 919-362-4200) They work well and are worth the investment. It provides peace of mind, but must be checked on, never the less.

Increase the amount of water during the absence of normal rainfall, as the plants grow larger and as it gets hotter.

The amount of water that a container receives can be managed in 4 possible ways: by adjusting the duration of the event; by changing the number of events offered per day, adding an additional micro-sprinkler per container or by changing to a micro-sprinkler with a different output. Changing water pressure is not recommended.

A brick in the bottom of #25 and larger socket containers will prevent the growing pot from getting a pregnant, round bottom. A brick or two may raise the roots out of standing water in poorly drained sites.

Raising the growing container will create an air space between the two containers. This might allow cold air to damage the roots in the winter, allow moisture to escape and dry out quicker, or allow Treflan fumes to escape (if used to control rooting out).

The Leaching Fraction is the volume of leachate divided by the total volume of irrigation entering the container multiplied by 100. This fraction should be 10-20%.

How to Determine Irrigation Output and Compare to Volume of Leachate

One way to determine the Leaching Fraction is to use 2 strong trash bags with no holes. If you do not have an empty socket, punch in another spaghetti tube wherever convenient and add a micro-sprinkler. Keep it plugged, except when you desire to test it. Let it spray into a bucket (for a day or a week). Water (A) collected in this container tells us how much water is applied to each plant during irrigation including rainfall.

Select a typical healthy plant to determine the volume of leachate. Remove the container from its socket, place it in a trash bag and return it into the socket pot; thus catching the water that drains out of the growing container. The water caught is referred to as the leachate (B). Be careful not to puncture the bag.

Compare the volumes from bag A and bag B. Measure the contents accurately in ounces The amount leached (B) divided by the total amount applied (A) multiplied by 100 tells us the percent leached or wasted. This is referred to as the Leaching Fraction. The goal is 10-20% for conventional and PNP production.

How much irrigation is needed?
No more than 20% of the irrigation applied (whether overhead or from microirrigation) should leach out of above ground containers or PNP. That means that 80% of the water stays in the container for plant use. This is referred to as a 20% leaching fraction.

Example: If 80 oz is applied per container (A) and 20 oz leaches out (B); 25% was leached, which is too much. 10 to 20% is the goal. Cut back on the amount by cutting the time or use multiple cycles. If less than 10% was caught, insure that the entire root systems are moist. Ten percent may only be possible with cyclic irrigation. This method will allow collection during one irrigation or multiple events.

This procedure is a simple way of determining if you're watering too much or too little. This should be compared several times throughout the growing season as the plants grow and demand more water, and as it gets hotter.

Container Media (Substrate)

Added next 5 paragraphs March, 2009

The pine bark supply is seriously limited due to the economy. Reduced housing starts have affected the timber harvest which affects the bark supply. Several of the bark suppliers are considering generating **'Whole (pine) Tree Substrate' or 'Clean Chip Residue'** to be marketed as substrate based on 5 years of successful research at southern land grant universities.

There are no serious negatives. I think the researchers have been surprised as I that it is working real well with no shrinkage or serious nutritional or moisture issues with annuals and woody ornamentals. It is used immediately, no composting.

There may be slight adjustments required in pH, nutritional and moisture management. The soluble salts have been high for the first 2 weeks until the excess leaches out and the pH is a little high. The bi-weekly monitoring of the leachate with a Myron meter would be wise while we learn to grow with it.

A nursery would be better off to have the entire crop growing in the same media or substrate to make it easier to manage, rather than two different.

The **Whole Tree Substrate** is made in the woods by grinding the entire pine tree (trunk, branches & needles). The **Clean Chip Residue** is made from the bark, branches and the needles after the wood/trunk is chipped. (The residue left from making the chips) It is approximately 40% bark.

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Pine bark has been the media of choice with particles in the 3/8 to ½-inch size. It is not sterile, but is considered initially to be disease and weed free. It will take some thoughtful planning and good management to keep it that way. Bark should be stored on a concrete pad, thick enough to accommodate the semi-truck that delivers it. The pad should be located on high ground so that runoff water does not wash weed seed or disease pathogens onto the pad and contaminate the bark.

Pine Bark sources:

McMinnville:	Morton's	931-473-2854
Clay County:	Barky Beaver	800-737-3646
Memphis:	J&B Co.	800-346-6398
Georgia:	Joe K. Smith Trucking	770-887-3125
	Pioneer Southern	800-552-8200
	Wooten Wood Products	912-375-6039
Alabama:	Sims Bark	205-381-8323
Carolina's	Seaside Mulch	800-641-0881

Because of the current demand, much of the pine bark delivered today is very fresh or referred to as being 'green'. The only concern using green bark is water management issues. The particles will be a bit larger and it will not hold as much water. The use of a wetting agent should help. It is also suggested that you test the pH of each incoming load of pine bark. We have occasionally found loads that tested below 4, indicating possible formation of acetic acid while stored in tall piles. Rainfall or irrigation may

remove the acid in a few weeks if it is stored in piles less than 4 feet. Finding a pH of 4.2 a few weeks later will allow use. Never use a bark that repels water. See 'Wetting Agents' in this chapter.

It is recommended to keep equipment on the bark pad clean. The tractor or skid steer with the front end loader should be pressure washed to remove mud from the tires and underneath the equipment each time it is returned to the pad. Avoid excessive driving and walking across the pad. Phytophthora root rot, other diseases and weed seed can be spread this way. Practice good weed control in the vicinity. Do not allow weeds to grow in or directly around the bark pile.

Turn the bark pile regularly if it is more than 4 or 5 feet tall. This will prevent the bark from drying out or allowing acetic acid buildup. Acetic acid can lower the bark pH to harmful levels. Irrigate the pile if necessary to prevent the bark from drying to the point of becoming hydrophobic (hard to wet). Construct some tall sprinklers to handle this. A white fungal growth can be seen binding the particles of bark together. The media actually repels water. The pH will be less than 4.3, perhaps even 3.8. Plants are not growing, a light to yellowish green, perhaps with some dying. Refer to item #22 in the 'Things That Can Cause Problems' section.

Wetting agents (Aqua-Gro or any commercial product or a liquid dishwashing detergent such as Ivory) can be used to re-wet a media pile of dry or green bark or media in containers that has dried out. While not critical, add a half cup to a 4-gallon backpack sprayer and merely spray over the surface. A larger spray tip would allow the operator to move faster. Dry or green bark can also be sprayed on the conveyor with the solution prior to blending. One pound per yard of granular Aqua-Gro can be added in the blender when mixing to facilitate initial watering.

Occasionally, water will seek a channel through the container media in containers, and leave dry areas. The use of a wetting agent is recommended to provide more complete wetting of the entire root system. This allows reduced cohesive and adhesive tensions of the water and allows lateral movement and more uniform wetting. Drench the wetting agent twice a year (in March and August for example to avoid issues) to help re-wet dry spots in the media.

Avoid using sand in the media. If sand is used, do not use sand from a river or builder's sand where the particles are uniform. River sand can have contaminants such as nematodes, pathogens, seed, etc. Sand from a pit would be safer. Order coarse sand, perhaps unscreened. Sand of uniform particle size clogs pore space in the bark media which makes drainage worse and is very detrimental to plant growth and livability.

