LLOYD MODEN: We do cover the aisles in the plastic houses, but it would double our cost to do so in the field.

BRUCE BRIGGS: Have you tried Goal (6)? Reported results look good for broad-leaved weed control.

LLOYD MODEN: We have not used it.

PHIL BEAUMONT: Why do you use such a high rate of Roundup? We have found we can add liquid dishwashing detergent and cut the rate one-half to one third.

LLOYD MODEN. 2⅔ oz/gal is the recommended rate. We feel the cost of additional chemical, which gives us better control, outweighs the cost of more labor to hand weed or repeat applications.

HUGH STRAIN· Do you use a spreader?

LLOYD MODEN. No. It is not suggested on the label.

EARL ROBINSON: Does MeBr help with disease control?

LLOYD MODEN: We have fumigated for so many years that we have few disease problems.

GERALD SMITH: Where do you buy the Kelty shoulder straps and hip belts?

LLOYD MODEN. We buy these at the outdoor backpack sports supply houses.

A VERTICAL AIR-ROOT-PRUNING CONTAINER[1]

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Abstract. A container was designed to prevent root circling and stimulate root branching A test with the air-root-pruning container using Pyracantha × 'Mojave' showed an increase in top and root weight, number of branches per plant and number of 2 in long roots 10 days after transplanting of 63, 38, 158, and 187%, respectively, compared to plants grown in conventional containers This container nests for shipping, can be filled by existing potting machines and can be handled and stacked for plant shipping like conventional containers

INTRODUCTION

Plants have long been grown in pots in greenhouses and homes. However, the practice of producing large numbers of

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[6] Goal — oxyfluorfen, Rohm and Haas

[1] Patent applied for

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 #10 food can with a few 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) turnover time decreased, 3) the root system of the plant remained undisturbed allowing planting to be done anytime, not just during early spring as with bare root or balled and burlapped nursery stock and 4) ease of display and handling made container grown plants attractive to the 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, especially that of woody plants in containers, has been the subject of numerous articles (1,4,5,6,7,8) 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 ½ to 1 full circle, reaches the bottom Here it may continue to elongate and circle sometimes for 5 or more revolutions.

Whitcomb (9) tried placing holes in the sides of container to improve root growth, but without success. Subsequent studies with tree seedlings grown in square, bottomless container on a raised wire bench showed that "air-root-pruning" was effective in stopping root elongation and wrapping 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 (7) 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 not practical or 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 with birch, 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 ¼ to ½ the height of the sidewall of the container so that the containers could be "nested" for stacking and shipping. Japanese black pine (*Pinus thunbergi*) and bald cypress (*Taxodium distichum*) trees were grown in the containers for one growing season. The vertical ribs in the lower ¼ or ½ 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.

EXPERIMENTAL PROCEDURES AND RESULTS

Methods: During February, 1981, the idea of air-root-pruning the roots system on the sides of the container instead of the bottom was born and studies begun. In order to study this container modification, vertical slits were cut in the sides of conventional polyethylene containers (Figure 1) In addition, horizontal cuts about ¾ inch long were made at the top and bottom of the vertical slit so that section of the pot could be forced out and a wire inserted to prevent closure. The vertical slits created were about ⅛ inch wide. Some slits opened clockwise and others counterclockwise. It is important that slits go clear to the bottom of the container and that they are offset. If they are not, roots do not grow out and are not air-pruned. *Pyracantha coccinea* 'Mojave' cuttings were planted in the new containers as well as in conventional containers of the same size and color. The growing medium for both containers was a 3.1:1 mix of ground pine bark, peat, and sand amended with 14 pounds of 17-7-12 Osmocote, 8 pounds of dolomite and 1 5 pounds of Micromax/cubic yard. Containers were located in full sun and were watered from overhead sprinklers as needed

RESULTS AND DISCUSSION

By air-root-pruning the roots on the sides of the container (Figure 2) the objections of the previous techniques were overcome: 1) Containers have a conventional bottom for ease of filling, handling and shipping. 2) Roots are more evenly distributed throughout the container medium, not mostly in the bottom (Figures 4 and 5). 3) The vertical air-root-pruning 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 (Table 1).

Figure 1. The container design with vertical slits to air-root-prune root tips as they circle the container. By alternating the opening of the slit, the root tips will be pruned whether they circle left or right.

Figure 2. Close-up of root development at the vertical slit in container. Note that the roots have been air-root-pruned at the slit and have stopped elongating. When the plant is placed in the landscape, however, the newly formed branch roots will elongate rapidly into the surrounding soil.

Figure 3. Root development of a pyracantha shrub (left) in a container with vertical slits and (right) in a conventional round container of the same size and composition. Note that some roots in the conventional container circle half way or more around the container even though these plants are only 3 months old.

