Pot-in-Pot Nursery Production

Robert Geneve

University of Kentucky

Pot-in-Pot Nursery Production

Robert Geneve

University of Kentucky

1. PNP as a production alternative
2. PNP set-up and maintenance
3. Irrigation scheduling

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

The nursery industry is highly dependent on container plant production. Utilizing sustainable inputs and adopting sustainable practices have become a significant trend for horticultural production world-wide. This has led to a significant increase in pot-in-pot nursery production in the US, especially for large caliper trees traditionally produced as field-produced balled – and - burlapped crops.

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

PNP is a combination of traditional container and field production where the growing container is placed within a semi-permanent, underground socket pot.

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

Pot-in-pot production was originally developed as the “Minnesota System” in the 1980s as an alternative to field and above-ground container production for tap-rooted shade trees.

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

The system proved to be equally useful for general nursery production.

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

The major advantages of pot-in-pot production compared to standard above-ground container production include a reduction in container blow-over tipping, root insulation protection from summer heat and winter cold extremes, and therefore, no need for winter protection.

Pot-in-pot also uses water more efficiently because it utilizes microirrigation rather than overhead watering systems

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

Pot-in-pot is arguably the most sustainable production system for nursery trees.

Compared to field produced trees, pot-in-pot uses water and fertilizer more efficiently and eliminates “soil mining” because it uses a renewable bark-based growing substrate rather than digging trees from the nursery field.

Pot-in-Pot Nursery Production

Introduction to Pot-in-Pot

The major disadvantage of a pot-in-pot production system is its high initial installation cost, but these costs can be spread over several years of production.

The initial costs can also be off-set by the higher planting density compared to field production.

Another problem encountered during pot-in-pot production can be roots escaping the growing container making harvest difficult.

Pot-in-Pot Nursery Production

Comparison of key features of pot-in-pot nursery production compared to above-ground or in-ground shade tree production.

Production system	Irrigation type	Substrate	Staking	Over wintering structures	Harvest time	Plants /hectare	Cost /plant
Pot-in-pot	Micro-irrigation	Bark-based	For plant structure	No	Any time	950	$ 21.50
Field	Principally overhead irrigation	Soil	For plant structure	No	Spring and Fall	770	$ 23.71
Above-ground container	Overhead irrigation	Bark-based	For plant structure and blow over	Quonset	Any time	870	$ 23.73

1996 study for three-year crape myrtle (*Lagerstroemia*) production on a typical 6 hectare USA nursery with plants grown on a spacing of 5.6, 6.3, and 6.2 plants per m^2 for pot-in-pot, field and above-ground containers, respectively.

Pot-in-Pot Nursery Production

Initial installation - Cost estimates

Tennessee	2009	$20,000 per acre
Kentucky	2012	$33,000 per acre

Pot-in-Pot Nursery Production

Initial installation - Site selection

Since pot-in-pot is a semi-permanent production system, care needs to be taken during its initial installation.

Most sites suitable for pot-in-pot should be relatively level (< 3% grade) with easy access to clean water for microirrigation.

The most important consideration is soil drainage where the socket pots will be located.

Pot-in-Pot Nursery Production

Initial installation - Site preparation

Without proper drainage, water will pool in the production holes during periods of sustained rain.

Tree and growing container was removed to show socket pot flooding

Pot-in-Pot Nursery Production

Initial installation – Site preparation

For many locations, this requires providing supplemental drainage such as a 4 inch drain tile beneath the planting row of socket pots.

Pot-in-Pot Nursery Production

Initial installation - Site preparation

Same site after initial planting.

Pot-in-Pot Nursery Production

Initial installation - Site preparation

Alternatively, growers in milder climates are experimenting with raised beds.

Pot-in-Pot Nursery Production

Initial installation – Site preparation

There are several options for digging the socket pot hole involving either trenching, augering or a combination of the two.

Pot-in-Pot Nursery Production

Initial installation – Ground cover

There are several strategies for nursery floor management around the containers. These include maintaining a bare weed-free area, grass/sod middles between container rows, or a geotextile nursery fabric covering each block.

Pot-in-Pot Nursery Production

Initial installation – Ground cover

Gravel base with grass aisles.

Pot-in-Pot Nursery Production

Initial installation – Ground cover

The fabric should be installed after the socket pots are set by fitting the size of the fabric to the tree block and cutting an “X” over each socket pot prior to setting the production container into the in-ground socket pot.

