Solutions for Pot-in-Pot Root Escape, Root Circling, and Heat Shock at Harvest©

Carl E. Whitcomb and Andy C. Whitcomb
Lacebark Inc. 2104 N. Cottonwood Road, Stillwater, Oklahoma 74075

INTRODUCTION

Heat, cold, and blow-over have been major problems plaguing plant production in the unnatural environment of man-made containers. In their natural environment, roots are protected by the insulating effect of soil and surface debris. Sensitivity to temperature extremes by plant roots appears to vary only modestly among species. Developing the pot-in-pot system (P+P) by installing a "socket" pot in the ground and inserting a production pot inside — seemed the golden solution for insulating container rootballs from temperature extremes. However, in many locations, P+P has turned out to be more akin to iron pyrites.

The pot-in-pot system was first tried with high expectations starting in 1973 (Hogan et al., 1974). Most tree species grew well a clay loam or a sandy clay loam soil. However, after two growing seasons with extensive rain periods, initial P+P studies ended with many dead plants. So P+P was written off as a good idea that did not work. The concept next surfaced, when Lancaster Farms, near Suffolk, Virginia reported success with P+P in deep sandy soils (Parkerson, 1990). Since then, there has been an assortment of successes, errors, and problems using P+P production (Fidler, 1999; Ruter, 1993; 1997).

P+P has turned out to be a classic case of the "good" news and the "bad" news. The "good" news is:

- Plants do not blow over;
- Roots are kept cooler in summer, warmer in winter, and subsequently more closely follow normal soil temperature patterns; and
- Some species in P+P produce more roots compared to conventional, above-round plastic containers.

The "bad" news is:

- Soils must drain well;
- Plants are still in conventional containers where roots can circle, intertwine, be poorly formed, and create major production problems at harvest;
- Root escape through drain holes is a major concern that can create chaos at harvest and severely shock plants;
- Techniques such as copper-coated pots and release of Treflan from Biobarrier® material are only moderately effective in controlling root escape problems;
- Once harvested and aboveground, when the sun hits the exposed side of black containers, root death occurs rapidly within minutes. With roots heavily concentrated against the inside wall of the plastic container, if a container is handled such that several sides are exposed to the sun — plant appearance and salability can be affected, transplant shock can occur, and the rate of establishment in the landscape is slowed; and

- Roots developed in a P+P system are more sensitive to heat compared to roots of the same species produced in aboveground containers. Ruter (1996) reported that P+P plants are more susceptible to root damage by high temperatures during post-production handling compared to plants gown conventionally above ground. In the revised edition of *Production of Landscape Plants II* (Whitcomb, 2001), I (Carl E. Whitcomb) reported, "some mechanism is needed to stop roots from circling and to stimulate root branching. At this point in time, I know of no practical solution", and "root escape is a major problem".

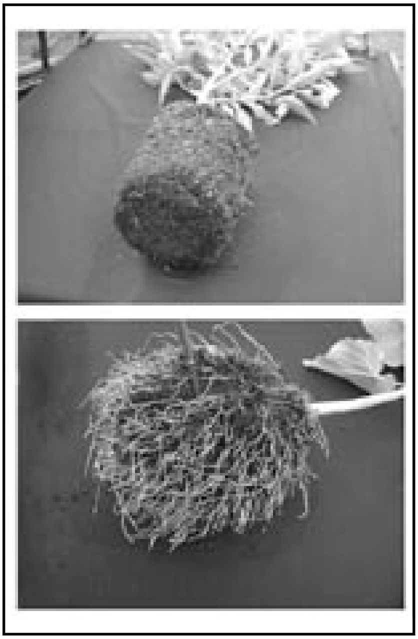

Figure 1. A very fibrous root system developed in the white fabric RootTrapper® container (top). Ten days after transplanting into 5-gal containers, catalpa seedlings were removed and evaluated for root growth. Large numbers of roots had grown out from the original root ball and some reached 23 cm (9 inch) in length (bottom).

In 2000, a procedure for laminating certain fabrics with white polyethylene was developed. The initial tests were done by sewing the coated fabric into containers that fit into cavities of a cinder block. Tree seedlings of several species were allowed to grow for 5 months. No root escape occurred with most species and only a few thread-sized roots exited seams — even with the aggressive catalpa. Root tips were trapped in the fabric, which stimulated branching. Seedlings are then removed and planted into 5-gal containers following removal of the fabric.

Catalpa (*Catalpa speciosa*) seedlings evaluated 10 days after transplanting, produced huge numbers of roots averaging 23 cm (9 inches) long (Whitcomb, 2003) (Fig. 1). These results suggested that making a container with coated fabric material might solve major problems of P+P.

METHODS AND MATERIALS

On 12 July 2003, a study was established using Nursery Supplies 57 L (15-gal), 6900T as the socket pot and production pot, or with the production pot made of a white, root-tip-trapping material called RootTrapper®. Growth medium was 3 pine bark : 1 peat : 1 sand (by volume), amended with Micromax®, dolomite, and Osmocote. The P+P containers were installed in a sandy loam soil with sufficient drainage. Plants were irrigated with one individual spray stake per container. Species used in the study were of 11- or 19-L (3 or 5-gal) size and included: loblolly pine (*Pinus taeda*), crapemyrtle (*Lagerstroemia indica*), pecan (*Carya illinoinensis*), shumard oak (*Quercus shumardii*), catalpa (*Catalpa bignonioides*), river birch (*Betula nigra*), and bald cypress (*Taxodium distichum*). Treatments were replicated three, four, or five times, depending on number of plants available per species.