Sand increases the bulk density of the media. The bulk density determines the amount of insecticide required to meet fire ant quarantine regulations. The heavier the media the more pesticide is required to control fire ants.

One of the biggest problems of container production is water management. Media that stays too wet too long is capable of killing roots or provide a habitat for root rot. Media that becomes too dry can stress the crop. Learning how to correctly water is difficult and critical. Irrigation management should not be handled by a new employee or an employee with little irrigation experience.

Learning water management is one thing. Having a media that will not drain is another. The cause might be: packed too tight, too much sand, or too many small particles. The height of the container also influences the wetness and dryness of the media. From the saturated layer at the bottom, the media becomes drier as you move up. Have you noticed how containers do not differ much in their height? This allows us to use one media recipe. Roots require oxygen to survive and grow. Poorly drained media is an invitation to reduced growth, root rot and death.

Once potted, pine bark can dry out quickly and can be difficult to re-wet. A fine textured organic amendment can be added to the pine bark to increase lateral movement of moisture in the containers and actually hold additional water and nutrients. Research has shown that 10-20 percent is helpful, but do not add more than 25 percent. Peat moss, fluff (ground household garbage), rice hulls, mushroom compost, cotton gin trash, composted yard wastes, coir, etc., are possible amendments. It is critical that the product be reasonable in price, consistently available and consistent in its characteristics (particle size, pH, texture, etc.), load after load. The additional expense must be considered. A blender (mixer) becomes much more necessary when adding an additional amendment. A fine textured amendment will be helpful in crops produced in all sizes of containers and especially when the water supply is short.

A 4:1 ratio of pine bark:organic amendment is a fairly common media blend. The units might be yards, cubic feet, scoops, wheel barrows or boxfuls; anything to measure in. A cubic yard is: 3' x 3' x 3' = 27 cubic feet.

A blender (mixer) is required to properly mix or blend the controlled release fertilizer (CRF), lime and minor elements with the bark and any other amendments. It is imperative that each container receive equal amounts of each of the amendments. Add the controlled release fertilizer last during the blending. Stop the blender when adequate blending has occurred to avoid damaging the prills.

Correct, proper blending of the ingredients is critical for uniform foliage color and growth. Also, if controlled release fertilizers are incorporated, the coating of the fertilizer prills can be weakened by the abrasive action of the blender sides if it is allowed to run too long. This might allow too much fertilizer to release too rapidly and cause burn to young, tender roots of freshly potted liners. Media (bark, fertilizer, lime, minor elements) can be mixed ahead of time, but must be stored in the dry to prevent the nutrients (salts) from releasing from the controlled release fertilizer. Moist bark or amendments can cause the fertilizer to begin releasing. Tender roots can be burned or killed almost immediately if they are potted into a media that has high soluble salts.

A new producer may think that a 1-yard blender will be large enough when just getting started; but, will be surprised how soon they wish they had purchased a larger size. Consider having your blender built slightly over size to reduce spillage, fall-out, etc., while blending. Have a 2.2-yard blender built instead of a 2. This provides sufficient space for all of the ingredients, without spillage. A 1-yard mixer was priced at $6,250; 2-yard at $7,850; and a 3-yard at $10,500 in Aug, 2007. A 16' conveyor to lift the media from the mixer outlet to a wagon or potting machine was approximately $3,800. If a mixer is not available, consider purchasing a blended media from another nursery with a blender and healthy crops.

Blenders and Potting Equipment. There are several sources in middle Tennessee that will custom build blenders, pot fillers, conveyors, tracking trailers, etc.

Several nurseries use an in-line mixing system. Hoppers are placed in-line to hold and meter out lime, minor elements, and controlled release fertilizer over the bark as it passes below on a conveyor belt. A hood over the final few feet of the conveyor keeps the ingredients in place while being mixed by high speed paddles. The media then falls a few feet into a small vat, where it is picked up and carried up a conveyor to a potting machine or pot filler. The stainless steel hoppers will not corrode from the fertilizer salts.

Prices for the media mixing systems are difficult to extract from the shops because every unit is custom made to fit a specific site or need, plus steel prices fluctuate, etc. In 2001, a 6 yd hopper for the pine bark, a 4 yd hopper for the finished product, 25' of conveyor between the hoppers, and 2 fertilizer boxes (about $3,500 each) was in the neighborhood of $40,000.

The number of containers produced and labor costs may encourage the consideration of purchasing a pot filler or potting machine. Be aware of the maintenance and the number of laborers required to keep the machine running at maximum efficiency when potting. Pot fillers don't have as many moving parts. They are useful for containers larger than #3 or #5. They keep the process moving and save workers' energy.

Potting Procedure

Liners should be readied for potting, especially container grown liners. Remove the container and remove the top half inch of media to remove any weed seed. Loosen the root system and remove any circling roots. If the roots are root bound and circling, consider cutting away the outer half inch of roots and media from the sides and bottom. Research by Ed Gilman, Univ. of Fla, suggests removing the outer inch of roots and media of air pruned containers because the root deflections occur further inside the rootball. This extreme effort is to remove deflected roots and avoid future circling and potentially girdling roots which is more critical on trees.

Fill media around the root system making sure the media is firm around the roots to remove any air pockets. The end goal is for the media to settle after several irrigation events (about a ½-inch below the lip of the container) to allow space for any future

topdressed materials and to trap water. Avoid using too much force to pack the media too tightly. Too tight would reduce the airspace in the media and prevent normal water movement down through the media which may ultimately cause plants to die. Container plants need to be watered very well immediately after being potted to provide moisture, leach excess salts and settle the media.

Planting liners too deep into the media is a major cause of poor growth, decline and even plant death. Tall liners should not be planted deep to increase their ability to stand up. Budded plants or cut-backs should not be planted too deep in order to hide the crook. Plant so the root flare will be visible, especially with tree liners. Caution labor repeatedly and then check and re-check to ensure a proper planting depth. Do not allow labor to place the liner (bareroot or potted) in the bottom of the container before adding media. This can cause long term harmful effects to the plants. It could mean not having a crop to sell.

One way to ensure the potting crew knows where to place the root system is to draw a line at the transition zone between the root system and the trunk or major stem. This line will make it easy for management to spot check later. This is an extra step; but consider your potential loses verses the potential gains.

Container grown liners may have previously been potted too deep when they were potted the first time. Potting depths may need to be adjusted while repotting to ensure roots are located at the proper depth in the container. The old 'Rule of Thumb' of planting at the same depth they were grown could be very, very incorrect. Planting depth is also a major concern with field produced liners.

If the nutrients are not incorporated into the media, it is a good idea to add the measured amount of CRF with minors when the container is about 3/4 full. Spread them over the media and finish filling the container with media. This will prevent losing the nutrients when the containers blow over. It is great for large containers, rather than topdressing.

Potting

Potting Time

PNP containers can be potted anytime liners, labor and empty socket pots are available. Generally, fall potting is preferred if potted liners are available and sockets will be available for overwintering. The potting of bareroot liners cannot occur until they become dormant from a hard freeze. This might be late October to early November. Fall potted containers could be ready for sale by late summer or early fall. It will take that long for the roots to hold the media together during the transplanting process. It is critical to match the correct size liner with the correct size container for optimum growth. Some producers strive for one year crops. Growing conditions vary with the weather. Some field producers let their labor pot when the weather is too bad to dig or load trucks. This allows labor to get their 40 hours.