Pot-in-Pot Nursery Production

Initial installation – Ground cover

There is an initial cost with using the fabric, but it can be easier to maintain during the production cycle and because cultivation equipment will not be required within the block, containers can be staggered between rows leading to more efficient spacing.

Pot-in-Pot Nursery Production

Initial installation – Irrigation

Water management is most often through a microirrigation system. This is an efficient way to deliver irrigation to each container using a microsprinkler (spray stake or trickle).

Pot-in-Pot Nursery Production

Initial installation – Irrigation

Spray stakes

Pot-in-Pot Nursery Production

Initial installation – Irrigation

Micro-irrigation allows for precise and efficient deliver of water to each container.

Pot-in-Pot Nursery Production

Initial installation – Irrigation

Like other microirrigation systems, initial water quality, filtering systems, fertigation and water pressure are all considerations that should be addressed prior to planting.

Pot-in-Pot Nursery Production

Initial installation – Container size and spacing

Socket placement and spacing must also be pre-determined.

This becomes a fixed spacing of a single size production container for the next five years or more.

Pot-in-Pot Nursery Production

Initial installation – Container sizes

Container sizes range from 7 to 30 gal.

Plants usually are produced on a 1-3 year cycle.

Pot-in-Pot Nursery Production

Initial installation – Spacing

As with field production, roadways and container spacing must consider access for equipment for spraying, cultivating and harvest as well as anticipated plant size.

Pot-in-Pot Nursery Production

Initial installation – Spacing

In general, growers plan for more trees per block for pot-in-pot compared to standard field production.

Pot-in-Pot Nursery Production

Rooting out of the container

Another consideration prior to setting the production container in place is whether a root barrier material will be used to prevent “rooting out”.

Pot-in-Pot Nursery Production

Rooting out of the container

For several nursery species (Birch, maple, willow, ash) rooting out of the production container into the socket pot and surrounding field soil can be a problem.

It makes harvest difficult and inefficient.

Several chemical deterrents are available to reduce this rooting out problem.

Pot-in-Pot Nursery Production

Rooting out of the container

One product is a root barrier consisting of a copper-treated fabric that is placed between the production container and socket pot.

A second option is using a volatile herbicide impregnated root barrier placed at the bottom of the socket pot. A tight fit between the socket and production container is necessary for optimal control of rooting out.

Pot-in-Pot Nursery Production

Rooting out of the container

Copper (Spin-out) - Tex-R root barrier

Pot-in-Pot Nursery Production

Rooting out of the container

A tight fit between the socket and production container is necessary for optimal control of rooting out.

Pot-in-Pot Nursery Production

Rooting out of the container

Sometimes it is important to send in reinforcements.

Pot-in-Pot Nursery Production

Harvesting

Another advantage of pot-in-pot production is that harvest is not tied to the traditional digging seasons for field-produced plants.

Mid-season harvesting can offer a competitive advantage if a market is available to use these trees.

Pot-in-Pot Nursery Production

Harvesting

Harvesting involves lifting the production container out of the socket pot.

Because of the size and weight of larger caliper trees, mechanical assistance is usually necessary.

Pot-in-Pot Nursery Production

Harvesting

Both physical and mechanical lifting machinery is available in the trade.

These machines basically attach clamps to the growing container rim and use physical leverage or hydraulics to lift the container from the socket pot.

Click here to see video

Pot-in-Pot Nursery Production

Irrigation Efficiency

Use of a microirrigation system also allows growers to consider several advanced irrigation practices that can minimize water use and fertilizer run-off and in some cases improve tree growth. These include adopting an on-demand system for scheduling irrigation based on plant water use that could also employ a cyclic irrigation strategy.

