Innovations and the Nursery Industry[1]

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Abstract

Two container designs are described that stimulate root branching and prevent root circling during production of nursery crops. In addition, the containers described accelerate the establishment of plants in the landscape and reduce losses. A pallet handling-overwintering-summer temperature modification system is described. This work unit solves several major problems related to container plant production. A root control system for growing nursery crops in the field is presented. This unique fabric container restricts root growth horizontally, but stimulates root branching and carbohydrate accumulation within the root system, thereby allowing transplanting any time and with little plant stress.

Index words: container design, handling, root growth, air-pruning, Field Grow Container

Introduction

The nursery industry has a strong tradition of following the practices of the past. The labor cost per plant product is among the highest of any aspect of agriculture and much higher than other industries. The labor cost per plant produced must be reduced and overall plant quality and performance increased.

Plants have long been grown in pots in greenhouses and homes, however, the practice of producing large numbers of plants out-of-doors in containers has developed primarily since the early 50's. The container nursery industry began in Southern California and spread rapidly across the southern states. The No. 10 food can with holes punched in the bottom was widely used and soon became known as the "one-gallon" container. During the 60's and 70's, the container nursery industry increased rapidly for several reasons: 1) landscape plants grew at a faster rate in containers than in the field, 2) production time decreased, 3) the root system of the plant remained undisturbed allowing planting to be done any time, not just during early spring as with bare root or balled and burlapped nursery stock, and 4) the ease of display and handling made container grown plants attractive to the retailer and consumer.

However, development of the container nursery industry was not without problems. The complex nutritional requirements of plants in containers took years to refine so that plant growth and quality was comparable to plants grown in the field. The medium for the container evolved from field soil, to mixes of field soil and compost, to soilless mixes. The far greater pore space of the soilless mixes aids in providing oxygen to the root system.

Root development, expecially that of woody plants in containers, has been the subject of numerous articles (1, 6, 7, 8, 9, 13) and is a common topic at gatherings of nurserymen. As a root grows from a cutting or seedling in a container, its path is out toward the side of the container and downward. When a root reaches the side of a round container, it follows the contour, and generally after 1/2 to 1 full circle, reaches the bottom, where it may continue to elongate and circle, sometimes for 5 or more revolutions.

Whitcomb (15) tried placing holes in the sides of containers to improve root growth, but without success. Subsequent studies with tree seedlings grown in square, bottomless containers on a raised wire bench showed that "air-root-pruning" was effective in stopping root elongation and encircling at the bottom of the container. Air-root-pruning also stimulated lateral branch root development because it caused the death of the root tip (2). Later studies by Hathaway and Whitcomb (9) showed bur oak trees (*Quercus macrocarpa*) grew larger and developed a more fibrous root system in a square bottomless container than in a conventional round container of the same volume.

Unfortunately, growing plants in bottomless containers on raised wire benches is neither practical nor economical. Therefore, additional container designs were studied. Birchell and Whitcomb (1) compared the growth of river birch (*Betula nigra*) trees in containers with vertical ribs on the sides, with or without bottoms. The vertical ribs stopped the circling or wrapping of the roots of a fine, fibrous-rooted species such as birch. In addition, when the vertical ribs were present there was no advantage to removing the bottom from the container for air-root-pruning. Dickinson and Whitcomb (3) tried placing ribs across the bottom and vertical ribs in round containers only 1/4 to 1/2 the height of the

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sidewall of the container so that the containers could be partially "nested" for stacking and shipping. Japanese black pine (*Pinus thunbergiana*) and bald cypress (*Taxodium distichum*) trees were grown in the containers for one season. The vertical ribs in the lower 1/4 or 1/2 of the container were effective in stopping circling of the pine roots, however, the more coarsely-rooted cypress either bent the rib and continued to circle or was stopped by the rib from circling but continued to elongate, creating a "tangled ball-of-string" effect.