On 31 Aug. 2004, two plants per species from each P+P container type were removed from the socket pot, beginning at 13:30 HR on a clear, sunny day and exposed for about 2.5 h to air temperatures of 36 °C (92 °F). The center of the exposed side of containers was marked for future reference, prior to replacement in the socket pots. Plants were maintained with normal irrigation and production conditions until 8 Sept. 2004, when they were again removed for evaluation. By this time roots killed by heat were black and distinct, in comparison to healthy roots. In addition, containers that had never been exposed to the sun were removed for comparison of root systems.

Figure 2. Root escape was severe with a conventional P+P production pot. With catalpa, three of six drain holes were fully blocked (top, left). Only a few roots escaped from the RootTrapper® production pot at the seams, and little growth occurred beyond the container wall (top, right). Loblolly pine also had extensive root escape in the conventional pot (bottom, left), but no roots escaped the RootTrapper® production pot (bottom, right).

RESULTS AND DISCUSSION

Root escape occurred with all species in P+P production with conventional pots (Table 1). Root escape of catalpa, crapemyrtle, and river birch plants also occurred with white RootTrapper® containers, however, the numbers of roots and size of roots that escaped was much less in the latter. Catalpa produced in conventional pots had escape roots of 1 to 2.5 cm (0.4 to 1.0 inch) in diameter, which filled drain holes and made difficult the removal of containers from their sockets.

However, the white RootTrapper® containers had fewer escape roots, which were 0.3 cm (0.1 inch) in diameter or less (Fig. 2). Escape roots were also few and less than 0.3 cm (0.1 inch) in diameter for crapemyrtle and river birch with the white RootTrapper® compared to conventional plastic containers. Furthermore, roots of the former were girdled and their growth was restricted where they grew through the vertical or bottom seam, thus facilitating removal of P+P containers from their sockets.

Root circling was extensive in conventional pots, with roots concentrated against the outside wall (Table 1). Root circling was not evident in the white

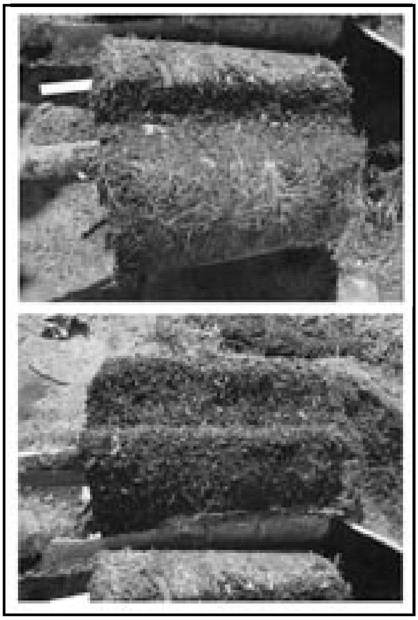

Figure 3. Sections were cut in a V-shape in the root ball of catalpa trees from top to bottom using a hand saw. Cuts were about 10 cm (4 inches) wide and 10 cm (4 inches) deep. Note that roots in the conventional container (top) were mostly on the outer surface and few roots grew internally into the growth medium. By contrast, few roots can be seen on the outer surface of the rootball after the RootTrapper® fabric was removed (bottom), but many roots can be seen internally in the growth medium.

Figure 4. Many of the catalpa roots in conventional black pots exposed to the sun for 2.5 h were dead (top). Note the distinct line of root death. In a few cases dead roots were beyond the exposed area. Those roots had originated on the side of the container not exposed to the sun, extended through the exposed area and beyond. When the root was killed in the exposed area, the root extending beyond was killed as well (top). Roots as large as 1 cm (0.4 inch) in diameter exposed to the sun were killed. Note the large root (bottom, right). New white roots grew within 8 days from root tissue that had survived the heat (below).

RootTrapper® containers, with root branching occurring in the container growth medium (Fig. 3). Sections cut from sides of rootballs showed many more roots distributed throughout the growth medium with RootTrapper® containers versus conventional containers. Better root distribution aids water and nutrient recovery and plant growth; also, root vulnerability to temperature extremes is reduced during harvest, shipping, and storage.

Following harvest and 2.5 h exposure to the sun, severe root death occurred in all black conventional containers (Table 1, Fig. 4). By contrast, roots against the inside surface of the RootTrapper® fabric containers remained white and had normal development, due to the 12 ºC (20 ºF) cooler rootball temperature (Fig.

Table 1. Evaluation of root escape, heat damage to roots, and root circling in conventional black plastic containers compared to white RootTrapper® containers used as production pots in the pot-in-pot system.