Pot-in-Pot Nursery Production

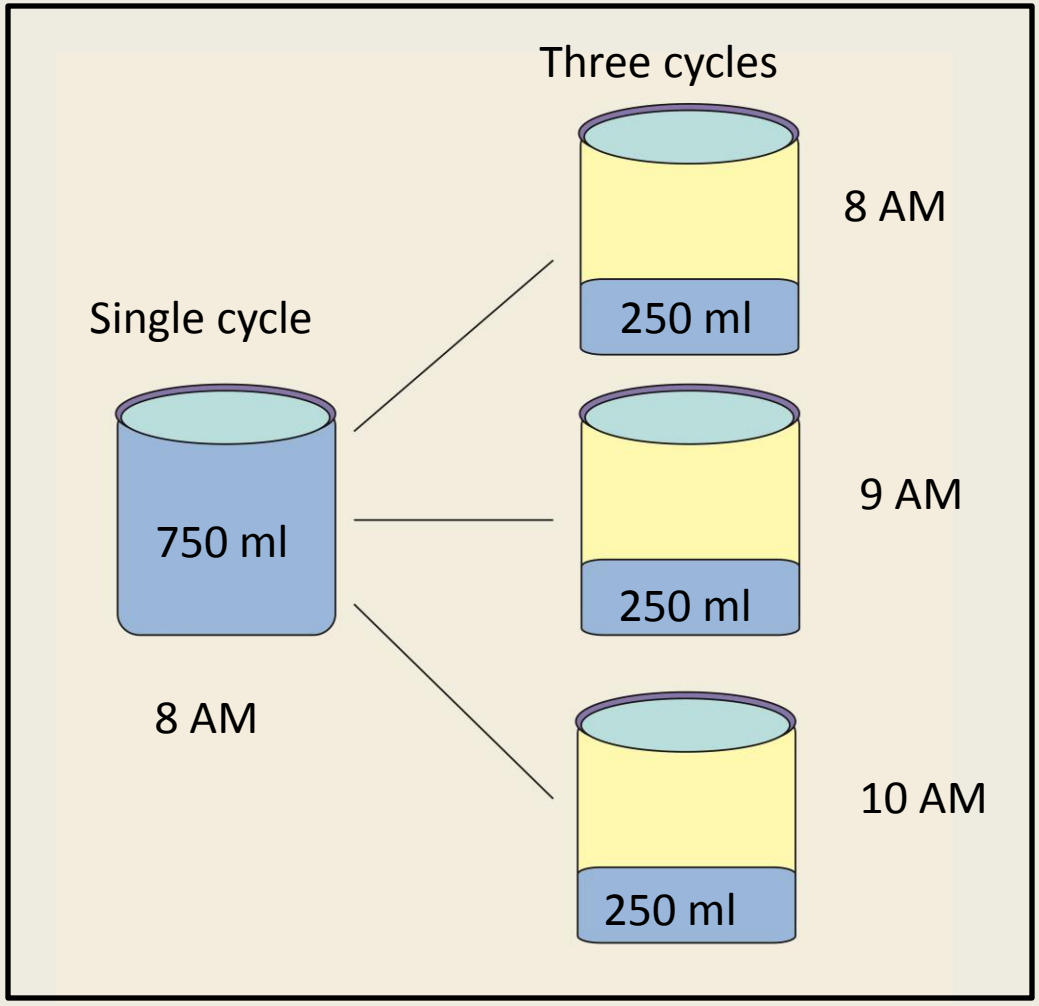
Irrigation Efficiency

Cyclic irrigation

Cyclic irrigation is the application of the daily irrigation divided into timed smaller quantities.

Cyclic irrigation reduces runoff by up to 30%.

It can also improve crop growth.



Pot-in-Pot Nursery Production

Irrigation Efficiency

Cyclic irrigation

Red maple (*Acer rubrum*)
15 – gal; pot-in-pot

Irrigation	Shoot dry weight (g)	Height increase (cm)	Trunk caliper (cm)
Single	1100.0	103.9	0.73
3 - cycles	⇨ 1349.4	⇨ 120.9	⇨ 1.88
6 - cycles	⇨ 1284.2	⇨ 113.0	⇨ 1.88

Fain, Tilt and Silbey, 2000

Pot-in-Pot Nursery Production

Irrigation Efficiency

Cyclic irrigation

Eastern redbud (*Cercis canadensis*)
7- gal; pot-in-pot

Irrigation time	Total water use (L plant $^{-1}$ •day^{-1})	Daily water use (L plant $^{-1}$ •day^{-1})	Trunk caliper (cm)
AM	59.9	3.0	0.29
Noon	71.1	3.6	0.36
PM	64.9	3.2	0.30

Nambuthiri and Geneve, 2014

Pot-in-Pot Nursery Production

References

Dunwell, W., S. Vanek, and D. Ingram. 2009. Pot-in-pot nursery production. http://www.uky.edu/Ag/CCD/introsheets/potinpot.pdf

R.L. Geneve. 2014. Nursery container irrigation. Comb. Proc. Intern. Plant Prop. Soc. 64:3-8.