These studies showed that the root system of a plant grown in a container could be improved: 1) as in the case of the bottomless container on a wire bench, and 2) that vertical ribs inside the container could improve the root structure of fine, fibrous-rooted plants, but only made the problem worse on strong, coarsely rooted plants. Both techniques were impractical for the production of nursery stock on a commercial scale.

Two new container designs hold great promise of improving not only the rate of growth and quality of container nursery stock during production, but accelerate the rate of establishment in the landscape and insure customer satisfaction as well.

The Vertical Air-Root-Pruning Container

During February 1981, the idea of air-root-pruning the root system on the sides of the container instead of the bottom was born and studies began (16). In order to study this container modification, vertical sections were cut from the sides of conventional polyethylene containers and set in approximately 3 mm (0.125 in) to create vertical slits. Some slits opened clockwise and other counter-clockwise. The slits must go clear to the bottom of the container. In addition, if they are not offset, roots do not grow out of these openings and are not air-pruned. *Pyracantha X* 'Mojave' cuttings were planted in the new containers as well as in conventional containers of the same size and color.

By air-root-pruning the roots on the sides of the container the objections of the previous techniques were overcome: 1) containers have a conventional bottom for ease of filling, handling and shipping (Fig. 1); 2) roots are more evenly distributed throughout the container medium, not mostly in the bottom; and 3) the vertical air-root-pruning stops root circling and causes stimulation in branch-root development. The increase in root surface area results in increased absorption of water and nutrients, which in turn results in increased plant growth.

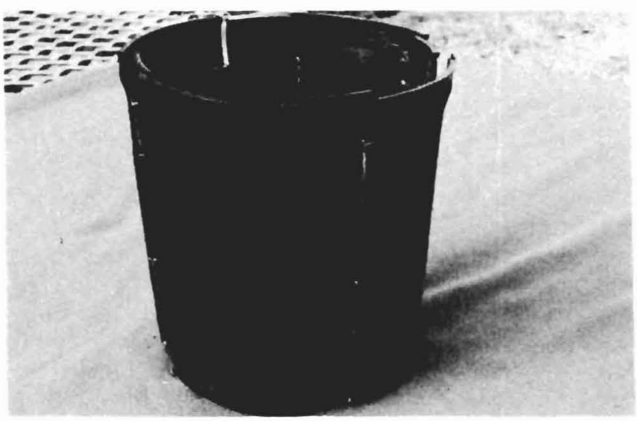

Fig. 1. Container design with vertical slits to air-root-prune root tips as they circle. The root tips will be pruned whether they circle left or right.

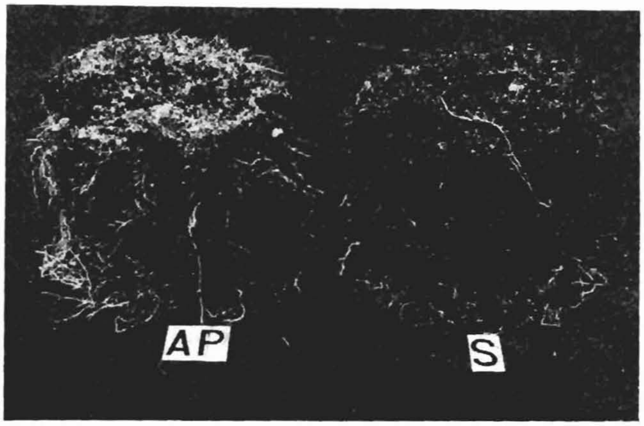

Fig. 2. Root development of pyracantha grown in a No. 2 (2 gal) container then transplanted into No. 5 (5 gal) containers and allowed to grow for 10 days. The stem of the plant was used to shake off the growth medium from the larger container. Note the greater number and vertical distribution of white roots on the vertical air-root-pruned container (AP) as opposed to the standard pot (S).