Potting by Hand or Machine
Whether potting is done by hand or machine depends on the pot size, the number to be potted, available labor, and the ability to afford the purchase price of the machinery.

Because PNP container sizes are usually larger than #5, machine potting is not feasible. But a pot filler is helpful. A pot filler is merely a vat that feeds media into one container at a time, as a worker holds the liner and controls the rate of feed. The container then moves on a conveyor, as other workers add additional media and pack it. A pot filler requires approximately 6 workers, with additional labor to unload the wagons. A pot filler keeps the process moving and increases worker efficiency.

Pot fillers are now mobile, allowing potting to occur a few feet from where the containers will grow. A short conveyor facilitates the process and may allow the outside row of PNP to be potted while in the ground. Mobile units are preferred for the #20 and larger sizes. The bark source needs to be near by or have an easy method to refill the unit.

Until you can afford pot fillers, larger containers may be placed around a pile of media and filled with corn scoops as a worker holds the liner vertical and doesn't allow the liner to be potted too deep. Potting is much easier when done out of the wind and cold, wet weather.

Re-potting, Stepping-up, Shifting-up or Bumping-up
Container grown plants must be re-potted annually before they become root-bound. This is especially important with container grown trees. Circling roots can ultimately grow, become girdling roots and cause tree decline several years prior to death. Trees in #3 containers are usually stepped-up into #10 or #15 containers depending on growth rate, 7's into 15's, 10's into 25's, etc.

The nutrients will also be depleted from last year. Compensate for the lack of nutrients in the old rootball. If blending: the same media and amendments used to pot new liners would be used in re-potting. Then topdress the recommended amount of controlled release fertilizer with minors (for the size of the old rootball) across the old rootball and then cover it with no more than 1 inch of unamended bark to avoid spillage from blow-over. Without this additional topdressing of nutrients, the entire plant may show nutrient deficiencies during the growing system.

Without a blender, if growing in 100% pine bark; merely topdress the nutrients required for the container size over the top and cover it with no more than 1 inch of bark to avoid spillage from blow-over.

Fertility

There are several controlled release fertilizers (CRF's) on the market: Osmocote by Scott's, Nutricote by Florikan, and Harrell's (Polyon) etc. Each contains nitrogen, phosphorus and potassium. Some formulations also contain the micronutrients. They are available in 3, 6, 9 or 12 month release rates (longevity) and available with several ratios of nitrogen, phosphorus, and potassium. Price of CRFs can vary by the time of the year ordered and the amount.

All CRFs will perform optimally if managed correctly. The release mechanisms of nutrients from the various CRF's function differently. **Nutricote** is released basically by temperature. Moisture is involved but is not as important as temperature. **Polyon** (by Harrell's) fertilizer is released by temperature only. It lacks an early release in spring, because of cooler weather. Therefore, Harrell's recommend either a liquid supplement in spring (150 ppm of 20-20-20 twice a week) and reduced as summer temperature progresses or a quick start fertilizer blended with the CRFs. In Tennessee, our spring rains prevent us from gaining much with liquid feeding, because of limited irrigation. If we do not need to irrigate, we do not liquid feed. **Osmocote** is released by temperature and moisture. Typically, Osmocote will release earlier in the spring than Nutricote and Harrell's.

A good management strategy is to keep all empty fertilizer bags for one growing season and tie into bundles by Lot numbers. The Lot number is stamped on each bag by the fertilizer company as a reference to the date and location of manufacture. If problems arise with a product, the bags and lot numbers can be valuable evidence.

Nutricote: www.florikan.com 800-322-8666
Polyon by Harrell's: http://www.harrells.com/products/nursery-greenhouse/ 866-245-5559
Osmocote by Scott: http://www.scottsprofessional.com/en/range/19 800-492-8255
Link to Sources of Allied Supplies & Services

Agricultural grade fertilizer, such as triple 8, 10, 13 or 15, can be incorporated at a rate of 1 pound per yard of media that contains the normal rate of CRF in order to provide a quick release fertilizer. It should only be used in early spring potting i.e. March 15 to May 1. It can also be topdressed over containers that were potted earlier. (One level teaspoon / #1 container, 2 tsp/ #3; 1 Tbl / #5; 2 Tbl/ #10; 3 Tbl/ #15l; 5 Tbl/ #25 container) The ag. grade fertilizers are very soluble and will only last about 3 weeks. If used too early in the spring, the nitrogen and phosphorus will be leached out of the container by the spring rainfall and not benefit the crop.

When selecting a CRF consider the longevity of the product and the time of year the ornamentals are potted. Use a 12 to 14 month CRF when potting in late winter to late April; an 8 to 9 month CRF material if potting April to June or July; and use a 3 to 4 month if potting after late July. Avoid using high nitrogen rates on *Malus* and *Pyrus,* because the vigorous growth produced is more susceptible to fire blight infection.

Fertilizer labels suggest a low, medium or high rate based on the plants fertility requirement (or salt tolerance). Select the correct rate for the crop. The high rate should only be used with crops that are considered high feeders. Plants can be successfully grown with lower rates of fertilizer if irrigated to minimize leaching. This is

easily done with micro irrigation. The BMP manual offers a list of plants and their nutrient requirements.

If the pH of the irrigation water routinely tests 7.0 or higher and the bicarbonate levels are reaching 200, choose a sulfur coated formulation (which is acid forming), such as Osmocote PRO. Most irrigation water in Tennessee from lakes and streams will test pH 7.0 to 7.5 (occasionally higher) and wells will vary from 4.0 to 8.0. A water pH greater than 7.0 will cause the container pH to increase over time.

Strive for a media pH between 5.0 to 6.0 during production. More nutrients are available to the plant for uptake in this pH range. If the pH range is higher or lower, some nutrients may not be available to the plant.

In order to keep the pH within the optimal range, we suggest beginning with 3 pounds ground Dolomitic limestone (avoid pelletized) per yard if the irrigation water pH is less than 7.0 and adjust from there in the future. If the irrigation water pH is 7.0 or higher, do not add lime to the media. Regular agricultural lime is calcium carbonate. Dolomitic lime contains calcium (Ca) and magnesium (Mg). In past years, 6 - 10 lbs of dolomitic lime was recommended per yard, however, research by Dr. Robert Wright at Va.Tech. has shown that often no lime is needed.

Minor elements (minors or micronutrients or trace elements) must be added to container media since none of the minors occur naturally in the components of container media. In contrast, field soil does contain the minor elements, generally in the correct amounts in Tennessee and seldom are applications of minor elements recommended. A minor element package is commercially available as MicroMax, Esmigran, STEM, STEP and Fritted Trace Elements. MicroMax, used at the labeled rate of 1.5 pounds per cubic yard of media, has proven to last longer than the other products in research trials. It is essential that proper blending occurs so that each container ends up with the same amount of nutrients. Minor elements include: iron (Fe), sulfur (S), calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn), manganese (Mn), boron (B) and molybdenum (Mo).

pH is the term used for the degree of acidity or alkalinity (basic). The pH scale is 1 to 14 with 7 being neutral, 1-7 is the acid side, and 7 to 14 is the alkaline side. Lime makes the media more alkaline; sulfur makes the media more acid.