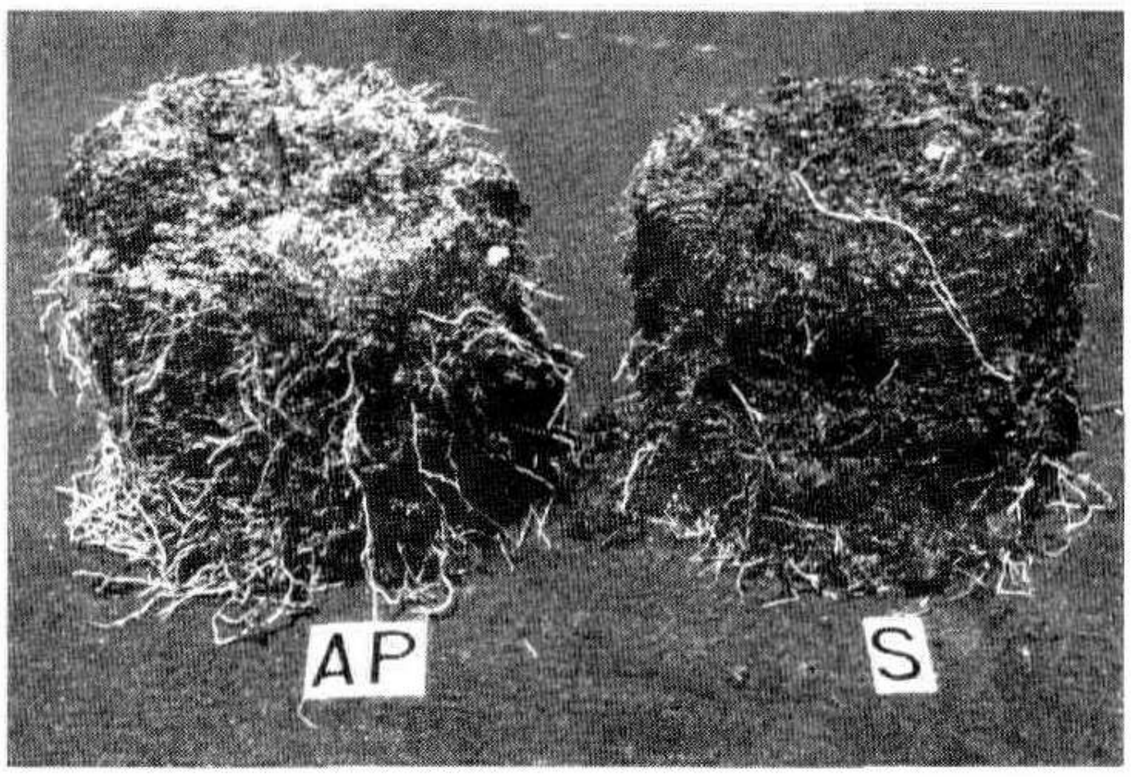

Figure 4. Root development of pyracantha grown in 2-gallon container then transplanted into 5-gallon containers and allowed to grow for 10 days. Note the greater number of white roots on the vertical air-root-pruned container (AP) as opposed to the standard pot(s).