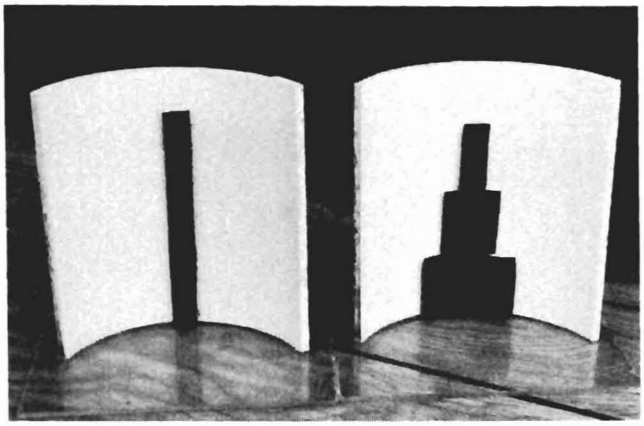

Fig. 3. Cross section of container made with the vertical rib (left) and stair-step rib with the recessed edge (right). In practice the stair-step rib would have many more steps than is shown here.

With nursery stock grown in conventional containers only a few root tips exist at the bottom of the container (Fig. 4). At time of planting in the landscape, the root tips extend into the surrounding soil (3). With the vertical air-root-pruning container, a great increase in number of root tips exists at planting time (Fig. 2), thus, establishment of the plant in the landscape is accelerated. Other advantages of the container are that it can be filled by existing commercial pot fillers without modification and it will "nest" or stack so that freight costs for shipping containers from manufacturers to nurserymen will not be increased.

A Stair-Step Container

As the work with roots and root reactions to obstructions in containers continued, it became clear that a con-

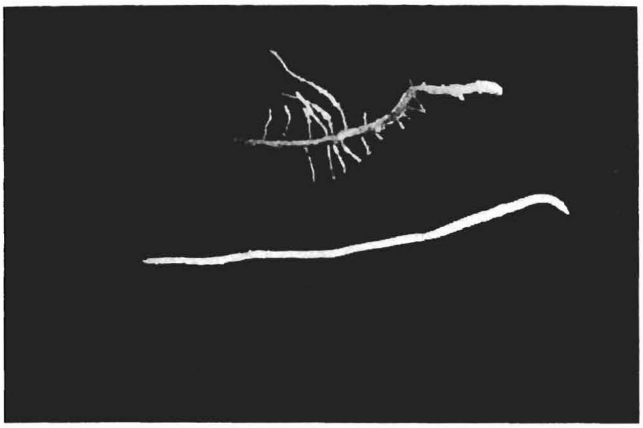

Fig. 4. Root development in containers with the stair-step apparatus (above) and in a smooth conventional (below).

Fig. 5. Gardenias grown in a conventional container (left) and a container adapted with a stair-step insert to prevent root circling and stimulate root branching (right).

tainer could be designed to control root circling and stimulate root branching without openings in the sidewall.

Experimental containers were constructed from 15 cm (6 in) thinwall, PVC pipe and fitted with several inserts to trap and control root tips and stimulate root branching. The most effective device created a stair-step offset in the sidewall of the container with recessed intersections between the stair-step and the sidewall of the container (Fig. 3). As a root contacts the sidewall of the container and begins to circle, it contacts the stair-step and the root tip is trapped in the recessed corner. When the root tip cannot deflect around the barrier, it loses its dominance and develops secondary branch roots (Fig. 4). The secondary branch roots are also trapped as they grow to the sidewall of the container and begin to circle (9).

Total root tips on the outer perimeter of the root ball of Virginia pine seedlings was increased by 200% compared to a conventional plastic container. When the pines were transplanted and examined 22 days later, the number of roots growing out from the sidewall of the root ball was 113% greater than the conventional container.

Gardenias grown in the stair-step container had 50% more branches and were more spreading in growth form than plants grown in conventional containers (Fig. 5).

Both container designs are currently being developed by private industry and will be available in the near future.