Other nutrients that can be added to the media include gypsum, Epsom salts or iron sulfate. Gypsum (calcium sulfate) provides calcium and sulfur without affecting the pH. Epsom salt (magnesium sulfate, $MgSO_4$) provides magnesium which aids in chlorophyll development. Iron sulfate or 90% sulfur can be added for crops like azaleas and some oak species that need a lower pH. If any of these products are used, 1 pound per cubic yard is sufficient of each. One pound per yard of granular Aqua-Gro can be added in the blender when mixing to facilitate initial watering.

Granular Subdue can be incorporated into the media that will be used for those crops prone to root rots, such as dogwood, azalea, holly, juniper, and yew. It can offer control for 2-3 months. The best prevention for root rot is to not over water.

If a soil mixer or blender is not available, consider purchasing a blended media from another nursery with a blender or purchase a CRF that contains the minor elements, for example the Osmocote PRO products. Most of the major fertilizer companies have a similar product. These products allow growers to grow plants in 100% pine bark and supply all of the nutrients required for that growing season. There are some drawbacks to topdressing however, such as the fertilizer spilling out when the pots blow over. It is suggested to apply the correct amount of CRF when the container is three-fourths filled then finishing potting. This avoids loosing the CRF if tipped over. Research results have shown that plants grown with microirrigation grow a slightly bigger/better plant when nutrients are incorporated in the media.

Liquid feeding can be used to compliment the controlled release fertilizer during the growing season. It is not recommended to use liquid fertilization as a sole source of nutrition. As discussed above, it can be used in spring to supplement nutritional requirements until CRFs release. However, liquid feeding can also used during summer months with CRFs when high nutrient demand plants are grown or when the CRF depletes early. Typically, a water soluble fertilizer like 20-20-20 is applied at a rate of 150 ppm twice a week. Stop liquid fertilizer applications by Sept 15 to allow normal acclimation for winter dormancy. For ease and convenience of using liquid fertilizers, a plumbed-in injector is most convenient.

Occasionally by mid-summer a few plants may have varying degrees of yellow foliage or chlorosis. Yellow foliage, sometimes with dark green veins, can be caused by 1) a media pH too high for the crop, causing iron to be unavailable, 2) root rot, or 3) plants planted too deep, causing root death. Chlorosis of pin oak may be more complicated than just a high pH[1].

To determine the exact cause of the yellow foliage, inspect the roots. The first major root should be within the top 3" of media. If several dead roots are found in the affected containers, send a sample of roots collected from several containers to the UT Diagnostic Lab through the local Extension office. Check the pH of the media or the container leachate. A high media pH (leachate) can be lowered by applying dry elemental 90 percent sulfur over the media surface of the container. Seek the advice of a specialist to make sure this is needed and for rates. Link to pH Adjustment

[1] In 2004, Tom Stebbins in the UT Diagnostic Lab found where Drs. Larson and VanDyk at Iowa State Univ., Hort. Dept. wrote that the "lack of available iron can be magnified by low soil temperatures; high soil moisture; large amounts of copper, manganese, or zinc; or excessive application of phosphorus" (in the soil).

Sulfuric acid can be injected through a proportioner to neutralize alkalinity and reduce the pH of irrigation water if the pH always tests over 7.0. But do not go to the trouble and expense of injecting sulfuric acid to solve irrigation water problems until you eliminate lime from the media and evaluate the use of sulfur coated controlled release fertilizers on the next crop. Use a professional to help guide you through this process.

Monitoring Nutrition

The Virginia Tech Extraction Method or the Virginia Tech Pour Thur is an easy, convenient method to monitor the pH and soluble salt levels in the container media without an expensive and time consuming analysis sent to a commercial lab. It can help detect a problem before visual symptoms occur.

The term 'electrical conductivity' or EC refers to the free charged ions available in the water. Soluble salts and EC refers to the same thing. More simply it measures the salts or fertilizer nutrients in the media solution available to the roots.

The leachate caught in this manner tests the same solution available to the roots. Fertilizer prills are not crushed. The collection and analysis can be done in the field with an accurate meter; results can be learned immediately. Or collected solutions can be brought to the office in sterile bottles for immediate testing or mailed to a commercial lab. Samples held for more than a day should be refrigerated.
No action should be taken from one reading, regardless of how high or low the numbers may be. Continue to monitor every 2 weeks and compare the results. If a problem is found, monitor more often, perhaps after irrigation or rain events totaling one inch. The results can be plotted on a graph with the dates along the bottom and the soluble salts on the left. The pH should be between 5.0 – 6.0 during production. Values above 7.0 may cause yellow foliage and poor growth.

Below are some suggested soluble salt readings for different types of crops using the Virginia Tech Extraction Method:

Salt Sensitive Plants	0.50 – 0.75 mmhos
Non-Sensitive Plants	0.75 – 1.50 mmhos
Deciduous Plants	2.00 mmhos

Irrigation water will usually supply some soluble salts, about 0.1 to 0.3 mmhos. That value should be subtracted from the container leachate readings to learn what is being supplied by the fertilizer.

<u>Benefit of Monitoring Nutrition</u>
Continued high soluble salt readings may indicate that the fertilizer has released too much and the containers should be leached to prevent root damage. Excess salts will

kill roots. Leaching is the process of removing excess fertilizer salts by extending the irrigation time, then waiting an hour or so and irrigating again to flush excess nutrients out. Retest the leachate after irrigation or rain events totaling 1-2 inches. Leach again if necessary. Continued high readings could also be caused by insufficient irrigation to leach excess salts away.

Continued low soluble salt readings in late summer may indicate that the fertilizer has depleted. Monitor weekly. If the soluble salt readings of the containers continue to equal the irrigation water readings, then consider topdressing additional short term fertilizer or liquid feeding until Sept 15. Low readings can also indicate excessive irrigation.

Detecting continued high and low soluble salt readings or continued high or low pH readings are ways that routine nutrition monitoring can indicate potentially critical problems and allow sufficient time for management to correct the issue before growth is affected.

The Myron L Agri-Meter reads both pH and EC. It is a good durable meter to use in the field. The Myron L Agri-Meter is available from Griffin at 1-800-766-6347; possibly BWI at 1-800-489-8873; & CASSCO at 1-800-962-1922 for about $360 in 2009. A qt. of 7.0 pH buffer solution and a qt. of 3.9 standardizing solution is $20 each. A small protective carrying case is $33. The pH sensor must not dry out. Keep the pH 4.0 solution in the small tube around the pH sensor year around. Make a note to check it monthly when not in use, especially during the winter. Avoid bouncing it in a dusty vehicle. Store away from excessive heat. Do not allow to freeze.

<u>The Virginia Tech Pour Through procedure:</u>

Obtain several square aluminum or plastic pie pans to catch the leachate. It is easier to pour from square pans, rather than round pans.

1. Select 1 or 2 containers of several different species at random. Flag and label (number) them so the same plants can be monitored throughout the growing season. Sample them about every 2 weeks, 1 hour after the irrigation event ends. If cyclic irrigation is used, sample 1 hour after the last cycle of the day finishes. Be consistent!