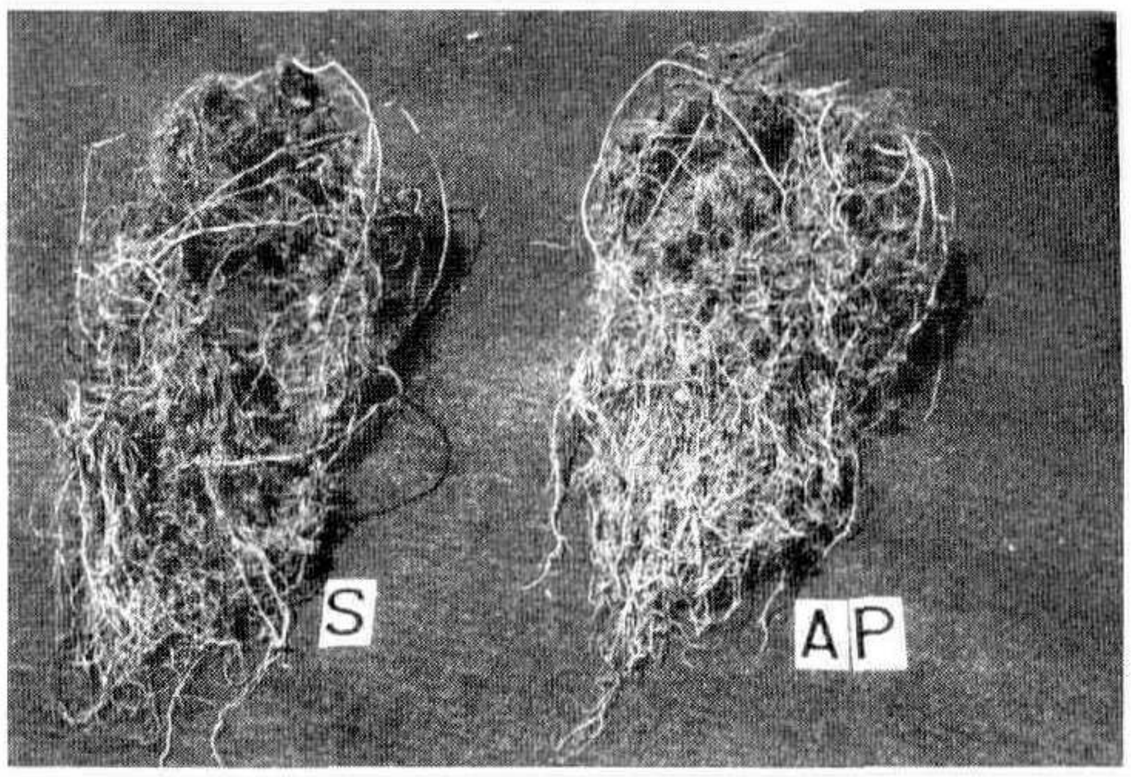

Figure 5. Root development of pyracantha in a standard pot(s) vs the vertical air-root-pruned container (AP). Note the numerous circling roots of the standard pot as opposed to the more fibrous root system and no circling of the air pruned pot.

With nursery stock grown in conventional containers only a few root tips exist at the bottom of the container (Figure 3). 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 (Figure 4 and Table 1); thus, establishment of the plant in the landscape is accelerated. Other advantages of the container are: 1) It can be filled by existing commercial pot fillers without modification. 2) This container will "nest" or stack so that freight costs for shipping containers from manufacturers to nurserymen will not be increased.

Table 1. Effects of vertical air-root-pruning on growth of Pyracantha × 'Mojave'

	Standard pot	Air-pruned pot	Percent increase
Branches/plant	12 5	32 2	158
Number of roots 2" long 10 days after transplant	44	126	187
Top weight (g)	93 3	152	63
Root weight (g)	109	192	38

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TED GOREAU: Must the slits be offset in opposite directions?

CARL WHITCOMB: Yes. Otherwise only the roots circling in one direction will be pruned.

BRYSON JAMES. Did just ribbing help?

CARL WHITCOMB: We found that roots still wrapped around the inside of the container

BRAD MAY: With our 85% relative humidity, we don't get air-pruning even if the roots come out.

CARL WHITCOMB. When we started our experiment, we had 85% relative humidity We still got root pruning. However, this is a legitimate concern.

TERRY GRACE· How hard is it to remove the plant from the container?

CARL WHITCOMB· We've had no problem

JIM BERRY: Do you get the same effect with strongly taproots?

CARL WHITCOMB: Yes, although it is not quite as dramatic Pecan will produce an extensive fibrous system but these roots do not remain functional following transplanting. However, that is not typical of other species.

JUDSON GERMANY: Will these containers require a separate watering system?

CARL WHITCOMB. I can't see that they will. The slits are not truly openings and seem not to affect water requirements.

BILL PINKHAM: What about a pot with a mesh screen at the bottom?

CARL WHITCOMB. We have tried that. A pot with a false bottom of any sort is hard to manufacture. Also, anytime the soil ball is elevated, the soil column is shortened and drainage is not as good

STEVE HAMMOND· We have found baskets effective in producing fibrous roots

CARL WHITCOMB. Yes. We have obtained similar results with wooden-slat type containers.

JUDSON GERMANY. What about a square container?

CARL WHITCOMB· Changing shape is no help unless slits are put at the corners.

STEVE HAMMOND. Have you tried a wider pot or using field soil?

CARL WHITCOMB· Oxygen content in the medium is a function of both surface area and depth. However, pulling in the oxygen at the surface is a function of depth since gravitational pull increases as the height of the soil column becomes greater.

I do not feel field soil has a place in container production Maintaining good water relations is very difficult, and sooner or later *Phythophthora* becomes a serious problem.

JOSE GARCIA: Are these pots available?

CARL WHITCOMB. We have contacted two manufacturers, but they are not producing them so far.

GROUND COVERS FOR HIGHWAY USE

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Abstract. Over 200 different kinds of plants were investigated over eight years for their adaptability, hardiness, propagation. maintenance, and general suitability for use as ground covers on slopes, medians, and flat areas along highways in Louisiana Rating for overall appearance, weed presence and crop establishment over a 13 month period indicated that liriope rated highest significantly *Lonicera japonica* 'Purpurea', *Trachelospermum asiaticum* and *Wedelia trilobata* rated highly also *Wedelia* kills back to the ground after exposure to 28°F The others are evergreen

Research was initiated in July, 1973, with the Louisiana State Highway Department to learn which low-growing ground cover, preferably under 2 ft, could be used to enhance safety and beauty, prevent erosion and reduce maintenance costs primarily on slopes, on entries and exits along the interstate highways (4).

There was very little information available on low-growing herbaceous and woody materials for the South (1,2,3). This study was undertaken with the following objectives: to obtain, select, and propagate plants for trial; to learn the best method of propagating and producing them; and to set up replicated field trials to learn how they would establish under local conditions. Ultimately the goal was to make recommendations for future plantings based on information obtained.

MATERIALS AND METHODS

A review of the literature was started in 1973 and collection made of various plant materials that had possibilities of fulfilling the objectives. Over the 8 year period 8 different