An Insulated Pallet System for Handling and Overwintering Nursery Stock

Overwintering plants in containers is a serious problem. Container plants are not grown in their natural environment; therefore, the roots are above ground and subject to the temperature extremes (12). To reduce root injury during overwintering, the nursery industry is currently using many different cold protection techniques; microfoam placed over the containers within a poly house (5), paper barriers placed around the pots (11), nutritional practices to prepare plants for the winter season (12), straw mulching and construction of temporary poly structures to cover the containers (4).

An insulated pallet was developed to protect the roots of plants grown in containers from the extremes of temperatures and to facilitate handling and prevent containers from blowing over. Our experimental system currently holds 36 No. 1 (one-gallon) containers spaced on 25 cm (10 in) centers (Fig. 6).

Direct sunlight does not contact the sidewall of the container in summer, thus the temperature of the root system throughout the growth medium is always about 1 °C (2 °F) cooler than the surrounding air temperature. This is in contrast to temperatures 10 to 20 °C (20 to 30 °F) higher than air temperature on the southwest side of exposed containers.

The containers are held by the structure and cannot blow over, therefore the growth medium can be lighter. Not only does the pallet eliminate the continued problem of standing plants up following a windy day, it allows a substantial weight reduction as well. For example, 36 No. 1 (one-gallon) containers with a mix of 3-1-1, bark, peat and sand weighed over 82 kg (80 lbs). On the other hand, when an additional part bark was substituted for the sand, the 36 containers weighed only 36 kg (80 lbs).

The container pallet system can be mechanized extensively, whereby one employee would handle hundreds of containers with a light-weight fork lift as opposed to individual handling of containers.

Fig. 6. Our current "system" includes a light-weight wire frame, aluminum covered insulated top and a light weight growth medium since the plants cannot blow over.

The insulating capacity of the pallet during the winter has provided protection for plant roots superior to mulches, barriers and poly covered structures, while leaving the plants in the same location in the field as during the growing season.

A functional design of the pallets would include an interlocking lip or insert such that the pallets would be placed tightly together for the winter. Only the outer parameter of a group of pallets would require special covering using additional insulating material. In mild climates, the tops of the plants would remain exposed, similar to a landscape setting. In more severe climates, a single layer of moderate density shade cloth and/or milky polyethylene would be spread over a large block of pallets to reduce winter injury and discoloration of evergreens.

In actual studies using several plant species, no detectable root injury to plants in containers in the insulated pallet occurred as compared to moderate to severe root injury and death with mulches, poly-covered structures or no protection (Fig. 7).

A further advantage to this system is that the plants remain dormant until normal temperatures for bud-break in the landscape, in contrast with the early bud emergence in poly covered structures.

Since the pallet supports the containers above the soil surface, the entrance of disease organisms through the drain hole cannot occur as sometimes happens with present techniques. The reduction or elimination of ground cover cloth and other expensive bed covering material would further support the use of a device of this type.

Some type of mass handling device must be developed for the container nursery industry in order to reduce the tremendous labor costs and protect the root systems from the temperature extremes of summer and winter. The insulated pallet system deserves additional attention for solving numerous labor, handling and cultural problems.

The Field-Grow Container

Container production is an effective system for small shrubs and some small trees, however, containers larger than the No. 5 (5 gallon) are not economical due to the tremendous labor, space and overhead costs. Summer heat and winter cold are major complications to any container-grown plant. In the case of trees, the wind is also the enemy; the larger the tree, the more frequently it blows over. The root system of container-grown trees is a concern to any nurseryman who has ever washed away the soil and observed the grotesque, deformed roots. There is increasing evidence to suggest that these deformed roots weaken and shorten the life of the tree (8).