2. Make preparations during the hour after the irrigation is shut off: collect some irrigation water, calibrate the meter, test and record the irrigation water.

3. Assistance may be required to lift the containers from their sockets. Sit the selected containers on concrete blocks, or something similar that will raise the containers at least 3 inches high in order to slide a pie pan under a drainage hole to catch the leachate dripping from the PNP container. The leachate can be collected in a clean bottle, pan or the meter itself for immediate testing.

4. One hour after the water shuts off: Pour 1 quart of water slowly over the surface of the media of a #10 or #15 container. If necessary, add an additional 6 fl. oz. of water

every 5 minutes until the leachate begins to drip. Use no more water than is necessary.

5. Tilt the container slightly to the front, toward the pan to facilitate the leachate going into the pan. A 12" length of 2x4 or a rock can be used to help tilt the container to allow the leachate from one hole to drip into the pan. Note: Wind can blow a top heavy tree perched on a concrete block over, especially while it is tilted. Assistance may be required to hold it.

6. Collect about 4-6 fl. oz. of leachate into sterile bottles or test on site with the meter. Be sure to rinse the cup or probe of the meter 2 or 3 times with the leachate, before testing the next one. Record the pH and soluble salts into a table so future readings can be compared. See the sample table below. Additional columns will be required for bi-monthly readings. Rinse the pans when finished for next time.

7. Be consistent with the procedure! It is critical that the moisture level be similar at each testing.

8. Replace the plants in their respective places. Do not keep the plants to be tested in one group. That harms part of the test related to receiving adequate moisture. .

	May 2		**May 16**		**May 30**	
Container Number	**pH**	**Soluble Salts**	**pH**	**Soluble Salts**	**pH**	**Soluble Salts**
Irrigation water	7	0.25	6.9	0.1		
1- maple	5.8	1.6	6.1	1.8		
2- oak	5.7	1.5	5.6	1.1		

Pursell Technologies, Inc. modified the Sta-Green Nursery Special 12-6-6 formulation in early 2001. It is now a 90 day product, rather than 30 days. The new label suggests 1/4 cup per #5 container; ½ cup per #10 container. But to finish the season in mid to late August, not wishing to keep the plants green too long and cause cold injury; ½ cup per #15 container, 3/4 cup per #25 container was suggested to one producer.

<u>The Virginia Tech Pour Through Procedure for Large Containers:</u>
Collecting leachate is more cumbersome with large containers than small containers. One way to collect leachate is to place a container with its plant in a strong plastic bag with no holes in it. Pull the bag opening tight around the bottom of the container lip to prevent overhead irrigation water or rainfall from entering the bag. Use duct tape to secure it in place. This bag will collect and hold the leachate that moves through the container during irrigation or rainfall.

Weed Control

Initial Weed Control in the Container Is more important for containers going to a fabric floor.

Potted liners bring weed seed usually, even if the weeds are pulled and removed. Research even proved that used containers after a washing still have seed stuck to their inside walls. Don't allow weeds to produce seed in the area; mow perimeters and grassed waterways frequently.

The use of a shaker can to apply a granular pre-emergence herbicide to individual containers immediately after being potted or at any other time is not recommended by the herbicide manufacturers or the authors; though frequently practiced. Besides, some of the granules might be loss when moving the containers to the production area. A shaker can, can not be calibrated. Too little is ineffective and too much may be harmful to a freshly potted root system.

Apply the pre-emergence herbicide after at least 1 good watering to settle the media. It would be good to erect an overhead irrigation boom to drive the trailers under for that initial soaking on their way to the production area. It is more economical to apply the pre-emergence herbicide while the containers are bunched together with a cyclone spreader. A high percentage of the granular product lands between the pots and is wasted when applied after the containers are spaced in the production area. While weed control is desired between the pots in the production area, sprayable pre-emergence herbicides are more economical.

Usually the only time PNP containers sit side by side is on the wagon, on their way to the production area to be placed into their socket pots. Application here is difficult unless the wagon is pulled between two loading docks or 2 other wagons at the same height, allowing a worker to apply a granular product with a cyclone applicator while walking on two sides of the wagon.

Granular herbicides must be applied when the air is very still and preferably from at least 2 directions. Foliage of shrubs act as an umbrella and make total coverage of the media surface difficult. Reduce the amount applied per pass and make multiple passes to achieve the total amount desired by placing calibration trays in the area. These plastic, square foot trays have different size dimples in each corner, denoting a rate per acre when full. The dealer can provide these free trays. Different brands have different trays with different size dimples because of a difference in bulk density.

The employee applying the herbicide and all labor handling those containers until they are placed in their sockets is required to wear the Personal Protective Equipment (PPE) prescribed on the product label. It could be a long sleeve shirt, long pants, waterproof gloves, shoes and socks, and protective eyewear.

Weed Control in the Containers with a Fabric Floor after the initial Treatment

The use of a shaker can to apply a granular pre-emergence herbicide to individual containers is not recommended by the manufacturers or the authors due to lack of calibration. A cyclone spreader would apply 90 percent of the granules to the fabric. It is anticipated that the spacing will be too narrow for any machinery.

The choices are hand-pulling or to calibrate a backpack sprayer and do the best job possible with a pre-emergence herbicide tank mix. Walk beside each row of PNP and spray the entire container surface or half with each trip. It will be more accurate to spray a continuous band rather than just the media surface. Water lines and branches will present a safety hazard and slow the worker. Don't attempt to apply the highest rates because of the difficultly to maintain a constant speed and pressure.

Weed Control for Bare Soil and Grassed Middles

The Middle Tennessee Nursery Production Web site http://www.utextension.utk.edu/mtnpi/index.html provides several handouts and Tables that will be beneficial. Click on Handouts, Weed Control

After the plants are in place, the rows and container media surface can be kept weed free by band spraying a pre-emergence herbicide tank mix. Walk beside each row of PNP and spray the entire container surface or half with each trip, depending on container size and interference of foliage. Spray a continuous band down the rows, between the pots as well as across the surface of the media. Bare soil middles must also be sprayed. Spray every 3 months during the growing season. The escapes must be hand pulled from the containers, hoed or spot sprayed with extreme care with glyphosate.

An Enviromist could be used to safely apply glyphosate next to the containers and possibly the middles of a bare soil floor, if the rows are sufficiently wide enough. A riding lawn mower pulling a small trailer with a 15 or 25 gal tank with an electric pump can be calibrated to apply a pre-emergence herbicide tank mix. A 4-wheeler can be used, but it must be capable of maintaining a constant speed in order to be calibrated. One to 3 additional nozzles will be required in order to maintain bare middles. These may be added on the front bumper or behind the tank. This is if the middles are too narrow for a tractor or a tractor is not available.

Space may force that the herbicides be applied with a back-pack sprayer. While a back-pack sprayer can not maintain a constant speed or pressure as accurately as a machine; it can be calibrated with the knowledge that the walking speed and tank pressure, even with a conscientious employee will vary hour by hour. Realizing the limitations, select a medium labeled rate.

PNP has inherited all of the typical field **and** container weed species to be dealt with. Barricade, Devrinol, Gallery, Pendulum, Pennant Magnum, Ronstar WP, and Surflan are sprayable pre-emergence herbicides, labeled for use in containers and field. Unfortunately, their list of labeled species in containers is short and needs to be expanded.