	Root escape[1]		Root damage[1,2]		Root circling[1]	
Species	Conventional container	Root-Trapper® container	Conventional container	Root-Trapper® container	Conventional container	Root-Trapper® container
Loblolly pine	10	1	10	1	10	1
Crapemyrtle	6	2	10	1	10	1
Pecan	6	1	10	1	10	1
Shumard oak	5	1	10	2	8	1
Catalpa	10	3	10	1	10	3
River birch	6	2	10	1	9	1
Bald cypress	6	1	10	1	10	1

[1] Root escape, root heat damage, and root circling were rated on a scale of 1-10, where 1= none and 10= severe; values are the average of two to three replications.

[2] Roots exposed to the sun for 2.5 h were evaluated for potential heat damage, compared to nonstressed roots.

5). In addition, since roots in the RootTrapper® containers were distributed throughout the growth medium and not concentrated at the inner wall; they were less vulnerable to temperature extremes (Fig. 3).

CONCLUSION

Constructing the production pot of white RootTrapper® fabric solves some of the problems of P+P production. It is important to note that drainage of water through the field soil outside the socket pot remains a critical ingredient and must not be overlooked when using this production procedure. Roots were present at the very bottom of all containers, which confirms that the growth medium used and soil drainage were satisfactory. Drainage through the myriad of stitch holes in the vertical seam and bottom of the white RootTrapper® container was sufficient. However, if drainage of soil supporting the socket pot is marginal, this technique is not recommended. Instead, above ground systems for

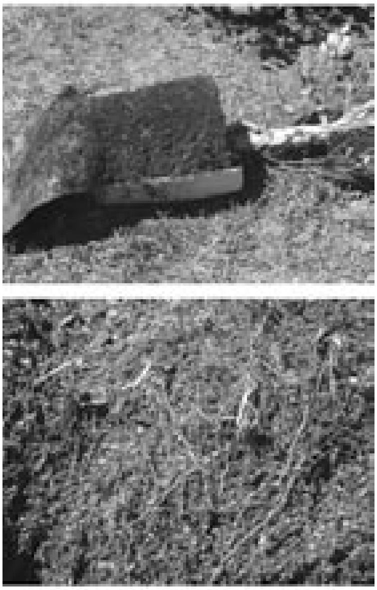

Figure 5. With white RootTrapper® fabric containers, white root tips were present on the exposed side of the container and on the surface of the exposed growth medium (above). When the surface of the root ball was brushed to remove some growth medium, many additional white roots were observed (below).

protecting plants from blow over and insulating roots from heat and cold should be considered (Whitcomb and Whitcomb, 2003).

LITERATURE CITED

Fidler, A. R. 1999. Pot-in-pot system: A container grown in the ground approach for diverse crops. Comb. Proc. Intl. Plant Prop. Soc. 49:297-299.

Hogan, C.R. and **C. E. Whitcomb**. 1974. Producing container nursery stock in the field. Okla. Ag. Exp. Station Research Report P-704: 43-44.

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

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.

Ruter, J. M. 1996. High-temperature tolerance of heritage river birch roots decreased by pot-in-pot production systems. HortScience 31:813-814.

Ruter, J. M. 1997. The practicality of pot-in-pot. Amer. Nurserymen. 185 (1):32-37.

Whitcomb, C.E. 2003. Plant production in containers II. Lacebark Inc., Stillwater, Oklahoma.

Whitcomb, C.E. 2001. Production of landscape plants II. Lacebark Inc., Stillwater, Oklahoma.

Whitcomb, C. E. and **A. C. Whitcomb**. 2003. Up with pots — solutions for heat, cold and blow-over problems. Comb. Proc. Intl. Plant Prop Soc. 53:255-264.

×*Chitalpa*: The Next Generation©

Richard T. Olsen[1] and Thomas G. Ranney

North Carolina State University, Department of Horticultural Science, 455 Research Drive, Fletcher, North Carolina 28732-9244

Hybridizations between distantly related taxa are often sterile and are a barrier in breeding programs for the development of improved hybrids. One way to overcome this barrier is through the development of allopolyploid forms of sterile hybrids. In this study, we compared the pollen fertility and reproductive behavior of diploid ×*Chitalpa tashkentensis* Elias & Wis. 'Pink Dawn' and induced allopolyploid ×*C. tashkentensis* 'Pink Dawn'. Pollen fertility was analyzed using aceto-carmine staining techniques and pollen germination tests. Female fertility was assessed through a series of controlled crosses between diploid and allopolyploid ×*C. tashkentensis* 'Pink Dawn' and diploid *Catalpa* and *Chilopsis.* Diploid ×*C. tashkentensis* 'Pink Dawn' were both male and female sterile, whereas allopolyploid ×*C. tashkentensis* 'Pink Dawn' had pollen germination equal to that of *Catalpa* and *Chilopsis.* Allopolyploid ×*C. tashkentensis* 'Pink Dawn' also demonstrated restored female fertility as seen in successful pollinations and fruit set. The restoration of fertility in ×*C. tashkentensis* 'Pink Dawn' allows for the development of a breeding program for the introduction of new and improved cultivars of ×*Chitalpa.*

[1]1st Place Student Awardee for Graduate Student Research Competition