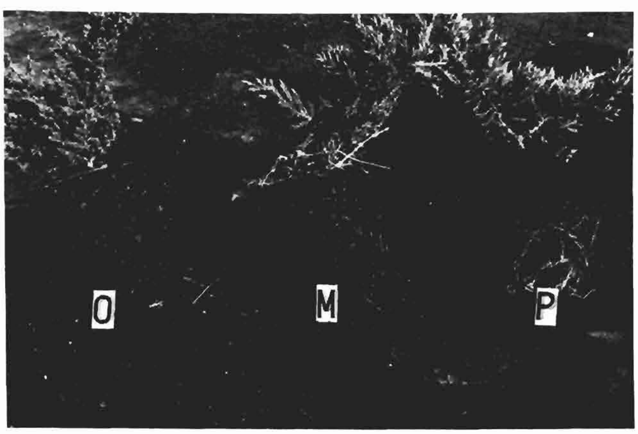

Fig. 7. Roots of Japanese garden juniper after being outside during the winter of 1981-82 with (O) no protection other than grouping together, (M) mulched heavily with straw, and (P) 2" styrofoam insulated pallet.

Fig. 8. A 'Field-Grow Container' with fiberglass planting sleeve inside to aid filling.

Fig. 9. 45 cm (18 in) 'Field-Grow Containers' planted on 1.2 m (4 ft) centers with 2.4 m (8 ft) rows. The liners were 1-year-old container grown pines. On this sloping site and sandy soil, wheat was used as a winter cover crop then killed using a very low rate of Roundup before the trees began growth in the spring.

This unique system combines the advantages of container growing with the ease and simplicity of field production while reducing labor costs (Fig. 8).

Balled-and-burlapped, the time-honored method of growing quality trees requires expensive machinery, or expensive labor for harvesting. Perhaps most importantly, research has shown that over 90% of the roots of field-grown trees dug balled-and-burlapped, or by machine are lost (14). This means stress and stress means diseases, insects, additional watering, losses, and replacements (17). The unique 'Field-Grow Container' eliminates all of these problems. There is no balling and burlapping in the field and expensive digging equipment is eliminated. Approximately 80% or more of the

Fig. 10. River Birch after one season in 45 cm (18 in) 'Field-Grow Container.' Root penetration through the soil and fabric held the soil mass together. This tree will grow one more season for 5 cm (2 in) + caliper. This tree was "dug" by inserting a spade around the outside and lifting of the stem. The entire "digging" operation took about 3 minues.

Fig. 11. Tree pulling clamp behind small Ford 1300 series tractor. The 5 cm (2 in) + River Birch tree and 51 cm (20 in) 'Field-Grow Container' required no spade work.

plant's root system is retained. Therefore, as with conventional above-ground containers, larger caliper trees can be successfully harvested, sold and delivered by the grower almost any time of the year (Fig. 10).

Harvesting trees 4 to 10 cm (1½ to 4 in) caliper is very simple (Fig. 10 and 11). Design of the 'Field-Grow Container' allows no root growth directly downward beneath the container and allows only small, fibrous roots to penetrate the sides of the container. Therefore, dormant trees can be removed from the ground with a clamping device attached to the tree trunk and lifted out by the three point hitch of a small tractor. In any season, minimal spade work by unskilled labor around the container will sever the small roots allowing for removal of the trees, so no large hole or digging directly under the tree is needed!

There is no root circling or distortion in the 'Field-Grow Containers.' The non-woven fibrous container side wall catches and holds the root tips as they grow and contact the sides of the container. When root penetration of the container does occur, the roots remain very restricted and are pruned by the fabric, thus causing more fibrous root development (Fig. 12, 13, 14).

The non-circling fibrous root system retained during harvest provides for much faster root regeneration and thus more transplanting success. Research at Oklahoma State University demonstrated that river birch, loblolly pine and green ash trees 5 to 8 cm (2 to 3 in) caliper can be successfully transplanted in 38 °C (100 °F) temperatures in central Oklahoma with no loss of leaves.

Because the roots are continually restricted, the concentration of stored food within the stem and roots of the plant is very high. This means greater stem caliper and branch development and very rapid root growth into the surrounding soil as soon as the fabric container is removed prior to planting (Fig. 14).