A tank mix of Barricade and Gallery, for example, should provide excellent weed control for 60-90 days depending on rate and amount of rain and irrigation. Here is one possible scenario to get a novice started: Begin with 1.5 lb Barricade plus 0.5 lb Gallery per acre and adjust from there. Spray Feb 15; May 1; July 15; Oct 1.

If 1 banding nozzle is used to spray over the containers on one side, then the vehicle must drive each middle twice, requiring that only half of the middle be sprayed with each pass. But, since the rows are fairly straight, consider spraying both sides and the entire middle with one pass. This will reduce time and fuel by half.

Most drivers prefer the nozzles mounted in the front so the plants, the middles, any obstructions and the spray pattern can be observed safely without having to constantly turn around in the seat.

Insect & Disease Control

Avoid spraying pesticides when the temperature and humidity at the time of application adds up to more than 140. Early morning hours around 5 or 6am may be best. This does not extend the wet period. Allow foliage to dry before dark to reduce pathogens.

Pub. 1589, "Commercial Insect & Mite Control for Trees, Shrubs & Flowers" is available at http://www.utextension.utk.edu/publications/pbfiles/PB1589.pdf or go to the links.

The "Container Nursery Task Calendar" under Container Production at this site should be helpful.

Information concerning how to submit plant disease samples or insects for identification or how to use the Distance Diagnosis (submitting images of the problem, not an actual sample), visit http://soilplantandpest.utk.edu/plantpestdiagnosis/index.htm It also explains the fee schedule.

Recommended Sanitation Practices

1. Store pine bark off the ground and on a high spot so rain run-off does not wash weed seed and disease pathogens into the pile. A concrete pad is considered best.
2. The mixing area should not be in a high traffic area. Wash all soil from the tires and underbelly of the loader before returning it to the mixing area if it leaves the pad. Mud from boots and tires can introduce pathogens and seed.
3. Never prop feet on containers. Do not use your feet to stomp the media in.
4. Don't allow mud puddles to develop in the driveways close to the containers, that would splash water onto the containers as vehicles pass.
5. Place large empty containers or barrels throughout the nursery for labor to throw trash and plant debris in. This would be a use for empty 30 gal pesticide barrels. Empty those containers routinely.
6. Pull dead plants to the aisles when found and remove frequently. If possible, burn the pile weekly. Containers can be re-used.
7. Used containers can be contaminated with various pathogens and weed seed. A handout entitled "Suggestions on Washing Used Production Containers, Regarding Weed Seed and Pathogens" is available.

8. Don’t discard pulled weeds or plant clippings on the nursery floor.

Winter Protection

None required, as long as pots are insulated by the soil up to their rim and a tight seal exists between the soil and holder pot and between the two pots.

Cooler night temperatures and shorter days begin the process of hardening plants off naturally. **Acclimation** is a process in which plants become less susceptible to cold temperature injury. Or we could define acclimation as the natural process in plants where they gain winter hardiness. I generally refer to plants becoming acclimated as gaining their antifreeze or putting on a sweater.

Acclimation occurs naturally during the fall. Long nights bring about the first stage of acclimation. The second stage is in response to lower temperatures. The gradual lowering of temperatures causes maximum cold hardiness. Acclimation involves changes in cell membranes to allow water to move freely out of the cells as tissues freeze.

Late fertilizations, especially nitrogen, high moisture conditions and late pruning can all interact to delay the normal acclimation process. We can assist with acclimation by irrigating less and stop liquid feeding Sept 15 to allow normal acclimation to occur. No dry fertilizers or CRF should be used that would cause plant tissue to be too tender going into the fall. Do not prune within 6 weeks of the average first frost date in the area, because pruning stimulates new tender growth that would be killed by frost.

The Rooting-Out Problem

Ash, birch, willow and maple are some of the worst genera to ‘root out’ or escape through the drain holes. This slows harvest, makes harvest more difficult, and may cause back strain. The plants do benefit from the moisture and nutrients available in the soil. Producers and researchers have tried to reduce root escapes.

Rooting-Out Problem Solutions:

1. The early idea of twisting the container inside of the holder pot monthly or so was difficult to do and generally ineffective for the more difficult genera.

2. Pot into a copper treated container to reduce root escapes.

3. Producers have tried laying a slightly oversize piece of ground cloth between the two pots to intercept the root escapes. Some roots still find their way to the drainage holes of the holder pot.

4. The next step some try is to treat that cloth with copper.

5. BioBarrier has trifluralin (Treflan) impregnated into a fabric. Pieces are placed

between the two containers. See comment below concerning a tight seal.

6. Research has tested the value of granular Treflan sprinkled into the holder pot.

Reducing Rooting Out Problems with Treflan & Bio-Barrier

	5% G **Treflan**	Amount of **Bio-Barrier**
#7	1 level teaspoon	16 nodules
#10	1 heaping teaspoon	
#15	2 level teaspoons	32 nodules/$1.00
#20	2 heaping teaspoons	
#25	1 level teaspoon	

Sprinkle the Treflan inside the bottom of the holder pot. The loose Treflan will provide root control for approximately 4-5 months. The degree of control and length of control depends on how tight the seal is between the two containers, to prevent the escape of the herbicide vapors.

Pieces of Bio-barrier must be stored in sealed poly bags when not in use to prevent the chemical leaving as a gas. It is expected that Bio-barrier pieces will only last three years when used in PNP. The effectiveness and duration is dependent upon a tight seal between the two pots and being quickly placed in sealed containers immediately following harvest, between crop cycles.

Researchers believe the Bio-Barrier and the loose Treflan offer the most effective control of root escapes. Granular Treflan is not labeled for this use.

Suggested Reference Books

Source of Quality Liners

It is imperative to find sources of high quality liners year after year, true to name, and in good quantity. Once a good source is found, work to build a good working relationship; based on trust and honesty. It could be advantageous to find more than one source for each species produced, in case of crop failures, or health of the individual, etc.

Friendly Advice

Do not try to learn how to propagate liners and set up a new container operation at the same time. Start the container operation and get it running smoothly before trying to propagate, unless an experienced propagator is hired. Remember to buy and sell good quality liners.

After years of troubleshooting problems in container production, it is a foregone conclusion, that once you have found a good growing medium recipe that produces good quality plants, do not change it in an attempt to save a penny per container.

The Inventory

Who will you sell to: retail or landscapers? Where is your market? What major cities are within 200 miles? Will the customer's pick-up or will you deliver? Are you located near an interstate or good major road? Will your product mix include shade trees, evergreen shrubs, flowering shrubs, and flowering trees? Upscale markets will demand named cultivars, rather than just the species (raised from seed).

Marketing

How will you position your business among the existing others: Will you grow the same inventory and compete on price, quality and service (delivery)? Will you grow (or buy and offer for sale) some of the new, different, little known species and cultivars that might be difficult to find, difficult to propagate, slow growing? Or will you grow the larger sizes in containers for the summer landscape market?

The plant inventory should be about 80% tried and true, bread and butter plants with good demand. Limit the new, different and exciting to about 20 % of the inventory.

Consider selling your container grown shade trees by caliper (and then perhaps by pot size); 2" in a 25, for example. I think it best the buyer realize he is not getting a 2" in a #10 container. Architects generally spec. caliper and not pot size.