Holcomb, M. and D. Fare. 2009. The pot-in-pot (PNP) production system. http://www.tnstate.edu/faculty/ablalock/documents/Pot-N-Pot.pdf

McNiel, R., B. Behe, and C. Montgomery, 1996. Physical and economic requirements for pot-in-pot nursery production. http://www2.ca.uky.edu/HLA/Dunwell/PNPMCN.html

Nambuthiri, S., A. Fulcher, and R.L. Geneve. 2015. Microirrigation systems for pot-n-pot nursery production. In: Recent Advances in Sustainable Micro Irrigation. Vol. 4. M.R. Goyal (ed.). Apple Press, Waretown, NJ. Chapter 21: pp. 295-309.

Parkerson, C.H., 1990. P & P: A new field-type nursery operation. Proc. Intern. Plant Prop. Soc. 40:417-419.

Pellet, H., 1983. An Update on Minnesota System of Container Production. American Nurseryman 157(1).

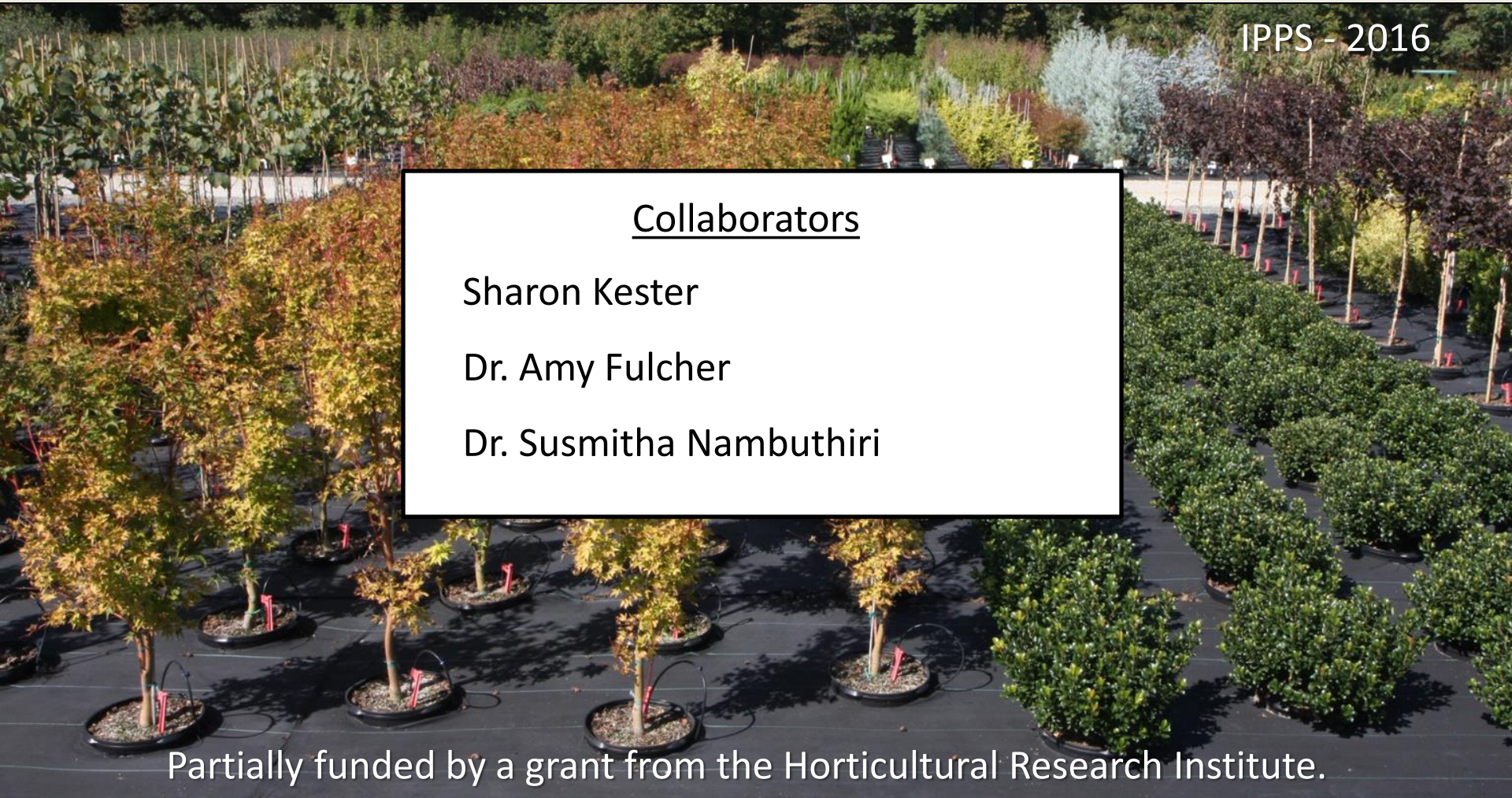
Pellett, H., M. Litzow, and L. Mainquist, 1980. Use of metal compounds as root pruning agents. HortScience 15: 308-309.