Because of the many roots and stored food within the tree, a ball size 20 to 25% smaller is needed with this unique container.

Fig. 12. The unique 'Field-Grow Container' helps produce a root system unparalleled in horticulture or forestry as no twisting or circulation occurs. These root systems are from 6.5 cm (2.5 in) caliper loblolly pines grown in a 'Field-Grow Container' (left) and conventional field production and dug B & B (right).

Fig. 13. This sycamore shows one large root and numerous small ones. The 'Field-Grow Container' was mistakenly planted too deep. The one large root that escaped grew unrestricted in typical field fashion. Consider how much of it was cut away when harvested. All others were controlled by the container, resulting in the many fine roots penetrating the container. Most roots will stay with the tree for transplanting. This clearly shows the effect of root control.

Fig. 14. This root shows girdling that occurs on 'Field-Grow Container' penetration. Note the fibrous root development at this point that occurred following transplanting.

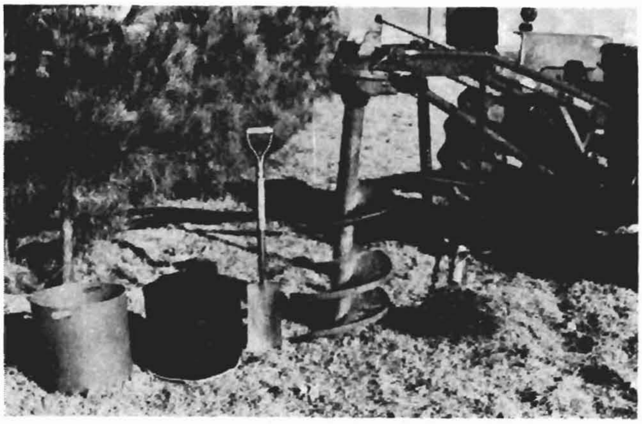

Fig. 15. The only tools needed for this unique 'Field-Grow Container' are: (L to R) sleeve for filling container; 'Field-Grow Container'; shovel for harvesting; power auger to dig hole to receive the container; and during the dormant season a clamp for pulling trees.

More efficient labor utilization is realized because any employee can harvest 'Field-Grow Containers.' The expertise and experience of ball and burlapping is not necessary.

Re-burlapping, customarily done when field grown, B&B trees are held by retailers or others for longer periods is eliminated as the fabric is non-degradable. This feature allows field growers to pull or remove trees at any time, hold them conventionally or place them back in the same or another hole, holding them until sale or delivery.

These features contribute to a more cost efficient method of growing specimen plants compared to B&B or conventional containers. Approximate labor cost is 50 to 60 cents to plant and 50 to 60 cents per plant to dig a tree of 5 to 8 cm (2 to 3 in) caliper.

The 'Field-Grow Container' system works best with an auger the same size as the outside diameter as the container (Fig. 15). When the trees are sold, the root ball will be attractive, flat-bottomed, and straight-sided that handles well and provides amazing performance for the customer—any time of year. However, the fabric 'Field-Grow Container' must be removed when the tree is planted into the landscape. Simply slit the sides of the 'Field-Grow Container' vertically with a sharp knife every 12.5 to 15 cm (5 to 6 in). With a quick snap, pull the strips of fabric down to where it is attached to the poly on the bottom. The fabric may then be left in the bottom of the planting hole or removed.

New container designs can stimulate root branching and improve plant performance. A handling system could ultimately reduce labor costs for container plant production. A technique for growing specimen trees and shrubs in field soils with reduced labor cost and improved plant performance is now available. I see a bright future for the nursery industry. The allegiance to old procedures are hard to put aside, however, innovations must come to make our product more attractive and economical with assured positive performance for the customer. Everyone that purchases a tree or shrub would like to think that they have a "green thumb." I'm convinced that if all the customer has to know to be successful with our products is "green-side-up" consumption would increase dramatically.

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