A major advantage of PNP for field producers is the cash flow generated in late summer and easy harvest. Sales will likely increase after the word gets out.
Summer harvested PNP containers are more perishable than conventionally produced containers, however. Roots of PNP produced plants are grown at 70 degrees and cannot tolerate excessive summer temperatures. The first day or two out of the ground could be the most critical. The producer/buyer must place the containers in shade immediately, cover the container with damp mulch, etc., and provide cooling overhead irrigation periodically during the days to avoid moisture stress.

PNP produced plants cannot be displayed at retail outlets on asphalt or concrete during the summer, due to higher temperatures than the roots can tolerate. Place the containers on soil, sod or mulch, under shade and with adequate irrigation.

Landscapers are expected to be the primary users of PNP plants during the summer when plants cannot be dug from the fields as B&B. Hopefully they will plant them quickly and water them adequately. Retailers may not purchase PNP plants during the summer heat unless they're pre-sold. Hopefully, PNP plants will not have to sit around.

Troubleshooting and Diagnosing a Problem

Most of the serious problems encountered with container production concern media, nutrition, moisture and their interactions. It is not easy to figure some of them out. Begin by looking at the roots. If the crop is young and not rooted in, work over a box or table, in order to save the media and fertilizer.

Extension agents, specialists and consultants will want to know the answers to the following questions as they seek the cause of the problem. Many may attempt to construct the production steps in a sequence of events.

Date or at least the month potted?
Media recipe?
Is it a new recipe?
Do all containers on the nursery contain the same recipe?
How much lime per yard was added?
What brand, analysis, longevity and rate of controlled release fertilizer?
Was the fertilizer incorporated, dribbled or topdressed?
Was the media mixed and stored ahead of time?
Where the liners bare root or potted?
Determine the source. Is the problem limited to one species from same source?
What do the roots look like?
Could roots have dried out before being potted?
Could plants have been over watered?
Could plants have frozen?
When did plants begin looking bad?
How many plants are affected, the percent of the species potted at same time?
Are they scattered in different irrigation zones or in the same area of the nursery?
Contact the liner source and ask if they have received similar complaints on that same plant.

Other questions may need to be pursued depending on the time of the year and the age of the plants.

How were the plants overwintered?
What is the color of the cambium wood?
How long have the symptoms been visible?

Knowledge of the previous winter and previous weather conditions will be needed. A rainy period may cause root rots. Are the roots dead or dying? A dry period may have allowed the fertilizer salts to accumulate and burn the tender roots, if irrigation was not increased to compensate for the lack of rainfall. Keep asking questions until something clicks, hopefully.

Investigators should make notes on the production details. They may keep looking at the media, nutrition and moisture interactions after pests are ruled out. If nothing can be concluded, they should begin again and ask most of the same questions again, to better understand the sequence and determine if other questions should be asked until something jumps out.

Eventually plant samples may need to be collected and sent to the UT Diagnostic Clinic.

Test the pH and the soluble salts on 2 to 3 occasions, separated by 2 to 3 irrigation events. Look for a consistently high or low pH or soluble salts.

The media at potting might start out at a pH of 5.0 to 5.5. Most of our irrigation water is about 7.0. By August the media could be 7.0 or more. A primary symptom would be yellowing foliage with dark green veins. Bi-weekly monitoring of the pH can alert and allow the producer to avoid this problem.

Occasionally, bark will arrive with a pH of 4.3 or have a white fungal growth binding the particles of bark together. This can be a problem from the beginning. Refer to #22 in "Things That Can Cause Problems**".**

Things That Can Cause Problems

Many potential problems concern the complex interaction between the relationships of the media, nutrition and moisture.

1) Sometimes sockets (holes) will begin to hold water that did not previously. Pine bark dust, sand, decayed bark and small particles will literally clog the drainage through the media. Partial size and partial size distribution is important. Request a porosity and a partial size distribution test of new media and of a current problem.
2) Blending media inadequately will jeopardize uniform plant growth. Containers will end up with unequal amounts of nutrients.
3) Not using minor elements.
4) Failing to check the root condition periodically for all the different crops and ages. Failing to check the media moisture periodically and balance it in your mind with the container size, the genera, time of year, recent rainfall, hours since last irrigation. A successful grower must develop a sixth sense. Successful growers must get their hands dirty and resist managing from the desk or truck.
5) Not monitoring the pH. Irrigation water may test around 7.0. The pH of the media may climb over the growing season and approach 7.0, causing some nutrients to no longer be available to the plant, even though they are present.
6) Assuming the crf has depleted and adding additional nutrients in late summer without checking the root depth, root condition, media moisture, pH and soluble salts. Insufficient moisture has caused experienced growers to assume the nutrition has run out. This has occurred when rainfall stopped, days became hotter and plants had grown larger; but extra irrigation was not applied to compensate. Looking at the rootball by removing the container may reveal a dry media, even after an irrigation event. A dry media will test high in soluble salts and may begin to damage the roots. Adding more nutrients can be harmful and also wasteful.
7) Watering on a schedule without allowing for rainfall or the absence of rain and therefore watering too much or too little.
8) Plants planted too deep within the container.
9) Producers frequently cause their own problems by seeking cheaper inputs and taking shortcuts to increase profits. Cutting too many corners can lead to disaster.
10) Herbicides can be applied too strong and result in growth reduction. Herbicides can be applied without uniformly, allowing weeds to germinate in some areas. Some granular preemergence herbicides will burn if applied during a flush of tender growth or to wet foliage. Plants can be damaged or killed with glyphosate (Roundup) drift.

11) Cold injury/ winter freeze damage: Can occur in fall or spring by an early or late freeze. Can occur during mid-winter by extremely low temps. Made worse by dehydration, so irrigate prior to cold spells.
12) Over fertilized or under fertilized.
13) Spray stake not properly positioned to provide proper coverage of media surface. Allowing some containers to be over watered while some may be under watered. Not segregating plants by genera and container size---by water needs.
14) Not having an irrigation suitability test done.
15) Not monitoring nutrition.
16) Not scouting for problems; pests.
17) Allowing weeds to take over.
18) Not following the simplest of sanitation practices.
19) Insufficient spacing, blank or dead foliage due to crowding.
20) Beginning with poor quality liners.
21) Lack of market planning.
22) Media is discovered to be dry after normal irrigation. Wilting may be observed. Dry spots are discovered within the root ball. A white fungal growth can be seen binding the particles of bark together. The media actually repels water. The pH will be less than 4.3, perhaps even 3.8. Plants are not growing, a light to yellowish green, perhaps with some dying.

The bark or media became hydrophobic (hard to wet) because it dried out excessively somewhere. It may have occurred in storage at the bark source, in storage at this nursery or possibly after being potted. Normal irrigation will not solve the problem. The plants must be irrigated excessively; perhaps 6-8 hrs/day until the media slowly absorbs moisture.

The use of a wetting agent, such as Aqua-Gro to break the surface tension and allow the hydrophobic bark to absorb moisture will help greatly to reduce the time and water required. A wetting agent solution sprayed over a bark pile or sprayed over the media of potted containers should work nicely after the irrigation is turned on. A liquid dishwashing detergent will work almost as well, but choose one that does not suds excessively. I believe Ivory or Ajax is good; Dawn, Joy and Palmolive are bad to suds. Merely spray the solution over the entire media surface of the dry containers. Consider repotting into good media and discarding the old if the crop has not been in that media very long. Might be easier in long run and allow the crop to be salable.