Ruter, J. M., 1993. Growth and landscape performance of three landscape plants produced in conventional and pot-in-pot production systems. *J. Environ. Hort*. 11:124-127.

Pot-in-Pot Nursery Production

Robert Geneve

University of Kentucky



Collaborators

Sharon Kester

Dr. Amy Fulcher

Dr. Susmitha Nambuthiri

Partially funded by a grant from the Horticultural Research Institute.

Figure 1. Typical components in a pot-in-pot production system. A. Containers on a high density planting using an in-row fabric floor management. Each tree is stacked and has an irrigation spray stake from main lines covered by the fabric. B. Floor management is with between row grass cover. Side view shows the relationship between the socket pot and the growing container.

An Introduction to Pot-in-Pot Nursery Production

Robert L. Geneve

Introduction

The nursery industry is highly dependent on container plant production. Utilizing sustainable inputs and adopting sustainable practices have become a significant trend for horticultural production world-wide. This has led to a significant increase in pot-in-pot nursery production in the US, especially for large caliper trees traditionally produced as field-produced balled – and -burlapped crops (McNiel et al., 1996). Pot-in-pot production is a combination of traditional container and field production where the production container is placed within an in-ground socket pot (Figure 1).

Pot-in-pot production was originally developed as the "Minnesota System" in the 1980s as an alternative to field and above-ground container production for tap-rooted shade trees (Pellet et al., 1980; Pellet 1983). The system proved to be equally useful for general shade and flowering tree production (Parkerson, 1990). The major advantages of pot-in-pot production compared to standard above-ground container production include a reduction in container blow-over tipping, root insulation protection from summer heat and winter cold extremes, and therefore, no need for winter protection. Pot-in-pot also uses water more efficiently because it utilizes microirrigation rather than overhead watering systems (Nambuthiri et al., 2015).

Pot-in-pot is arguably the most sustainable production system for nursery trees. Compared to field produced trees, pot-in-pot uses water and fertilizer more efficiently and eliminates "soil mining" because it uses a renewable bark-based growing substrate rather than digging trees from

the nursery field. Compared to above-ground container production, pot-in-pot results in a reduced use of plastic where Quonset structures are required for overwintering.

The major disadvantage of a pot-in-pot production system is its high initial installation cost, but these costs can be spread over several years of production. The initial costs can also be off-set by the higher planting density compared to field production (McNiel et al., 1996). Another problem encountered during pot-in-pot production can be roots escaping the growing container making harvest difficult.

Since pot-in-pot is a semi-permanent production system, care needs to be taken during its initial installation. Most sites suitable for pot-in-pot should be relatively level (< 3% grade) with easy access to clean water for micro irrigation. The most important consideration is soil drainage where the socket pots will be located. Without proper drainage, water will pool in the production holes during periods of sustained rain. For many locations, this requires providing supplemental drainage such as a 4 inch drain tile beneath the planting row of socket pots.

Socket placement and spacing must also be pre-determined. This becomes a fixed spacing of a single size production container for the next five years or more. As with field production, roadways and container spacing must consider access for equipment for spraying, cultivating and harvest as well as anticipated plant size. In general, growers plan for more trees per block for pot-in-pot compared to standard field production. There are several options for digging the socket pot hole involving either trenching, augering or a combination of the two. There is an excellent University of Kentucky on-line video prepared by Dr. Amy Fulcher that describes each type of installation procedure (Fulcher, 2004 <http://www.youtube.com/watch?v=wNeBurkznIk>). Regardless of the digging method, the socket pot should be placed level with the grade with only the top of the rim above ground.