Bark becomes hydrophobic when it is stored in tall piles for several months. Regardless of average rainfall or sprinklers used, the interior of the pile will dry severely. Proper bark pile management is required: Turn the bark pile regularly if it is more than 4 or 5 feet tall or keep it less than 4-5' tall. This will prevent the bark from drying out or allowing acetic acid buildup. Irrigate the pile if necessary to prevent the bark from drying to the point of becoming hydrophobic (hard to wet). Construct some tall sprinklers to handle this. Wetting agents can be used if necessary. Acetic acid can lower the bark pH to harmful levels.

Definitions

Anaerobic - Refers to without oxygen, as in anaerobic decomposition. Occurs with bark media if bark piles are too tall and not turned often.

Bulk density - The weight of dry substrate per unit volume of substrate (g/cc).

Air space - The percentage of container volume occupied by air-filled large pores from which water drains following irrigation.

CRF (crf) – A controlled release fertilizer. A controlled release homogenous fertilizer refers to each pellet of fertilizer containing NPK and minors; rather than each component offered in individual separate particles (a blended fertilizer).

Dirt - What is swept from the floor or is on your pants.

Fluff - Ground household garbage.

Fungicide - A chemical that kills fungi.

Herbicide - A chemical that kills plants, not necessarily just weeds.

Hydrophobic (hard to wet) Turn piles of pine bark or wood mulch regularly if it is more than 4 or 5 feet tall. This will prevent it from drying out or allowing acetic acid buildup. Irrigate the pile if necessary to prevent it from drying to the point of becoming hydrophobic (hard to wet). Construct some tall sprinklers to handle this. Wetting agents can be used if necessary. Acetic acid can lower the bark pH to harmful levels.

Insecticide - A chemical that kills insects.

Irrigation - The redistribution of previous precipitation.

Leaching Fraction - The volume of leachate divided by the total volume of irrigation entering the container multiplied by 100. This fraction should be 10-20%.

Liner - A young plant ready to be planted in the field or container. Could have started as a rooted cutting, seedling, bud or graft. Can be 6 inches or 6 feet tall.

Media - What plants in containers grow in. Normally pine bark based. Substrate is the new term for media.

Miticide - A chemical that kills mites.

Pesticide - The catch-all term for all of the chemicals that kill plants, insects, mites, fungi, bacteria, nematodes, etc, etc.

Pesticide Signal Words -- Caution, Warning, or Danger – tell you how likely the pesticide is to make you sick. It appears in large bold print on every pesticide label.

Caution - The least poisonous. Considered safe when used according to directions.
Warning - More poisonous or irritating.
Danger - Very poisonous. Considered dangerous even when used according to the directions. These products also have 'a skull and crossbones' in addition to the word 'Danger'.

pH is the term used for the degree of acidity or alkalinity (basic). Lime makes the media more alkaline; sulfur makes the media more acid. The pH scale is 1 to 14 with 7 being neutral. 1-7 is the acid side. 7 to 14 is the alkaline side.

Phytotoxicity or Phyto - "Anything that alters the appearance or growth (rate) of a plant." Dr. Chuck Powell in McMinnville May 2, 2002

Planting depth – Plant so the root flare or collar is level with the soil or media surface. Too deep is worse than too high. Roots too deep will die without sufficient oxygen.

Postemergence herbicide - A chemical that kills a plant after (post) it has emerged out of the ground, such as glyphosate (Roundup).

Preemergence herbicide - A chemical that kills a germinating seedling before (pre) it emerges out of the ground, such as Surflan.

Soil - What Mother Nature grows plants in; in a field or landscape.

Substrate - New term for media.

Weed - A plant in the wrong place. An unwanted plant, wherever it is. Could be a dogwood tree in a block of maple; a walnut tree in a corn field.

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References:

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Denton, Paul; UT Ext. Soils Specialist, Knoxville
Tilt, Ken, Auburn University's Ext. Nursery Specialist
BMP Manual, "Best Management Practices, Guide for Producing Container-Grown Plants", Southern Nurserymen's Assoc., July, 1997. phone 770-953-3311; e-mail: mail@mail.sna.org
"Starting a Container Nursery Business", Jan, 1993; Circular ANR-690, for $2.25. Mail request to Extension Publications, Duncan Hall, Auburn Univ, Auburn, AL 36849-5630

Table 1: Number of pots* filled with a cubic yard of media:

(Assuming a bareroot liner, because a potted liner will require less media.)

# 1	187-369
# 2	104-140
# 3	68-70
# 5	49-57
# 7	26-35
# 10	20-22
# 15	15
# 20	10
# 25	7
# 45	4
# 65	3

* Nursery Supplies catalog
http://www.nurserysupplies.com/pdf/2008%20BROCHURE.pdf

(Precise container dimensions vary with manufacturer; media physical properties vary with moisture content; machine vs. hand filling and degree of packing are reasons why it is difficult to predict number of pots filled by a yard of media.)

Table 2: Container Size to Pot into

Plant size to be sold:	ANLA Nsy Stds
3' tall	#1
4'	#2
5'	#5
6'	#5
7'	#7
8'	#10
0.75" caliper	
1.00"	
1.25"	#10
1.50"	#15
1.75"	#25
2.00"	#25
2.50"	#25
3.00"	
3.50"	
4.00"	
4.50"	
5.00"	
6.00"	

Table 3: The parameters that should be tested and desirable ranges for specific elements in irrigation water.

Phosphorus (P)	0.005-5.000 mg/l
Potassium (K)	0.500-10.000 mg/l
*Calcium (Ca)	40.000-120.000 mg/l
*Sulfate (So_4)	24.000-240.000 mg/l
Magnesium (Mg)	6.000-24.000 mg/l
Manganese (Mn)	0.500-2.000 mg/l
Iron (Fe)	2.000-5.000 mg/l
*Boron (B)	0.200-0.800 mg/l
*Copper (Cu)	0.000-0.200 mg/l
SAR	0.000-4.000 mg/l
*Soluble Salts	0.000-1.500 mmhos/cm
Zinc (Zn)	1.000-5.000 my/l
*Sodium (Na)	0.000-50.000 mg/l
Aluminum (Al)	0.000-5.000 mg/l
*pH	5.000-6.500 mg/l
Molybdenum (Mo)	0.000-0.020 mg/l
Chloride (Cl)	0.000-140.000 mg/l
Fluoride (F)	0.000-1.000 mg/l
Nitrate ($N0_3$)	0.000-5.000 mg/l
Ammonia (NH_4)	undetermined
*Alkalinity (Bicarbonate)	**0.000-100.000 mg/l $CaCO_3$

*Key parameters to be considered. Borrowed from Auburn's pub.

**BMP says <61 is no concern; 61- 214 is a concern; >214 is severe. 180 is high for bedding plants

For additional information contact: Mark Halcomb, UT Extension Area Nursery Specialist, 931-473-8484 mhalcomb@utk.edu

Comm/ PNP/ Pot-N-Pot