There are several strategies for nursery floor management around the containers. These include maintaining a bare weed-free area, grass/sod middles between container rows, or a geotextile nursery fabric covering each block. The fabric should be installed after the socket pots are set by fitting the size of the fabric to the tree block and cutting an "X" over each socket pot prior to setting the production container into the in-ground socket pot. There is an initial cost with using the fabric, but it can be easier to maintain during the production cycle and because cultivation equipment will not be required within the block, containers can be staggered between rows leading to more efficient spacing.

Another consideration prior to setting the production container in place is whether a root barrier material will be used to prevent "rooting out". For several nursery species, rooting out of the production container into the socket pot and surrounding field soil can be a problem. It makes harvest difficult and inefficient. Several chemical deterrents are available to reduce this rooting out problem. One product is a root barrier consisting of a copper-treated fabric that is placed between the production container and socket pot. A second option is using a volatile herbicide impregnated root barrier placed at the bottom of the socket pot. A tight fit between the socket and production container is necessary for optimal control of rooting out.

Water management is most often through a microirrigation system. This is an efficient way to deliver irrigation to each container using a microsprinkler (spray stake or trickle). Like other microirrigation systems, initial water quality, filtering systems, fertigation and water pressure are all considerations that should be addressed prior to planting. It is usually more efficient if plants are grouped by their relative water use requirements. Inspect irrigations lines on a routine basis for leaks or malfunctioning lines to avoid extended periods where containers are not being irrigated. Use of a microirrigation system also allows growers to consider several advanced irrigation

practices that can minimize water use and fertilizer run-off and in some cases improve tree growth. These include adopting an on-demand system for scheduling irrigation based on plant water use that could also employ a cyclic irrigation strategy (Geneve, 2014; Nambuthiri et al., 2015).

Another advantage of pot-in-pot production is that harvest is not tied to the traditional digging seasons for field-produced plants. Mid-season harvesting can offer a competitive advantage if a market is available to use these trees. Harvesting involves lifting the production container out of the socket pot. Because of the size and weight of larger caliper trees, mechanical assistance is usually necessary. Both physical and mechanical lifting machinery is available in the trade. These machines basically attach clamps to the growing container rim and use physical leverage or hydraulics to lift the container from the socket pot.

This has been a quick overview of typical pot-in-pot production issues. There are several more in-depth discussions of this system from University Extension publications available on-line. Both the University of Kentucky (Dunwell et al., 2009) and University of Tennessee (Holcomb and Fare, 2009) have excellent publications that are currently available. Each includes a extensive publication lists concerned with the economics and production of pot-in-pot plants.

Literature Cited

Dunwell, W., S. Vanek, and D. Ingram. 2009. Pot-in-pot nursery production. http://www.uky.edu/Ag/CCD/introsheets/potinpot.pdf

R.L. Geneve. 2014. Nursery container irrigation. Comb. Proc. Intern. Plant Prop. Soc. 64:3-8.

Holcomb, M. and D. Fare. 2009. The pot-in-pot (PNP) production system. http://www.tnstate.edu/faculty/ablalock/documents/Pot-N-Pot.pdf

McNiel, R., B. Behe, and C. Montgomery, 1996. Physical and economic requirements for pot-in-pot nursery production. http://www2.ca.uky.edu/HLA/Dunwell/PNPMCN.html

Nambuthiri, S., A. Fulcher, and R.L. Geneve. 2015. Microirrigation systems for pot-n-pot nursery production. In: Recent Advances in Sustainable Micro Irrigation. Vol. 4. Management, Performance, and Applications of Micro Irrigation Systems. M.R. Goyal (ed.). Apple Press, Waretown, NJ. Chapter 21: pp. 295-309.

Parkerson, C.H., 1990. P & P: A new field-type nursery operation. Proc. Intern. Plant Prop. Soc. 40:417-419.

Pellet, H., 1983. An Update on Minnesota System of Container Production. American Nurseryman 157(1).

Pellett, H., M. Litzow, and L. Mainquist, 1980. Use of metal compounds as root pruning agents. HortScience 15: 308-309.

Ruter, J. M., 1993. Growth and landscape performance of three landscape plants produced in conventional and pot-in-pot production systems. J. Environ. Hort. 11:124-127.

Figure 1. Typical components in a pot-in-pot production system. A. Containers on a high density planting using an in-row fabric floor management. Each tree is stacked and has an irrigation spray stake from main lines covered by the fabric. B. Floor management is with between row grass cover. Side view shows the relationship between the socket pot and the growing container.